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THE CHALLENGE OF MANAGING KNOWLEDGE IN INNOVATIVE ORGANIZATIONS: Internal Versus External Knowledge Acquisition

Andrea Deverell
University of Limerick
Limerick, Ireland

Astrid Heidemann Lassen
Aalborg University
Aalborg, Denmark

Abstract

Ideas are no longer generated solely within a firm's internal boundaries but also sourced from the external knowledge environment. Therefore, firms can no longer rely solely on internal knowledge to develop new ideas or solve problems. This paper is based on empirical research which investigates different knowledge acquisition strategies utilized by firms during the innovation process. It suggests that there is a relationship between the kind of innovative activity (cumulative or radical) and the sourcing of knowledge (i.e., the internal and/or external environment). Two hypotheses are derived from the literature and tested empirically. These hypotheses are based on the premise that cumulative type organizations focus primarily on internal knowledge or existing core competencies within the firm and are less likely to scan the external environment for ideas and knowledge, whereas radical type organizations are continually pushing out the boundaries of knowledge and replacing existing core competencies with new ideas and knowledge and are therefore predisposed toward utilizing external knowledge. The research findings confirm the hypotheses and enable the development of a third dimension based on a dual ability to focus on both cumulative and radical innovation aligned with the most appropriate knowledge acquisition strategy.

Keywords

Knowledge acquisition, technology transfer, radical and cumulative innovation, agility and resilience

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1 INTRODUCTION

Interest in knowledge management and technology transfer on the part of academics and practitioners has increased dramatically in recent years. This is evident in the growing number of publications dealing with this topic (Chesbrough 2003; Kaplan 1999; O'Connor and Ayers 2005; O'Reilly and Tushman 2004). With the advent of the information age, the growing importance of university based scientific research, and the increasingly diffuse nature of knowledge, knowledge monopolies have effectively become a thing of the past (Chesbrough 2003). As a result, knowledge has become widely accessible and available to all, and this has directly impacted how people acquire and manage knowledge.

Continuous developments in computing and information technology have acted as catalysts to the rapid dissemination of knowledge, providing a means to reach a globally dispersed audience. This coupled with the development of organizational information systems has provided firms with the capability of storing and organizing large quantities of information. In this reality, increasing interest is being shown in the successful sourcing, use and protection of knowledge as an essential competitive variable, providing advantages to firms effectively managing this resource over those that do not (Argote and Ingram 2000; Darroch 2005; Kogut and Zander 1996).

The realization of the connection between knowledge and an organization's innovation ability has resulted in the emergence of complex models for the transfer of knowledge between firms, research institutes, inventors, entrepreneurs, universities, and other sources. In today's knowledge economy, a firm's ability to leverage knowledge in order to innovate is crucial.

The present paper is built around the perception of the existence of a strong connection between a firm's ability to leverage knowledge and its ability to innovate. This is dealt with in more detail in section 2.1 of this paper. An initial review of the literature has revealed the need for the development of a clearer understanding of the relationship between knowledge, innovation, and organizational productivity. In this paper, the authors limit the scope of research to that of the relationship between knowledge and innovation. In particular, the authors have been intrigued by the generic use of the term innovation in the context of knowledge. While the existence of varying degrees of innovation is clearly recognized in the literature, there is little recognition of this complexity in the field of knowledge management and therefore it requires further investigation.

As such, the aim of the paper is to further unfold the question: *What is the relationship between cumulative/radical innovation and internal/external knowledge acquisition respectively?*

In order to explore this relationship, the authors initially conducted a literature study on knowledge management and innovation in order to be able to discuss the existing insights into the connections between knowledge and innovation, and in this way establish a frame of reference.

Additionally, four case-studies in industrial firms involved in respectively cumulative and radical innovation have been carried out, providing evidence on the methods of knowledge acquisition used in each type of firm.

The structure of the paper is divided as follows. Section 2 provides the theoretical background to the study, which is framed around the concept of closed (section 2.3) and open (section 2.5) innovation, giving rise to the development of two hypotheses regarding the relationship between cumulative/radical innovation and internal/external knowledge acquisition. This is followed by a brief summary of the research methodology, discussing the approach applied in the construction of this paper. Four case studies are then presented, revealing characteristics on historic development, innovation strategy, and knowledge acquisition strategy for each of them. The findings in the cases provide an empirical foundation for discussing the hypotheses developed through theory, and highlight possible extensions of theory on open versus closed innovations systems, which is presented and discussed in section 5. Section 6 outlines the major conclusions of the paper and points to areas of further research that will provide additional contributions to the understanding of the area of research, which are not covered in the present paper.

2 THEORETICAL BACKGROUND

2.1 Knowledge and Innovation

Knowledge-based assets and organizational learning capabilities are increasingly recognized in the literature as potential sources of competitive advantage. The ability to acquire and utilize knowledge effectively is argued to be critical for the firm's innovation activities and performance (Cohen and Levinthal 1990).

Modern literature on innovation emphasizes the importance of the ability to utilize external knowledge sources in innovation activities (Chesbrough 2003; Cockburn and Henderson 1998; Cohen et al. 2002; von Hippel 1988). For example, according to Chesbrough (2003), openness to using external sources of information and ideas in the firm's innovation processes, as well as interaction among different partners, is of high importance when creating value through innovation activities. Firms are increasingly dependent on their customers, suppliers, and other complementary capabilities as initiators of product and process improvement and sources of new ideas (von Hippel 1988). This perspective is also reflected in the seminal distinction made by March (1991) between exploitation and exploration, equal to and introvert versus extrovert focus on acquiring knowledge for the development of innovation.

2.2 Levels of Innovation: Cumulative to Radial Innovation

For the purpose of this paper two definitions regarding the level of organizational innovation are defined by the authors. *Cumulative innovation* is defined as the incremental improvement and introduction of existing products/technologies or services, which are perceived as low to medium risk, into existing markets usually building on a firm's core competencies. *Radical innovation* is defined as the development of signi-

ificantly new ideas, which are perceived as high risk into new markets often resulting in the destruction of a firm's core competency and the creation of new competencies.

Intensive competition on global markets has effectively forced firms to be increasingly innovative in their approach but also in their product offerings. Continual improvement or cumulative innovation is no longer perceived to be enough to sustain a firm in the long-term. Hamel (1996, p. 69) eloquently states that "pursuing incremental improvements, while rivals reinvent the industry, is like fiddling while Rome burns." Firms can, therefore, no longer rely solely on internal knowledge generation in order to develop new ideas or solve complex problems, but must source knowledge from the external environment as well. The literature presents pros and cons that support both views. Darr et al. (1995) and Baum and Ingram (1998) have suggested that firms benefit most from knowledge generated within the boundaries of the firm, while, Menon and Pfeffer (2003) and Chesbrough (2003) contend that innovative firms benefit from knowledge generated from inside and outside the firm.

Whichever knowledge acquisition model is supported, the knowledge possessed by the company has, as such, become an essential factor in relation to a firm's ability to innovate. Argote et al. (2003), suggest that research should focus on establishing the conditions under which using internal versus external knowledge is more likely to improve a unit's performance. This paper suggests that an organization's innovation strategy should be aligned with its knowledge acquisition strategy.

Current research on knowledge management outlines the importance of the location of organizational boundaries and the implications this has on knowledge transfer and organizational performance (Argote et al. 2003; Chesbrough 2003). Boundaries can restrict or facilitate the flow of knowledge into and out of an organization. In this context, the open and closed innovation paradigms developed by Chesbrough are used as a means for classifying the link between organizational type and knowledge acquisition strategy. Both are discussed below.

2.3 Closed Innovation Paradigm

The closed innovation paradigm, as described by Chesbrough, is an organizational psychology that fundamentally believes that innovation can be managed. According to Cooper (2000), an organization's ability to succeed rotates around its aptitude to organize or manage innovation to achieve an expected end (i.e., market success and profitability). Others have suggested that by building on a firm's core competencies (Hamel 2000), making sufficient finances available, establishing a well-defined innovation process (Cooper 2002), and developing the ability to research, develop, and market new technologies an organization can succeed in developing a competitive edge. It is undeniable that many firms have achieved and will continue to achieve profitability through this kind of an innovation system.

What is closed innovation? The closed innovation system is based on the premise that innovation happens within a firm's boundaries (Chesbrough 2003). Traditional innovation theory suggested that firms can develop competitive advantage by building in-house research and development competencies that effectively enable the development and commercialization of new products, processes, or services. Clear organizational boundaries enable the careful protection of ideas. Business development strategy

is normally based on clearly defined objectives and justifiable product/market trajectories. New ideas are screened to fit the organizational psychology and culture. The development and maintenance of core competencies is central to the firm. A closed innovation system's organizational boundaries are represented by solid lines, which signify an impermeable barrier to the outside world.

2.4 Closed Innovation Systems and Cumulative Innovation

Closed innovation characteristics are based on the above premise that organizations can manage innovation. Chesbrough (2003) and Bessant (2003a) contended that closed innovation systems are fundamentally focused on the continuous improvement of existing products/processes and services, and are critical to sustaining and enhancing shares of mainstream markets (Baden-Fuller and Pitt 1996) and meeting ever more demanding requirements from existing customers (Bessant 2003b). This focus on improvement of the existing consequently leads to a certain degree of path dependency and lack of ability to accommodate or initiate change. Business opportunities are carefully selected to fit organizational strategy or current technology trajectories. Innovation operating routines are refined and stable. There are normally strong links and knowledge flows along clear channels within the organization's boundaries.

Dosi (1982) argued that while a firm's experience is important, it can often greatly reduce its ability to spot opportunities and move into areas outside what it considers core competencies. There is a dichotomy between a firm's need to innovate in order to compete in today's global economy and its learned inability to be agile and responsive to emergent challenges. Current management literature suggests that organizations should build strategy around their key resources: financial, human, and capital (Fahy 2000; Prahalad and Hamel 1994). The resource based view of the firm suggests that competitive advantage can be gained through the identification and deployment of key capabilities possessed by a firm into the marketplace. Some researchers (Barney 1991; Grant 1991) have suggested that competitive advantage can be sustained by organizations as they are difficult to duplicate. Resources are generally buried within the organization. It is not surprising, therefore, that when presented with the need to change, most firms are unable to alter the inertial forces driving a firm down a particular path (Garcia and Calantone 2002).

Based on this understanding the authors develop the following hypothesis regarding the relationship between cumulative/radical innovation and internal/external knowledge acquisition:

H1) Organizations implementing a cumulative innovation strategy are more likely to implement internal knowledge acquisition strategies.

2.5 The Open Innovation Paradigm

As mentioned above, there have been other attempts at identifying the role played by the external knowledge environment in the development of new innovations. These

include the idea of networked or distributed innovation involving end-users in innovation (Herstatt and von Hippel 1992) and the triple helix model which suggests that there are a number of players central to successful innovation: companies; research institutes, and the public sector (Etzkowitz 2002).

Kusunoki's (1997) assertion that radical innovation requires change at a variety of organizational levels furthers the argument that it is necessary to address radical innovation with a different set of organizational capabilities. These capabilities must be built to support open innovation (Chesbrough 2003), tolerate a level of chaos and emergence or at least the ability to adapt to circumstances that are continuously changing (Vidgen 2004) and break path dependency and over reliance on best practices (Bessant 2003a).

Besides technological capabilities, introducing radical product changes technological capabilities, introducing radical product change to a market often requires a new set of organizational capabilities embedded in structures, communication channels, and information processing procedures of organizations, and it is usually quite difficult for established firms to adjust the organization's capabilities for developing innovative products (Kusunoki 1997, p. 32).

What is open innovation? Open innovation is described as distinct from closed innovation insofar as innovations are not only developed internally using an organization's own capability but also externally. Chesbrough (2003) suggested that organizations with open innovation systems have boundaries that are porous. Open innovation systems work like the process of osmosis: knowledge is passed in both directions between the internal organization and the external environment and it crosses organizational boundaries, enabling the internal organ to grow and develop. In accordance with the dynamic capability view of the firm (Teece et al. 1997; Zott 2003), an open innovation system considers the firm essentially a knowledge processing and utilizing entity, focusing on interfirm performance differences mainly from dissimilar abilities among firms in order to exploit existing assets and to explore and build up new capabilities. As such, the organizational capabilities of sensing weak signals and seizing opportunities (Teece 2000) essentially contribute to innovative performance and long-term competitiveness. Ideas that originate internally can often be researched or developed externally (e.g., in a research laboratory, university or other relevant organization). Ideas can also be sourced externally and researched internally or externally.

2.6 Open Innovation Characteristics and Radical Innovation

Open innovation characteristics are built around the premise that there are a variety of sources that assist in the development of innovations. These sources exist both internally and externally to the organization. Open innovation views innovation as a process that effectively gets an idea to market, but it is by no means a linear static process. Organizations implementing an open innovation strategy do not operate within clear mental frameworks but rather these models emerge over time and are subject to

continual change. They are path independent and generally involve a probing or learning type environment. They are risk taking and often run with multiple parallel bets. They tolerate a level of ambiguity and chaos and inevitably except a level of failure. Operating patterns are emergent and often poorly documented. Finally knowledge flows are less structured and peripheral vision is important. Intellectual property is developed internally or sourced externally and ownership is generally shared. Drawing comparison to the distinction between cumulative and radical innovation, open innovation systems seem to provide circumstances that favor the development of radical innovation. Radical innovation is, in contrast to cumulative, characterized by its emergent and nonlinear nature, its path independency, and the creative combination and use of several sources of knowledge (Christensen 1997; Leifer et al. 2000).

Based on this understanding, the authors develop a second hypothesis regarding the relationship between cumulative/radical innovation and internal/external knowledge acquisition.

H2) Organizations implementing a radical innovation strategy are more likely to implement external knowledge acquisition strategies.

3 RESEARCH METHODS

This paper draws on the perception that there is a strong connection between the knowledge acquired by a company and its ability to innovate. However, the authors found it interesting to open up both the terms *innovation* and *knowledge* even further and explore the relationship between the degree of innovation and the source of knowledge empirically.

The empirical investigation was carried out in four industrial organizations (two Irish and two Danish) over a period of 3 months in 2005. The cases were developed based on qualitative semi-structured interviews with senior managers, middle managers, and developers to examine their perception of innovative capabilities and knowledge acquisition and the factors that contribute to development and integration. In the following analysis of the cases, citations to these interviews will be used in order to illustrate and validate the conclusions drawn. As such, the citations referred to do not reflect the number of informants in each case, but are selected expressions made by key informants that underline central points particularly well.

The four case companies were all involved in high-end technological innovation and were selected based on their variability in order to ensure a qualitative insight into cumulative, radical, and ambidextrous innovation. This insight was aimed at providing answers to the stated research question. The reliability of the results as well as the validity of the differences emerging was ensured by applying a protocol on innovation strategy and knowledge acquisition strategy to all cases.

While no two innovation projects in the study are the same, the authors observed patterns in relation to process characteristics and conditioning factors. Despite the fact that the research was conducted in two different countries, the analysis of the four cases gives no reason to suspect a bias due to national differences. As such, the authors have not found it necessary to add a comparative analysis based on national characteristics, but have evaluated the cases on the same grounds in connection to the topic of research.

Table 1. Company Profiles: Case Studies

Company Profiles	Case Study 1	Case Study 2	Case Study 3	Case Study 4
Established	1989 2000 (Reengineered)	2003	1976 1993 (Reengineered)	1999
Industrial Sector	Industrial Printing	Editing and Television	Audio products	Power Conversion Technology
Number of Employees	1989 – 45 2005 – 24	6 (3 Internal, 3 External)	185	35
Ownership	VC and Private	Shared Ownership, OM, Director, VC.	Shared Ownership, OM	Shared Ownership, OM
Intellectual Property	Developed Internally 100% Ownership	Developed Externally Shared Ownership	Developed Internally and Externally Shared Ownership	Developed Internally and Externally Shared Ownership

4 EMPIRICAL FOUNDATION

The following section provides a brief introduction to each case study, followed by a description of each firm's innovation and knowledge acquisition strategy, with particular focus on the existence of organizational boundaries. The concluding subsection focuses on the links between the two elements. In this way, the exploratory research provides an empirical frame for analyzing hypotheses 1 and 2 developed above.

4.1 Case Study One: Print Inspection Ltd.

4.1.1 Background

Print Inspection Ltd. was established in 1989. The company's core product is printing inspection equipment and it is focused mainly on the industrial printing sector. The firm currently employ 25 people. In 2000, the company was reengineered and its core business refocused. According to John, CEO, "*This was necessary, as the firm was doing a little bit of everything but nothing particularly well.*" The reengineering process effectively resulted in the identification of a number of core competencies and the realization of the central role played by the knowledge or experience gained by the firm over time. As a result, the firm is now very focused on the management of internal knowledge and the only links to the external environment are through sales representatives to

end customers. Intellectual property is developed internally and owned 100 percent by the company. The company does not hold any patents.

4.1.2 Innovation Strategy

Print Inspection implements a cumulative innovation strategy. This is evident by the description of the organization. The company has been in existence for the last 16 years and its core technology remains the same. The product roadmap that guides the organization over 6 month periods is based on re-releases that involve incremental improvements normally requested by the customer or suggested by the engineering team. The company builds on previous innovation in an incremental fashion. As John stated, *"We are doing the actual development on features for 4.1 but we are also doing prototyping and feasibility for features for 4.2....cumulative innovation is probably a lot to do with our roadmap and our steady incremental forward movement."*

The reengineering process that took place in the organization in 2000 establishes the organization's commitment to core competencies or existing knowledge and reinforces the view that the firm is clearly focused on cumulative innovation. When questioned on the reasoning behind the reengineering process, John pointed out that *"core competencies have been developed over a 10 year period in Print Inspection Ltd., and we are not about to destroy them, rather leveraging them to their true potential."*

4.1.3 Knowledge Acquisition Strategy

The recognition of the existence of a number of core competencies has enabled the firm to focus on its own capability to innovate. However, John suggests that he has concerns that this focus may impede them from spotting other opportunities and cause the organization to suffer from what he termed limited thinking: *"Breaking out of our roles and thinking beyond the current state is difficult."* Knowledge is acquired on a need to know basis, driven mainly by product improvements and customer requirements. John revealed that, *"as the product is based on our key expertise we normally have the solution internally."*

Learning mainly takes place in the internal organization: *"A lot of learning gets done within the organization....its not nice and neat and formalized."* John felt that people predominately learn from interacting with each other. The only mention of external learning was trade shows but he felt that *"they are soon enough going to be dead"* as they are merely social occasions. Learning is mainly web-based now. A key learning activity for Print Inspection is to encourage exchanges between the technical knowledge gained through research and the experience gained in the field with customers.

Print Inspection's intellectual property is developed in-house. Certain components are bought off the shelf. The company does not currently have any licence agreements or hold any patents. Intellectual property is kept secret through nondisclosure agreements. John stated that intellectual property is *"our own but not through patents."* Key intellectual property includes mechanical design of product, software development, and lighting systems.

4.1.4 Conclusions

Core competencies are an integral part of Print Inspection Ltd. The company's policy of moving from a broad to a narrow competency base has enabled them to focus on key niche markets while continually improving performance. The organization is firmly focused on cumulative innovation and driven by internal knowledge. As such, Print Inspection's innovation strategy is aligned with its knowledge acquisition strategy. However, there is evidence of an awareness of the existence of limited thinking as expressed by John which he believes is a concern (Dosi 1982; Stalk et al. 1992).

4.2 Case Study Two: Picture Sounds Ltd.

4.2.1 Background

Picture Sounds Ltd. was established in 2003. The business core product is a software music composer, aimed at the editing and television industry. The firm currently employs three internal staff and subcontracts work to three external staff (university based researchers). The company was started by an entrepreneur who came up with the initial idea but was uncertain if it was technically possible. Having clarified that the idea was indeed possible and identifying the relevant expertise within a university, the entrepreneur recruited a partner who was to provide the balance between entrepreneurial ambiguity and financial and business strategy. The company, in collaboration with the university, has developed the product to prototype stage and will take the product to market in the next 6 to 8 month period.

Intellectual property (IP) is developed in collaboration. This involves both internal and external knowledge sources. IP ownership is shared between key stakeholders.

4.2.2 Innovation Strategy

Picture Sounds implements a radical innovation strategy. The organization had to seek and create completely new competencies. The innovation pattern can be described as creative destruction: *"It's now technically possible to create relationships between pictures and sound that were never technically possible before....I think it is going to result in a series of art forms for the 21st century which have no parameters in anything we understand at the moment."* When questioned by the researcher if there were identifiable core competencies within the organization, he replied *"that while there were definable skill sets within the organization, it was too early to suggest that there were clear core competencies."* As Richard, the owner pointed out *"they haven't blended yet....It's kind of like a group of musicians."* Some of the key skills that are identifiable are clearly based on product requirements and include music (composition and editing skills), finance (management and control), software (development), and unique research ability (within the college). He felt that keeping all of these diverse abilities playing in harmony is the complicated task.

4.2.3 Knowledge Acquisition Strategy: Original or Unique Competencies

Identifying the technical ability to bring the initial idea to reality was crucial. According to Richard, *“engineers particularly look at me and say you’re mad, you can’t do this....the senior researcher is absolutely the key to all this, because he said yeah we can do that, you are right.”* Before meeting the researcher people felt that this is not how the world works, and the arguments were ontological rather than technical. Identifying the expert in the college was a turning point for the fledgling company.

There is a fluid boundary between the internal and external organization. Knowledge is passed between both entities. Richard reveals *“it would be inconceivable not to go out and look.”* Picture Sounds also has in place a formal advice structure which involves various experts from the public and private sector. Picture Sounds is a virtual knowledge organization.

Intellectual property was the biggest challenge facing Picture Sounds Ltd. Richard stated, *“There is a lack of understanding of IP....in many cases the starting point for negotiation was absurd....If you are a traditional company you won’t get researchers like the ones we have got.”* He also suggested that *“if you don’t get the researchers you won’t get the venture capital as it is intellectual property that they invest in.”* Managing the interaction between the venture capitalists and the college was very challenging: *“The college’s due diligence process is very understandable, they need to guarantee intellectual flexibility.”*

Richard reveals that *“ownership had to be discussed at all levels....no researcher is going to get involved if the company wants to own everything....somebody else makes a fortune and you can be sure that it is not the academic.”* Picture Sounds worked with the college and venture capitalist to find middle ground that was acceptable to each partner. Richard also pointed out that *“finding middle ground was difficult....I have no issues with sharing, I don’t think people own ideas, it’s the other way round, the ideas own the people....just as the aborigines suggest that the land owns them.”*

4.2.4 Conclusions

External knowledge plays a central part in Picture Sounds Ltd. The entrepreneur was initially driven on by his passionate belief that his idea was a good one, without the knowledge of its technical feasibility. The competencies required for developing the innovation are unique and were only found by chance. Organizational knowledge boundaries can be described as porous, enabling knowledge to pass freely in both directions (Chesbrough 2003). Finally the intellectual property model in Picture Sounds Ltd. is one of shared ownership (O’Reilly and Tushman 2004). Richard *“by the time this gets any sense of reality it will not be mine any more than it will be anyone else’s.”*

4.3 Case Study Three: TC Electronic Ltd.

4.3.1 Background

TC Electronic (TC) was founded in 1976 by two brothers; KR and JR, as a true entrepreneurial firm where one brother (JR) took care of the finances, the organization

and the business, and the other (KR) dealt with the development of products and was a visionary on the technological area. From the beginning, TC was very much influenced by the two brothers' personal interest in optimizing the quality of guitar pedal effects. Thus, the firm from the outset had the prime focus of creating extremely high quality audio products. Especially KR's interest in and flair for technology and his ability to create new ideas meant that the company was able to do so, and this soon gave the firm a strong brand name in the industry.

In 1985, TC, as one of the first in the world, moved from analogue into digital signal processing, inspired by the development in other electronic industries, and had thus spotted a worldwide tendency ahead of all competitors. In this sense, TC developed a *disruptive innovation* (Christensen 1997) and was able to take over large amounts of market share.

Up through the 1980s, the turnover increased and sales expanded to several countries. Managing director MPL explains, *"In the '80s we usually produced one fantastic product for one market, and when we then discovered that the technology could be used in another market, we just went ahead and produced a product for this market."* In this sense, the company was very influenced by external input, even though the actual development remained a primarily internal activity.

In 1993, with 25 employees, the organization underwent a major reengineering process including a partial change of ownership. New competencies in the form of management skills were attracted from the outside and the company limited the market focus to professional audio products. During the next one and a half years, a radically new technology was developed which aimed at offering unique sound effects to these environments. This resulted in high growth for a number of years (40 percent annually).

The firm now employs 185 people. New products are still developed on the basis of the existing technology, but the organization continuously seeks out new opportunities on its own and in cooperation with academia as well as a large network of companies within different areas of sound processing.

4.3.2 Innovation Strategy

TC implements a radical innovation strategy, which is suggested by the very large number of technology/product developers employed in the firm. Of the 185 employees, 40 are developers. MPL explains that the personality profiles he asks for in his employees combine the ability to work in teams, be self-reliant and very highly skilled. *"The TC people all have to be able to work with other people and see the quality in other people's work. However, being innovative means that people also have to be unique, and we hire the very best."* The structure of TC is very organic and non-hierarchical. The high level of responsibility that most employees have is a key element to the success and a driving factor for both personal and technological development. Therefore, formalities are very limited in the company and a casual and light-hearted ambience is encouraged and nurtured. MPL believes that *"all these elements create an atmosphere of being a part of something important and groundbreaking."*

In addition to employing innovative individuals internally, TC is also engaged in cooperation with research institutions and other companies in order to be a part of the development of new knowledge even though this might not be directly applicable in TC products at the present time.

It is the explicit strategy of TC to continuously be engaged in front-end innovation as well as creating cumulative innovation based on existing technology. MPL recognizes the difficulty of striking the right balance: *"We had this 4-year-old space acoustic and launched it on the German computer market. All reviews and all home pages praise it to the sky stressing that it's the most innovative thing that has happened to the market for a long time. In here, people just shake their heads, because it's old and dusty to them. So they haven't been able to see the opportunity in the market—they don't understand what business is, but are so caught up in exploring all aspects of the technology."*

4.3.3 Knowledge Acquisition Strategy

MPL very explicitly emphasizes the importance of external knowledge sources for the success of TC Electronic. To him, the technological capabilities of the firm are developed based on a long tradition of research in acoustics in Denmark. The skills his employees have are due to this, and the continued development of knowledge in the field advances as fast as it does because it is pushed forward by several different companies and research institutions. *"In the 1950s, Brüel & Kjør were world leaders within the world of precision instrumentation for acoustics and vibration measurement. They played a major role in the development of acoustics and vibration sciences themselves. DTU and AAU today have leading research centers within acoustics and the Aalborg region is cluster for extensive development of the mobile industry. In addition, there is Oticon and GN producing digital hearing aids, B&O working with digital sound processing in TVs and loudspeakers, and several loudspeaker producing companies such as Jamo and Dali. All this involves focus on and research in digital sound processing and has created a great ambiance for world leading development of front-end technology"*

MPL explains that he spends much of his time networking with a wide range of different actors in order to both stay close to the progress of competitors and get inspiration from sources outside his normal scope. By doing so, he wishes to create a balance between inspiration for radical and cumulative innovation. *"Our R&D department is extremely visionary, skilled and creative, and can create products of the future continuously. However, without being market-oriented these products are in danger of being ahead of the market, thus not generating sales. On the other hand, in a high-technology company all development cannot be based on market analysis, as this will lead to a short termed vision, creating 'me-too' products and not innovative products."*

4.3.4 Conclusion

The innovation strategy of TC Electronic emphasizes the balance between internal and external knowledge generation. Internal developers are often leading within their fields and able to generate radical inventions. However, in order to transform these inventions into real opportunities in the market, MPL encourages interaction externally as this will create the needed market understanding as well as enhance the technological understanding. This is emphasized at all levels of the organization, as all are expected to contribute to continued development. On several technological developments, TC has

shared ownership with external partners, such as research institutions or other industrial companies.

4.4 Case Study Four: B&O ICEpower Ltd.

4.4.1 Background

The company started in 1994 when B&O discussed the possibility of basic research within audio power transition with an associate professor at the Technical University of Denmark (DTU), with the purpose of increasing the energy efficiency and the quality of audio equipment. A Ph.D. project was initiated jointly between the company and the research institution, giving the employed Ph.D. researcher (KN) access to both worlds.

By 1996, KN had achieved the first groundbreaking results on what was to become the ICEpower technology. He explains that it was made possible primarily due to three factors: a systematic approach, determination, and the ability and possibility to combine several sources of knowledge available in the company and the research institution.

By 1997, B&O decided to start the implementation of the technology in their products. However, KN saw wider perspectives in the technology and introduced the idea of creating a spin-off company. This was done in 1999 as a joint ownership between KN and B&O. KN explains how the knowledge from B&O this way remained a continuous source of knowledge and competencies. Today ICEpower employs 35 individuals and has a customer base including many well-known brands such as Sony, Bose, and Sanyo.

4.4.2 Innovation Strategy

The initiation of the development of the ICEpower technology was a result of a radical innovation strategy, where two sources of existing knowledge realized the benefits both could gain from cooperating. By establishing such cooperation, a very fluid border was created between the two, creating room for KN to exploit the knowledge of both.

This radical approach to innovation, however, becomes even clearer when looking at how KN continues the development of ICEpower today. KN's vision for ICEpower is *“technological leadership within audio power conversion in a wide/broad sense—from the power plug to the acoustic output. The most intelligent solutions to any power transition function in audio relations.”* This he wants to achieve by creating an organization aimed at interacting with external sources, such as competitors, research institutions, and the founding company.

4.4.3 Knowledge Acquisition Strategy

The radical innovation strategy of ICEpower also reflected the knowledge acquisition strategy of the company. KN has deliberately placed the physical setting of the company very close to the research institution that participated in the original

project, as this gives him the opportunity to interact with students and researchers on a frequent basis. KN explains that he continuously has a handful of Master's students working on ICEpower-specific projects as their Master's thesis. This gives him the opportunity to explore new areas at very low costs, as well as stay closely connected to the ideas developed at the research institutions. He refers to this as "*the playground of ICEpower, creating grounds for new radical breakthroughs, performed in an integrated cooperation with DTU.*"

Also from a market perspective KN is focused on developing the company through the use of external knowledge. He explains that through establishing partnerships within areas that ICEpower neither possesses nor wants to develop internally, he is able to reach new markets and increase the implementation potential of the technology. These partnerships will also enable him to learn about new venues.

4.4.4 Conclusion

The creation of ICEpower itself was a result of cooperation between an industrial company and a research institution. This founding openness toward use of external knowledge sources is also reflected in ICEpower today, as close cooperation with research institutions is part of the strategy on how to be able to continuously generate radical breakthroughs in spite of a limited internal research capacity due to its small size. In addition, ICEpower is also, to a high degree, focused on cooperation with industrial relationships, and draws benefits in particular from the continued mutual partnership with B&O. The intellectual property model is, for this reason, also based on shared ownership. As such, the innovation strategy and the knowledge acquisition strategy are closely connected, aimed at interacting with external knowledge resources in order to explore new opportunities.

5 DISCUSSION

Through the development of an understanding of the concepts of open/closed innovation systems and cumulative/radical innovation strategies, the authors have arrived at two hypotheses regarding the relationship between innovation strategy and knowledge acquisition strategies. In the following, these hypotheses are discussed in light of the empirical findings, giving grounds for their rejection or validation. The findings are discussed below under the hypothesis headings established in sections 2.3 and 2.4. The following offers an overview of each hypothesis and provides a brief summary of the evidence drawn from the case studies. Each hypothesis is illustrated in the conceptual model (Figure 1). Section 5.3 puts forward a new proposition which suggests that it is necessary to extend the understanding of innovation and knowledge acquisition strategies into a third dimension.

5.1 Hypothesis One

Organizations implementing a cumulative innovation strategy are more likely to implement internal knowledge acquisition strategies.

Case study one demonstrates a clearly focused innovation strategy of cumulative innovation, evidence of which is provided in the following: products are continually improved, formally catered for in the company roadmap; there is a definite focus on core competencies, which have remained mainly unaltered over time; there are clear organizational boundaries; and the internal research and development team play a central role in innovation, with little evidence of external knowledge linkages. This case study suggests that, as an internally focused organization, they are less likely to look to the external knowledge environment for opportunities, ideas, and knowledge. The owner-manager himself suggests that he is fearful that they are blinded by their own abilities and cannot move outside their own areas of speciality to explore new, novel ideas or radically different applications of their own technology.

This provides evidence that cumulative innovation is indeed dependent on internal knowledge that is developed and improved over time. It also suggests that organizational boundaries are as suggested by Chesbrough (2003), an impermeable barrier to the outside knowledge environment. It identifies a clear link between organizational innovation strategy which in this case is one of continual improvement in line with the requirements of existing customers and knowledge acquisition strategy which is based on building and harnessing core competencies. The empirical findings hence provide a validation of the first hypothesis.

5.2 Hypothesis Two

Organizations implementing a radical innovation strategy are more likely to implement external knowledge acquisition strategies.

Case study two has built its existence around external knowledge. The knowledge acquisition model is based on a direct collaboration with the research institution or university. The company is completely reliant on external knowledge without which it would not be in existence. The organizational boundaries are extremely porous and knowledge passes in both directions, continuously enabling the internal organization to absorb knowledge produced externally. The organization implements a radical innovation strategy which has literally forced them to search for knowledge in the external environment. This suggests that if radical innovation requires new knowledge, an organization is more likely to scan all available knowledge sources. This provides evidence of hypothesis two: that organizations implementing a radical innovation strategy are more likely to implement external knowledge acquisition strategies. This case study suggests that organizations following this strategy often do not possess the knowledge required for radical innovation internally as it is dramatically new. The knowledge that needs to be created for a radical innovation is often highly research intensive; most organizations do not have the in-house expertise to carry out blue sky research. There are many knowledge sources external to the organization that are skilled to do the necessary research required to bring a radical idea into fruition.

The empirical findings thereby also support the second hypothesis.

It should, therefore, be noted that hypotheses one and two are both identifiable in the selected case studies. There is evidence to support both hypotheses. Case study one suggests that organizations implementing a cumulative innovation strategy are more

likely to implement internal knowledge acquisition strategies, while case study two demonstrates that organizations implementing a primarily radical innovation strategy are more likely to implement an external knowledge acquisition strategy. Both these assertions are in line with current theory and practice.

5.3 Extending the Understanding of Innovation and Knowledge Acquisition Strategy into a Third Dimension

Based on the empirical findings, the authors argue that there is indeed a need to extend even further the understanding of the relationship between cumulative/radical innovation and internal/external knowledge acquisition.

Case studies three and four fit elements of an open innovation system. However, they demonstrate not only the competency to source knowledge from the internal and external environments but also a dual ability to manage both radical and cumulative innovation at a strategic level. The literature suggests that these kinds of organizations are rare (O'Connor, and Ayers 2005) but do exist (O'Reilly and Tushman 2004). O'Reilly and Tushman suggested that some organizations have successfully developed radical innovations while at the same time protecting their traditional businesses. In order to achieve this, companies have set up organizationally distinct units that are tightly integrated at the top management level. Hence, this exploratory research provides evidence of a new proposition that calls for further empirical research. The proposition is built on the evidence of a limited but existent ability to manage a dual strategy of cumulative and radical innovation supported by relevant internal and external knowledge acquisition strategies.

The proposition suggested by the authors is aimed at effectively establishing a continuous focus on both cumulative and radical innovation, referred to as ambidextrous innovation, and is formulated as the following:

(P) Organizations implementing a dual innovation strategy (cumulative and radical) are more likely develop the abilities to acquire knowledge both internally and externally.

The authors suggest that this is the ability to integrate an internally focused iterative innovation strategy and an externally focused radical innovation strategy that will place new demands on both the organizational structure and the individuals concerned. This new proposition is not based on an easily definable entity but rather an organic, learning organization with a dual ability. The individuals and the organization must grow and build on past experience while at the same time pushing out the boundaries of knowledge into exciting new areas. This will require the development of new organizational and individual mindset: the ability to move across industry boundaries, source knowledge from diverse locations, and develop creative intellectual property models while at the same time enabling the individual within the organization an element of intellectual freedom.

This proposition has a number of preliminary implications:

- (1) Individuals and organizations will need to sidestep their own cognitive limitations.
- (2) Developing core competencies is central, but the ability to move outside these competencies is also important.
- (3) Organizations need to move toward a ubiquitous state where location is not as central as access to groundbreaking research.

Integrating the two validated hypotheses and the proposition of an extended understanding of the relationship between cumulative/radical innovation and internal/external knowledge acquisition into one visual frame, the conceptual model emerges (see Figure 1).

6 CONCLUSIONS AND FURTHER RESEARCH

The aim of the paper has been to unfold the question: *What is the relationship between cumulative/radical innovation and internal/external knowledge acquisition respectively?*

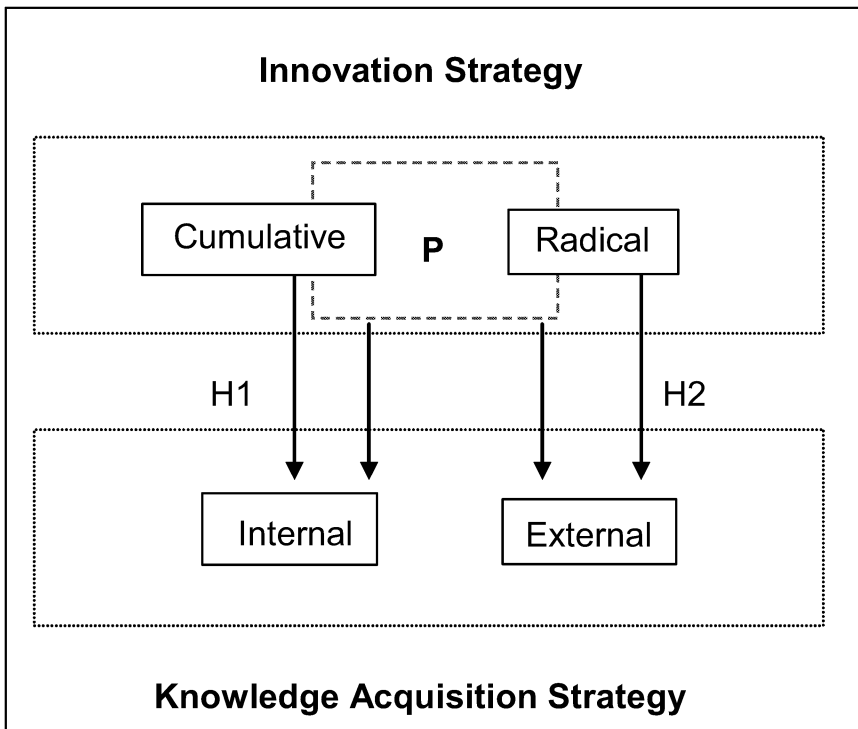


Figure 1. The Conceptual Model

This was achieved by the development of two hypotheses through theory and by testing with four case studies. The case studies gave rise to a validation of the two hypotheses, showing a relationship between cumulative innovation and the implementation of an internal knowledge acquisition strategy and a radical innovations strategy and an external knowledge acquisition strategy.

The case studies, however, also revealed a need for extending the understanding of the relationship between innovation strategy and knowledge acquisition strategy even further. As a result, the authors developed a proposition built around the need for the development of best practice for dual innovation strategy involving a clear focus on both cumulative and radical innovation and internal and external knowledge acquisition.

An interpretation of these results is that cumulative innovation requires well-organized, clearly focused, competency-based knowledge whereas radical innovation requires a firm to move out of its comfort zones, breaking down organizational boundaries to locate and transfer in and out new knowledge and capabilities. This creates a clear dichotomy with the potential of driving the firm in two opposing directions (internal and external). However, proof does exist that firms can successfully combine a number of knowledge acquisition strategies and evidence of this is presented in the case studies (2, 3, and 4). This new breed of firm manages to transfer knowledge across fluid boundaries, and to locate value proposition on knowledge that is purchased or developed in collaboration with a third party, thereby enabling them to develop organizational agility. However, this tends to be on a project by project basis rather than at an organizational strategic level.

This indicates that in order to successfully drive both cumulative and radical innovation, companies must align innovation strategy with knowledge acquisition strategy. Otherwise, they are likely to fail at both kinds of innovation. The inability to manage current knowledge and competencies can be as fatal as being blinkered to external knowledge.

To conclude, therefore, agility and the ability to move between cumulative and radical innovation is central. In order to do this, firms must manage to leverage their current competencies but at the same time move outside their traditional knowledge boundaries and create porous, living learning organizations. From the evidence presented in this paper, the authors concur with prior research (Chesbrough 2003; Cockburn and Henderson 1998; Cohen et al. 2002; von Hippel 1988) that the ability to utilize external knowledge sources in radical innovation activities is crucial.

However, while there is recognizable evidence to suggest that firms are successfully acquiring knowledge from both the internal and external knowledge environment, there is still a sizable distance to go before firms can successfully develop ambidextrous capability enabling focused radical and cumulative innovation (O'Connor and Ayers 2005; O'Reilly and Tushman 2004). Finally, further research in the space between knowledge management and innovation is necessary in order to clarify the most effective models for knowledge acquisition to actively support diversity in innovation at both the organizational and individual level.

This empirical research project has opened up a number of interesting opportunities for further research. The case studies were focused on the acquisition of knowledge from the internal and external environment. While not in the scope of this study, an important first step toward building an ambidextrous or dual ability to support innovation strategy and knowledge acquisition is to identify a set of metrics to measure effects

on productivity and profitability. The case studies revealed interesting and new intellectual property models, which are increasingly complex in nature and continue to evolve rapidly to support novel knowledge acquisition strategies. There is a need for further research to establish the most effective methods to support novel knowledge acquisitions strategies. Other areas of interest include the importance of physical location versus virtual location on knowledge acquisition.

There are also a number of limitations to this research project that need to be addressed in further research. First, case studies, while probably the most appropriate research method for this kind of research, are often criticized as a “less desirable form of inquiry than either experiments or surveys” (Yin 1989, p. 24). Many of the arguments made concern the ability to generalize from the research findings. However, case studies do permit generalization of a theoretical nature (i.e., generalizing from data to theory; Yin 1989). While concerns remain on the external validity of research findings generated by case studies, the method appears to be gaining acceptance as a means of generating new insights into complex organizational phenomena (Slappendel 1996). Second, this study was limited to in-depth case studies in Ireland and Denmark and it would be interesting to see if the findings of this study are applicable to a broader audience of firms drawn from a number of other countries and diverse industrial settings.

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About the Authors

Andrea Deverell is pursuing a Ph.D. investigating novel knowledge acquisition strategies as a means for increasing innovation and creativity in organizational contexts. She has over a decade of experience in higher education, both as lecturer and administrator, and her work has focused on effective collaboration and knowledge transfer between academia and industry. From 1999 to 2003, Andrea served as Technology Transfer Officer based in the Office of the Vice-President of Research, University of Limerick. In this role she facilitated over 35 collaborative research projects between academia and industry. Andrea is an active member of the Global Continuous Innovation Network (CINET). She is author of a number of papers in the field of Innovation and coauthor of "Assessing the Role of Open Source Software in the European Secondary Software Sector: A Voice from Industry," which received a Best Paper award at The International Conference on Open Source System, Genova, Italy, 2005. Andrea can be reached at andrea.deverell@ul.ie.

Astrid Heidemann Lassen is currently in the process of completing her Ph.D. at the Center for Industrial Production, Aalborg University, Denmark. Her research interests lie within the fields of corporate entrepreneurship and radical innovation. Astrid can be reached at ahl@iprod.aau.dk.