An investigation into the practices and underlying factors during the fuzzy front end of radical innovation

An Investigation into the Practices and Underlying Factors during the Fuzzy Front End of Radical Innovation

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A Thesis Submitted for the Degree of
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Supervisor Dr. Ann Ledwith

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DECLARATION

The work presented in this thesis is entirely my own work. It has not been submitted previously to any other institute for this or any other academic award. Where use has been made of the work of other people it has been acknowledged and referenced.

Signed: _____ Date: _____

John Nicholas

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DEDICATION

This thesis is dedicated to the memory of my mother
Leasie Nicholas who died on August 4th 2012

ACKNOWLEDGEMENTS

Undertaking a doctoral research is a major commitment. It is a sometimes lonely journey, punctuated with periods of seemingly no progress followed by a sudden breakthrough. These periods I referred to as the 'peaks and troughs' of the research process. Each played an important role; the elation accompanying a 'peak' not only erasing the despair experienced during a trough but also galvanising my determination to reach the final destination. On the journey many people have assisted and supported me in this undertaking. Some warrant special mention.

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As always I saved the best till last. To my wife, Michelle, thank you for allowing me time and space when required, thank you for always being there, thank you for picking me up when I was down, thank you for just being you.

ABSTRACT

A familiar theme in innovation studies revolves around the issue of exploitive and explorative behaviour. Exploitive behaviour is using existing capabilities to improve present returns; incrementally improving current innovations. In contrast explorative behaviour requires that firms explore and develop new capabilities, that they seek radical innovation. Overall the performance of Ireland, with regard to radical innovation, compares poorly with the EU27 average. Patent applications are relatively low and company turnover attributed to 'new to firm' or 'new to market' is below the EU27 average. Small to medium enterprises are collaborating less and introducing fewer new products and their general innovation involvement lags behind that of larger companies. These statistics make the study of radical innovation in Ireland interesting and appropriate.

Using an established model of the radical innovation process developed by Tidd and Bessant (2009) as a starting point, this thesis explores the fuzzy front end (FFE) of the radical innovation development process by examining search and selection practices in innovating companies. The overarching aim of the thesis is to establish the underlying factors characterising the FFE of the radical innovation process, and assess what their effect is on innovation success. To this end, three surveys were developed from a literature review that explored search and selection practice and these surveys applied to a group of innovating companies in Ireland. Subsequent analysis indicated that there are 5 underlying search factors and 4 underlying selection factors characterising radical search and selection.

The 5 underlying factors characterising radical innovation search practice are:
1) Market awareness 2) Engaging with customers 3) Internet enabled search
4) Open environment 5) Internal networking.

The four underlying factors characterising radical innovation selection practice are:
1) Fostering and supporting radical selection, 2) Prototyping as a selection tool,
3) Strategic and operational flexibility and 4) Differentiating between radical and incremental innovation.

The identified practices and underlying structure represents a practical way for an organisation to focus on the dimensions and practices that are required for a company to enhance its capability in the search and selection phases of radical innovation. Moreover the search and selection practices/factors that are linked with success offer tools practitioners can utilise in their radical innovation endeavors. This study highlights the gap that exists between the practices of firms who have a record of successfully introducing radical innovations and those that do not. In particular, the usage of the selection practices and selection factors have a strong impact on company performance. If innovation managers want to develop radical new products and prepare their companies for the inevitable radical shifts that occur within markets then they need to consider the search and selection practices that they use in order to build a long-term radical innovation capability.

PUBLICATIONS

Journal Papers

Nicholas, J., Ledwith, A., Bessant, J. (2013). Reframing the Search Space for Radical Innovation, *Research Technology Management*, 56 (2), 29-44.

Ledwith, A., Martini, A., Nicholas, J., and Nosella, A. (2012). Exploring radical innovation search practices. *International Journal of Technology Intelligence and Planning*, *8* (4), 389-405.

Aloini, D., Cantarello, S., Ledwith, A., Martini, A., Nicholas, J., Nosella, A., (2013). "Searching for radical product ideas: Exploratory and confirmatory factor analysis for construct validation" *(in review).*

Conference Papers

Nicholas, J., Ledwith, A., Bessant, J., (2011). "Selection strategies for discontinuous and radical innovation in established companies" International Product Development Management Conference (IPDMC), Netherlands.

Nicholas, J., Ledwith, A., Bessant, J., (2010). "Search strategies for discontinuous innovation in established companies", International Product Development Management Conference (IPDMC), Spain (Winner of the Christer Karlsson Best Paper Award).

Book Chapters

Nicholas, J., Ledwith A., (2013). "Discontinuous innovation search for SME and Large organisations" In: Augsdörfer, P., Bessant, J., Möslein, K., von Stamm, B., Piller, F., eds. *Discontinuous Innovation: Learning to Manage the Unexpected (Series on Technology Management)*, London: Imperial College Press, pp 161-178.

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Chapter One Introduction

‘It is not the strongest of the species that survives, nor the most intelligent, but the one most responsive to change’

Charles Darwin (1809 -1882)

1.1 OVERVIEW OF RESEARCH

Innovation is a requirement for companies operating in dynamic market environments (Jansen et al. 2006). Companies that do not engage in innovation run the risk of becoming isolated from their customers and the markets they currently occupy. In today’s ultra-competitive global landscape innovation is a critical success factor for a company’s long-term survival (Dervitsiotis 2010). When considering innovation companies have a number of different approaches that can be pursued. Incremental innovation offers one avenue for company growth and long-term survival. This type of innovation represents work a company does to improve their current products by developing new products using a variation of the current technologies employed by the company (Tushman and Nadler 1986). The alternative perspective is for a company to focus on radical innovation. This type of innovation represents work a company does developing very new technologies/products and potentially targeting or creating new markets of demand (Koberg et al. 2003). These are the two extremes of innovation. Obviously innovations will fall in-between these two extremes and potentially have characteristics from each. This is dealt with in more detail in Section 2.2.

Engaging in innovative activity has been shown to improve performance and long term success (Darroch and McNaughton 2002, Lumpkin and Dess 1995, Zahra 1993, Roberts 2007, Knight and Cavusgil 2004, Cefis and Marsili 2006, Storey 1994, Cooper 1993, Mosey et al. 2002, Bessant et al. 2004). Typically incremental innovation is the route chosen for most companies. This type of improvement strategy works well for the majority of companies, however, radical innovation should be used intermittently to

'jump start' the incremental innovation process (Terziovski 2002). While every company cannot operate at the forefront of their industry; they should be poised to quickly migrate to a new and improved technology or product if an innovation is developed by one of their competitors that is a threat to their business. If a company does not react to the development of a radically new product or technology from a competitor it can face a rapidly declining market share and possible extinction (Christensen 1997).

Companies are becoming increasingly adept at protecting their products and technologies through the use of patents. A company that introduces a radically new product or technology will have a competitive advantage (World Intellectual Property Indicators 2010). The competitive advantage radical innovation brings can result in growth levels that are significantly larger than the growth of the industry (Bessant et al. 2004). Radical 'new to market' innovations offer significant growth opportunities for both small and large companies (Storey 1994, Cooper 1993). Mosey et al. (2002) demonstrated that companies with aggressive growth ambitions with a history of repeatedly introducing innovative new products that opened up new market were the best performing companies. Radical projects deliver a significantly higher competitive advantage (Verworn et al. 2008). This can be explained by the fact that radical innovations often do not address a recognised demand but instead create a new demand, which cultivates new industries with new competitors (Garcia and Calantone 2002).

Much of the innovation research that has been completed focuses on how the innovation process relates to incremental innovation. Typically, incremental innovation is easier to manage and plan for as it is relatively low risk for the company and repeatable processes can be implemented to ensure continued success. The majority of firms use Stage-Gate® processes to manage their innovation efforts (Cooper 2008, Griffin 1997). Such processes are clearly defined so that there is a wealth of empirical evidence that defines best practice in managing incremental innovation across a range of different conditions (Kahn et al. 2006, Cormican and O'Sullivan 2004, Griffin 1997, Balbontin et al. 2000). Much less is known about the management of radical innovation. In part this is because radical innovation is a relatively rare event (Un et al. 2010, Bower and Christensen 1995), but it is also because radical innovation, by definition, involves higher levels of uncertainty and tends not to occur within the normal, observable

routines of the firm (Sull 1999, Bower and Christensen 1995). Much radical innovation appears to occur by chance, on an ad-hoc basis.

All innovations originate from ideas (Boeddrich 2004). These ideas are formulated during the very early stages of the innovation process, i.e. the fuzzy front end (Smith and Reinertsen 1991, Koen et al. 2001, Reid and De Brentani 2004). This phase of the development process represents the phase between the first identification of an opportunity and when it is judged ready to enter the structured development process (Kim and Wilemon 2003, Koen et al. 2001). It is described as 'fuzzy' because it is perceived as being difficult to control and manage (Khurana and Rosenthal 1998), yet it is also identified as a phase that is critical for new product success (Cooper and Kleinschmidt 1996, Cooper and Kleinschmidt 1995, Markham 2013). The fuzzy front end is the root of success for firms involved with radical new product innovation (Reid and De Brentani 2004), however, companies typically perform poorly at this phase (Dooley et al. 2002). A product is more likely to be successfully developed and marketed when the fuzzy front end activities are carefully managed (Kim and Wilemon 2002).

Decisions at this stage define the direction the development process will take. Selection and development of radical projects provides a platform for the long-term growth and survival of companies (Leifer et al. 2000). The fuzzy front end of the innovation process, particularly for radical innovation, has been particularly difficult for researchers to investigate (Reid and De Brentani 2004), however, according to Backman et al. (2007), the greatest opportunities for improving the overall innovation process lie in the very early phases of innovation process. In recent years research has been completed on the radical innovation process though it does not focus exclusively on the fuzzy front end (O'Connor and Rice 2001, O'Connor et al. 2008, Tidd and Bessant 2009). As discussed, the fuzzy front end encompasses the activities early in the development process when companies seek to identify new product opportunities and select viable ideas to enter a more structured development process. Given that certain companies perform better at radical innovation the question arises as to what do they do different in their approach that increases their capability to produce radical new products?

1.2 IMPORTANCE OF INNOVATION IN CURRENT ECONOMIC CLIMATE

To survive in the current economic climate companies are required to innovate. Moments of economic uncertainty often provide the unique opportunity to start new businesses or launch radical new products (Strangler 2009). This can be achieved by translating moments of uncertainty into moments of opportunity through radical innovation (Razeghi 2008). History demonstrates many examples of companies/products that were launched during what would be perceived to be unfavourable market conditions that were largely successful and the innovating companies often prospered to become global leaders in later years.

- Ryanair was set up during the 1980's in the midst of recession when few people could afford foreign travel and expanded into one of the world's largest airlines.
- Henry R. Luce launched the Fortune Magazine during the 'Great Depression'. While it might have appeared to be poor timing to launch what at the time represented a premium priced publication, the magazine was a huge success not in spite of the Great Depression; it was a success because of the Great Depression.
- Apple originally launched in 1975, reinvented their company image in 2001 just after the 'dot-com' bubble had burst. After the bubble had burst many companies were suspicious of new technology, however, Apple developed a prototype for a new personal music player, the ipod, which went on to form the platform to re-establish Apple as one of the preeminent consumer product companies in the world**.**

Stangler (2009) found that more than half of the companies on the 2009 Fortune 500 list were launched during a recession or bear market. That means that during times of economic slowdown, some of tomorrow's most successful companies are being launched. Recent statistics also reflect this and reveal that the number of entrepreneurial start-ups has increased during the current recession (Tam 2009, Fairlie 2009). During recessionary times established companies need to not just survive but also innovate and grow to defend their market share from lean and efficient start up companies who have the potential to dominate the next generation. Of course, the alternative perspective is that for every success story there are many company failures. There is empirical

evidence that economic downturns lead to higher new venture failure rates (Song et al. 2010). However, if that new venture is a radical innovation, serving emerging market needs, and is introduced into markets with an established industry technology standard then its chances of success are higher (Song et al. 2010) demonstrating the danger radical innovation can pose to established companies that are setting the current 'industry standard'.

1.3 RATIONALE FOR RESEARCH IN IRELAND

Radical innovation, especially within the current climate, represents a route to growth and survival. Ireland is a small open economy so excellence in innovation to drive international trade is essential for economic growth and more importantly economic recovery (Forfas Annual Report 2010). Developing an innovation-driven economy would increase and maintain competitive advantage and increase the productivity of the country. To achieve this, Ireland must continue to deliver consumer-driven innovative products and services as well as further developing new business models, new organisational structures and skills for innovation. The management of the public sector finances over the previous decade means that if Ireland is to turn its economy around and return to economic growth and prosperity then it is likely that it is the private sector that must provide the stimulus. There are a number of measures that can be used to assess whether Irish companies are working towards achieving the goal of an innovation driven economy summarised below.

Innovation Involvement

Irish companies perform relatively well in comparison to the EU average on 'self reporting' innovation surveys (Community Innovation Surveys 2004-2006, 2006-2008) as shown in Table 1.1.

Table 1.1 Company involvement in innovation according to company size

	Ireland (% companies innovating)			**EU average (% companies innovating)**		
	Small	*Medium*	*Large*	*Small*	*Medium*	*Large*
CIS (2006-2008)[1]	*40.1*	*61.4*	*75.7*	*34.4*	*52.3*	*70.1*
CIS (2004-2006)	*47.2*	*65.3*	*75.1*	*34.9*	*52.8*	*70.8*

[1]Most recent Irish CIS data available

Innovation Growth

The European Innovation Score Card (2009, 2010, 2011), a comparative assessment of the innovation performance of EU Member States, places Ireland in a group of 'innovation followers' and is viewed as a 'slow to moderate' innovation grower within the EU27.

The scorecard (2011) divides the countries based on performance as follows:

Innovation Leaders

Denmark, Finland, Germany and Sweden are the Innovation Leaders, with innovation performance well above that of the EU27 average and all other countries.

Innovation followers

Austria, Belgium, Cyprus, Estonia, France, Ireland, Luxembourg, the Netherlands, Slovenia and the UK are the Innovation Followers, with innovation performance below those of the innovation leaders but close to or above that of the EU27 average.

Moderate Innovators

Czech Republic, Greece, Hungary, Italy, Malta, Poland, Portugal, Slovakia and Spain are the Moderate Innovators with innovation performance below the EU27 average.

Catching up countries

Bulgaria, Latvia, Lithuania and Romania are the Catching-up Countries. Although their innovation performance is well below the EU27 average, this performance is increasing towards the EU27 average over time.

Patent Applications

Ireland performs poorly in comparison to the EU27 average in terms of patent awards (Eurostat/SCO) as seen in Table 1.2.

Table 1.2 EU patent applications according to country (per million inhabitants)

	2004	2005	2006	2007	2008	2009[e]	2010[e]
EU 27	108.46	112.97	115.63	117.02	115.84	112.12	111.01
Ireland	58.16	68.39	66.88	68.23	73.36	73.02	75.7[e]
UK	95.09	93.67	93.5	94.14	89.23	84.44	81.47[e]
France	128.23	133.51	133.28	133.28	134.18	134.27	134.73[e]
Germany	268.25	279.46	289.87	290.15	291.47	276.96	273.04[e]
Sweden	229.37	248.43	267.43	286.89	301.66	294.98	303.4[e]

[e]Eurostat estimate available only (most recent data available).

New Product Turnover

Contribution to company turnover of new-to-firm and new-to-market innovations of Irish companies is below EU average (Community Innovation surveys 2004-2006, 2006-2008).

Table 1.3 New product innovation turnover per country

	2004 (%)[2]	2006 (%)[2]	2008[1] (%)[2]
EU 27	13.7	13.4	13.3
Ireland	10.1	12.6	11.0
UK	13.9	8.5	7.3
France	11.7	No data available	13.2
Germany	17.6	19.2	17.4
Sweden	13.4	15.0	9.2

[1] 2008 most recent available results

[2] This indicator is defined as the ratio of turnover from products new to the enterprise and new to the market as a % of total turnover.

Innovation Performance Indicators

The Innovation Union Scoreboard (2011) shows steep declines in several performance indicators including; Venture capital (-9.2%), Innovative SMEs collaborating with others (-10.9%), SME innovating in-house (-5.1%) and SMEs introducing product or process innovations (-14%).

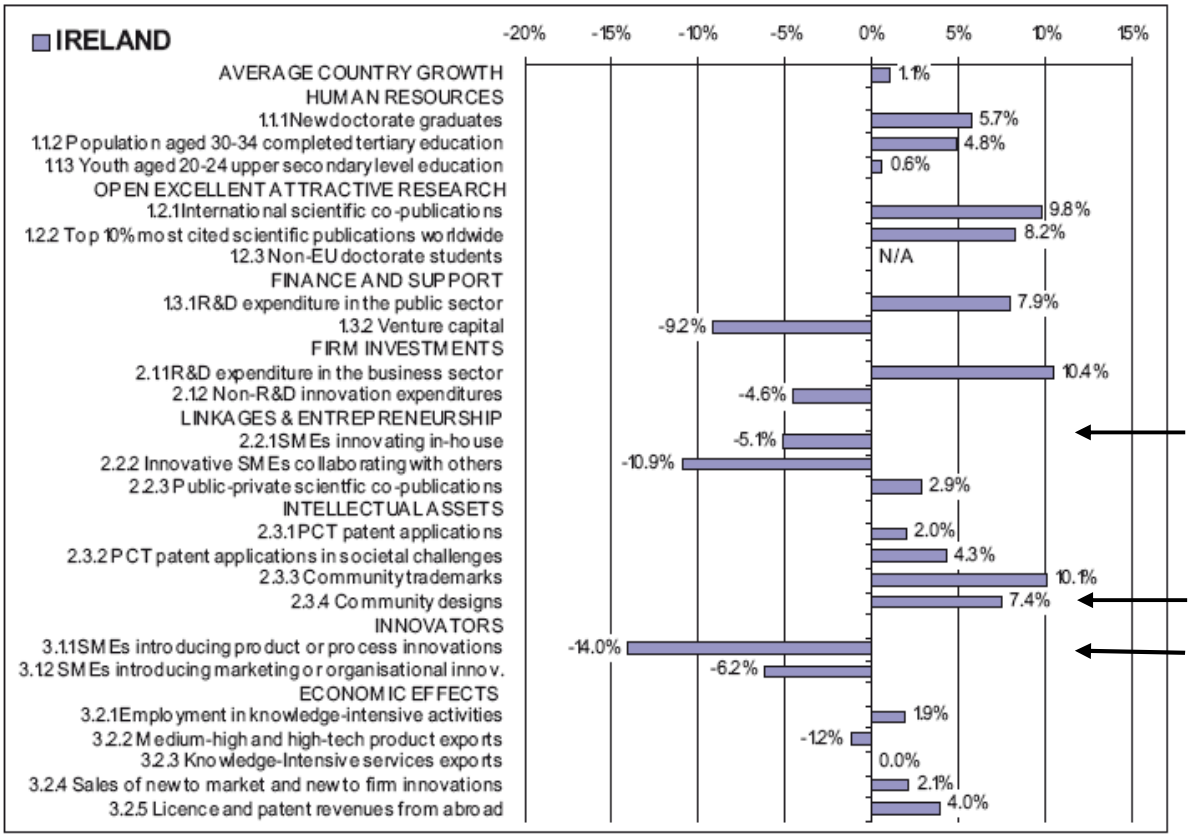


Figure 1.1 Ireland: Innovation performance indicators (European Innovation Scorecard 2011).

SME Performance

SME's lag behind large companies (see Table 1.1) in their innovation efforts and performance (Community Innovation surveys 2004-2006, 2006-2008) e.g. only 40.1% of SMEs engaged in innovation in comparison to 75.7% of larger companies.

To summarise, the performance of Ireland with regards to innovation compares relatively poorly with the EU27 average and is declining in certain measures. Patents applications are low in comparison with other EU nations and company turnover attributed to new to firm/market performance is below the EU27 average. SMEs are collaborating less and introducing fewer new products and their general innovation involvement lags behind that of larger companies. These statistics suggest that research in the area of radical innovation in Ireland is warranted to reverse this poor innovation performance.

1.4 TOWARDS A RESEARCH QUESTION

As discussed in Section 1.1, innovation is critical for a company to survive and grow. Radical innovation in particular, can offer a route to rapid growth and the root of its success is thought to lie in the early stages of the development; the fuzzy front end. The current economic climate continues to offer opportunity for companies willing to take risks and engage in radical innovation. However, within the Irish setting, performance in innovation, particularly of the radical kind falls behind that of the EU and is declining (Community Innovation surveys 2004-2006, 2006-2008, European Innovation Scorecard 2011). The focus for this study is the fuzzy front end of the radical innovation development process. The following reasons justify this decision:

1. Extensive research already exists on managing incremental innovation (Kahn et al. 2006, Cormican and O'Sullivan 2004, Griffin 1997, Balbontin et al. 2000).

2. Statistics suggest Irish performance in this area is not as strong as comparable EU member states and performance is declining (Community Innovation Surveys 2004-2006, 2006-2008, The European Innovation Score Card 2009, 2010, 2011).

3. Radical innovation is important for the long term survival and growth of companies (Mosey et al. 2002, Christensen 1997, McDermott and O Connor 2002, Chandy and Tellis 1998, Sood and Tellis 2005).

4. The fuzzy front end of the development process is viewed as being vital for development success (Cooper and Kleinschmidt 1995, Iwamura and Jog 1991, Reid and De Brentani 2004, Verworn et al. 2008).

Given that many companies e.g. 3M, Apple, etc achieve higher performance at radical innovation that others then the question arises as to what do they do different in their approach that increases their capability to produce radical new products? Are there best practices even at this relatively unstructured early development stage that influence success? What are these practices? How common is their usage? Are they related to

each other? Answering this line of questioning would result in a useful taxonomy outlining the fuzzy front end for radical innovation.

Camp (1989) defined 'best practice' as a technique, method, process or activity that is more effective at delivering a particular outcome than any other technique, method, process or activity within that domain. Thus a 'best practice' in radical innovation is any practice that promotes greater success in the development of radically new products and services. Individual practices can generally be grouped according to 'factors' assuming they share some common theme (Dooley et al. 2002). The research question can be formulated as follows:

'What are the key success factors in managing the front end of radical innovation?'

The research question is illustrated in Figure 1.2 and consists of 'radical innovation success factors' which have an influence on 'radical innovation success'. This research question will be further developed in the following chapter.

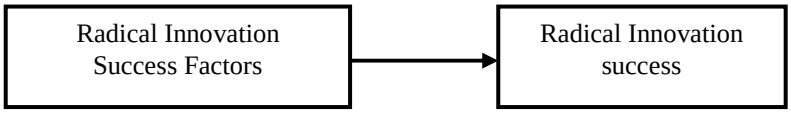


Figure 1.2 Research question

1.5 THESIS OUTLINE

This thesis examines the challenges involved for companies in Ireland to consistently replicate the skills required to manage the fuzzy front end of innovation. The thesis is structured as follows:

Chapter 2:

> Existing literature on innovation is reviewed. Definitions of innovation are explored. Various models of innovation are discussed and a model around which to base this research is selected and expanded upon. Best practice during the early stages of the radical innovation process is explored before the final research sub-questions are developed.

Chapter 3

Chapter 3 discusses the relevant philosophical perspectives and their implications in the context of the objectives of the research. A research design consistent with the adopted philosophical approach and overall research objectives of the project is developed and three phases of empirical research, data collection and analysis are outlined.

Chapter 4

This chapter presents the results of the two surveys relating to the 'search' and 'selection' phases of radical innovation. The primary focus for this chapter is on the usage of individual search and selection practices.

Chapter 5

This chapter presents identification and confirmation of the search and selection factors for radical innovation using SPSS and Lisrel.

Chapter 6

This chapter discusses the results of the preceding two chapters in relation to the research questions and existing literature in the area.

Chapter 7

This chapter presents the final conclusions to the thesis. The contribution, implications and limitations of the research are discussed as well as suggestions for future research.

1.6 CHAPTER SUMMARY

This chapter presented the introduction to this thesis. The first section introduced the research topic; innovation. The different types of innovation, their importance for companies wanting to grow and the management of the front end of the radical innovation process were briefly introduced. The importance of innovation, in particular in the prevailing economic climate was discussed before the innovation performance of companies in Ireland was analysed. Based on several issues that emerged from this background information, a generic research question was formulated. The final section contained an overview of the structure of the thesis. The following chapter outlines the literature relevant to the primary research question to the thesis topic.

Chapter Two Literature Review

2.1 INTRODUCTION

The purpose of this chapter is to present a review of the literature on innovation as it is related to the research question posed in Chapter 1. The research question is formulated as:

'What are the key success factors in managing the front end of radical innovation?'

This chapter is structured into four different sections as follows:

Section 2.2 summarises the higher level literature relating to innovation. Definitions for the key concepts involved in the study are discussed. The concept of exploitive innovation vs. explorative innovation is introduced. The measurement of innovation success is explained and SMEs involvement in radical innovation is discussed.

Section 2.3 discusses how radical innovation, in particularly the fuzzy front end may be managed. Two models of radical innovation are discussed; the O Connor, Leifer et al. (2008) model outlining three radical innovations phases representing discovery, incubation and acceleration (the DNA innovation model) and the Tidd and Beasant (2009) model outlining four phases of search, selection, implementation and capture.

Section 2.4 outlines the radical innovation search space and the challenges involved for companies wanting to engage in radical innovation search. Radical innovation search best practice is explored across a number of themes.

Section 2.5 outlines the radical innovation selection space and the challenges involved for companies wanting to increase their capability to select radical innovations for development are highlighted. Radical innovation selection best practice is explored across a number of themes.

2.2 INNOVATION LITERATURE

2.2.1 Introduction

This section offers definitions for some of the key concepts involved in the study. The concepts of 'exploration' and 'exploitation' are introduced. Measuring innovation success in the context of this research is discussed. Key differences between large and SMEs in relation to radical innovation are explained.

2.2.2 The Innovation Continuum

Innovations can be characterised according to two broad categories; product innovation, which represents changes to the products or services that an organisation offers to their customers; and process innovation, which is a change in the way those products are made or how the service is delivered to the customer (Tushman and Nadler 1986). Within the two broad categories, innovations are typically classified according to technological newness. As shown in Figure 2.1, an innovation can be placed on an innovation continuum ranging from incremental innovation at one extreme and radical innovation at the opposite extreme.

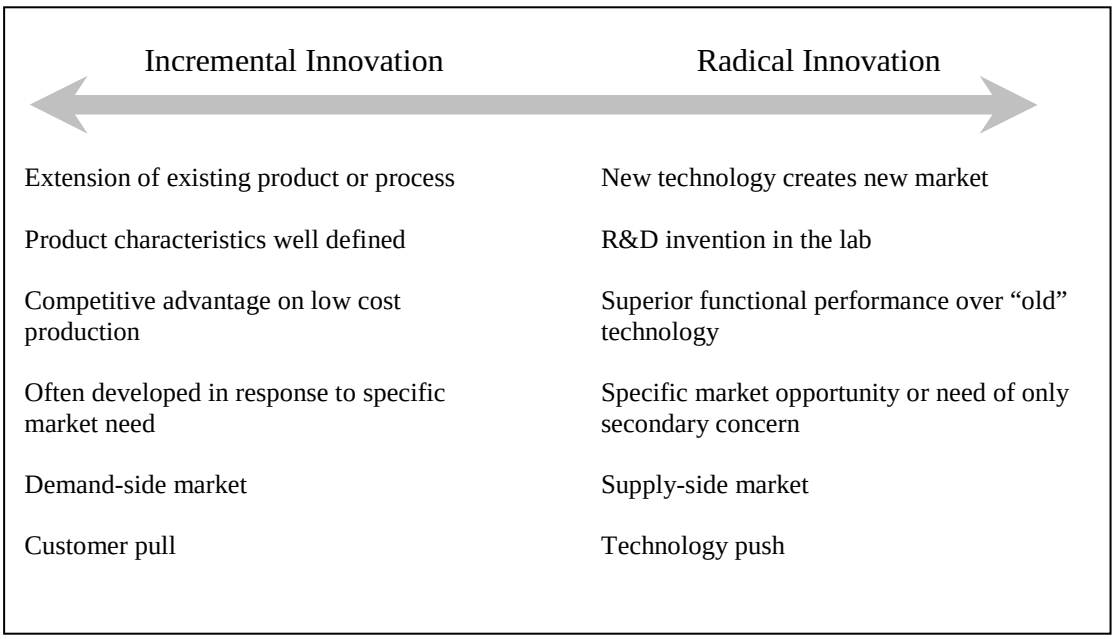


Figure 2.1 Continuum of innovation (Mohr et al. 2004)

On this continuum of innovation Tushman and Nadler (1986) identify three broad levels of innovation in terms of newness.

1. Incremental innovations: These provide small changes to an existing product such as adding or updating features or a small process change which results in a higher quality or slightly lower cost.
2. Synthetic innovations: These innovations combine existing technologies together to create significantly new products or process improvement that results in a significant improvement in terms of quality or cost.
3. Discontinuous innovations (radical): These innovations involve the development and application of significantly new technologies or ideas or a new method of processing.

The three levels of innovation described focus on the newness of the technology in a product. The newness of the technology in a new product is not the only perspective that an innovation can be viewed from. This incremental or radical change can be measured on any number of different criteria including; newness of the technology to the firm or world, business model newness, product-market fit, newness of technology to customer, newness of product to customer, degree of value add-on etc (Wheelwright and Clark 1992, Mosey 2005, Koen et al. 2011, Veryzer 1998, Tushman and O'Reilly 1996, Mohr et al. 2004, Davila et al. 2005). The following definitions classify innovation on a continuum according to the effect the innovation may have on overall business performance.

Wright (2008) identifies three degrees of innovation follows:

1. *Incremental innovation* is an innovation that will not provide a dramatic change in business performance.
2. *Substantial innovation* provides greater opportunity to value-add as it engenders the creation of business opportunities that are likely to lead the industry.
3. *Radical innovation* can turn an industry on its head, creating new bases of performance, new competitors and new business models.

Kleinschmidt and Cooper (1991) identified three classes of new products in terms of newness to the innovating company/market:

1. Low innovative products: Consist of modifications to existing products, redesigned products for cost reduction etc. (23% of products in their research).
2. Moderately innovative products: Consist of new lines to the firm with products that are not that innovative (i.e. not new to market but new to firm only), new products in existing lines etc (47% of new products in their research).
3. Highly innovative products: new to the world products and innovative new product lines to the company (30% of new products in their research).

Innovations may also be assessed according to multiple continuums. Figure 2.2, for example, shows innovation measured in terms of technology newness and business model newness in an innovation matrix.

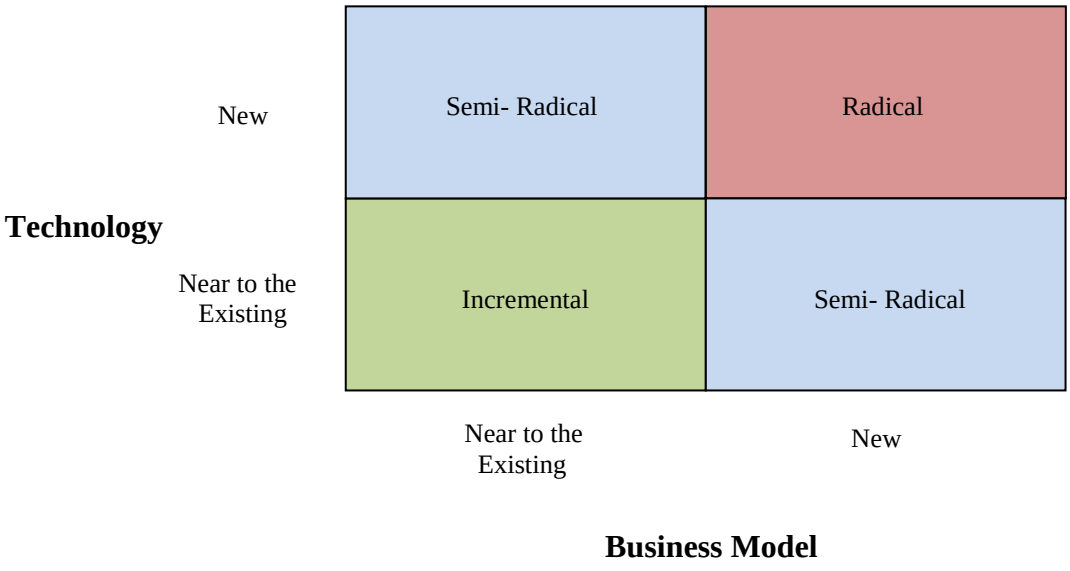


Figure 2.2 The Innovation Matrix (Davila et al. 2005)

A trend emerges with regards to researchers' definitions of innovation newness. At one end of the continuum of newness lies incremental innovation which represents the gradual updating of products and process. This gradual updating of a product or process will not result in huge sales increase or increase in profits but is required for an organisation to stay competitive in their market. This type of behaviour is frequently referred to '***exploit***' type behaviour where a company exploits their existing market

using their existing capabilities (Benner and Tushman 2003, March 1991, He and Wong 2004, Gupta et al. 2006).

The next level of innovation i.e. synthetic/substantial innovation involves a much greater change in terms of the product or process that is being developed. This change may open up new markets to the organisation and increase sales or result in large drop in cost but it will not necessarily turn the organisation into a dominant market player.

The other extreme of the continuum is radical innovation and represents major changes to products or technology or major changes to the delivery of products or technology that is likely to have a dramatic effect on business performance. This type of behaviour is also referred to as '***explore***' type behaviour where companies explore and expand into new markets and technologies that may not leverage on their existing market strengths (Benner and Tushman 2003, March 1991, He and Wong 2004, Gupta et al. 2006).

2.2.3. Innovation and this Research

As can be seen from the previous discussion single working definitions for the different types of innovation are difficult to identify due to the number of different perspectives innovation can be viewed from. Recent research confirms that there is no universally accepted definition for a 'radical innovation' (Augsdorfer et al. 2013). However, for this research a definition is required in order to differentiate between the different types of innovations. The selected perspective is the potential effect that an innovation has on overall business performance. To this end, three definitions of innovation are adopted in line with Wright (2008):

Incremental innovation

An incremental innovation is unlikely to provide a dramatic change in business performance.

Substantial innovation

A substantial innovation provides greater opportunity to value-add as it engenders the creation of business opportunities that are likely to lead the industry and provide a competitive advantage to the company developing them.

Radical innovation

A radical innovation can turn an industry on its head, creating new bases of performance, new competitors and new business models.

Whilst this research is only concerned with radical innovation it is still important to have definitions for the other categories in order to distinguish between the different levels of innovation.

2.2.4. Measuring Innovation Success

Measures of new product success can be grouped in three categories (Griffin and Page 1993).

Customer-based success

- Customer satisfaction;
- Customer acceptance;
- Market share goals;
- Revenue goals;
- Revenue growth goals;
- Unit volume goals;
- Number of customers.

Financial success

- Met profit goals;
- Met margin goals;
- IRR or ROI;
- Break-even time.

Technical performance

- Competitive advantage;
- Met performance specification;
- Speed to market;
- Development cost;
- Met quality specification;
- Launch on time;
- Innovativeness

Griffin and Page's (1993) measures have been adopted in a range of different studies (Huang et al. 2004, Langerak et al. 2004).

Measuring Radical Innovation Success

Many of the measures mentioned previous are difficult to apply to radical innovation and the fuzzy front end given the length of time a radical innovation may take to develop. Often a lag time exists between the development of an innovative product that causes large R&D expenditures and the income earned from the sale of the product (Koberg et al. 2003). Furthermore a radical innovation often creates new bases of performance and platforms of products so measuring success is extremely complicated. The contribution of the fuzzy front end needs to be assessed in the context of the total development cycle and overall NPD performance (Kim and Wilemon 2002). For this research performance measures are required in order to answer the research question. The following performance measures are to be used:

1) Number of radical products commercialised

At a company level, innovation success has often been defined and measured as the number of new products or services generated in a given period (Ettlie et al. 1984, Smith et al. 2005). Hayton (2005) measured innovation success by the 'number of new products, services, and processes and the number of radical products, services, and processes produced by a company'. Katila and Ahuja (2002) measured innovation success 'as the number of new products a firm introduced'. Zahra et al. (2002) measured success across multiple measures ensuring to separate number of incremental products from number of radical products developed. In line with previous research 'number of radical products released' is to be used as the immediate or more short term success measure for radical innovation for this research (Smith et al. 2005, Hayton 2005, Bao et al. 2012, Katila and Ahuja 2002, Katila and Chen 2008).

2) Market position

Hart and Craig (1993) and Hultink and Robben (1995) research demonstrates it is necessary to include measures that indicate both short-term success and long-term innovation success. The same measure is usually not appropriate for measuring long-term and short-term success. Molina-Castillo and Munuera-Aleman (2009) found that there was no difference in measurement over short or long term with measures such as

customer measures but there was in other measures relating to market share. Radical innovations allow firms to establish competitively dominant positions and therefore build competitive advantage (Veryzer 1998, Bollen 1998). Sorescu et al. (2003) demonstrated that market dominant companies introduced more radical innovations that non-dominant companies and also that the values of those radical innovations were far higher than that of the non-dominant companies.

Equally there is literature that indicates dominant incumbent companies are reluctant to engage in radical innovation as they have too much invested in the existing technology trajectory to cannibalise their market (Christensen 1997, Chandy et al. 2003). Chandy et al. (2003) do specify that dominant firms, when under threat due to radical innovation invest more aggressively in the radical innovation relative to the existing product generation than do non-dominant companies. Given that dominant firms have greater technological, financial, and market-related resources, which put gives such firms an advantage over non-dominant firms overcome the risks associated with radical innovation and radical innovation can result in growth levels that are significantly larger than the growth of the industry (Bessant et al. 2004); it may be inferred that being more market dominant is an indicator of longer term innovation success. In the long run, the most innovative companies tend to have the largest market shares, are generally the most profitable, and are usually the most capable of surviving during economic downturns (Atun et al. 2007).

The Arthur D Little consultancy firm developed a measure of market position that has been used frequently by researchers measuring market position (Coate 1983, Hood 1991, Jolly 2012, Loch 2000, Graver 2004). This measure is adopted for this research.

- Dominant: This is rare and typically short-lived. There is little, if any, competition, usually a result of bringing a brand-new product to market or having built an extremely strong reputation in the market;
- Strong: Market share is strong and stable, regardless of what your competitors are doing;
- Favorable: Your business line enjoys competitive advantages in certain segments of the market. However, there are many rivals of equal strength, and you have to work to maintain your advantage;

- Viable/Tenable: Your position in the overall market is small, and market share is based on a niche, a strong geographic location, or some other product differentiation. Strong competitors are overtaking your market share by building their products and defining clear competitive advantages;
- Weak: There is continual loss of market share, and your business line, as it exists, is too small to maintain profitability.

2.2.5 SME vs. Large Companies

Significant differences exist between large organisations and SMEs (Welsh and White 1981, Ghobadian and Gallear 1997; Gray and Mabey 2005, Ledwith 2000). As a consequence of these differences, SMEs hold a number of advantages over large companies when developing radically new products including a shorter decision-making process due to fewer layers of management, greater functional integration, a closeness to customers, less resistance to change and a more innovation friendly atmosphere (Tidd and Bessant 2009). There are also disadvantages which SMEs have to overcome, in comparison to large companies, to successfully develop new products including a lack of access to resources, a lack of external contacts, employees working multiple functions within the company and the SME being dominated by the owner's or chief executive's personality (Hadjimanolis 1999; Kaufmann and Tödtling 2002; Tidd and Bessant 2009).

Schumpter (1934) is credited with initiating the argument that small entrepreneurial firms are most likely to be the source of innovation. However, more recent research shows small companies are more likely to follow a defender strategy (Brouthers et al. 1998, Aragón-Sánchez and Sánchez-Marín 2005) meaning they focus more on their existing products and markets with no focus on exploration of new territory i.e incremental innovation is favoured more than radical innovation. Meyers and Roberts (1986) research suggested that small technology based firms often tended to adopt one technology and avoid high levels of diversification.

Certain studies point to the fact that SMEs are better at innovation than large companies (Rothwell 1978). Wakasugi and Koyata (1997) found that, while the number of new

products developed and the number of patent applications increased in accordance with firm size, there was no evidence of economies of scale in relation to NPD activities suggesting that small firms can be as efficient in their product development activities as large firms. Chandy and Tellis (1998) found that size does not necessarily represent the primary driver of innovation involvement. The size of a company does not have a significant influence on the creation of radical innovation, providing that the underlying organisational and cultural conditions are present; companies of all sizes can create entirely new products. (Herrmann et al 2006). Research on SME's by Ledwith et al. (2006) found that the growth of small firms is most likely to occur through the innovation and development of new products/processes. Verhees et al. (2009) research showed SMEs engaging in radical innovation have higher expectations about their performance. This high expectation in turn leads to increased performance. The most innovative SME are competitively aggressive and willing to take on greater degrees of risk (Blumentritt 2004).

Previous research has identified several aspects of what is considered to be critical for successful innovation in SMEs (Dodgson and Rothwell 1991, Bowen and Ricketts 1992). The success factors highlighted in these studies among others included: promoting an innovative culture, analysing competitors and developing alliances and partnerships. To be successful at innovation the company must articulate an innovative positive strategy and pursue it. Mosey (2005) demonstrated that SME producing new to market products use product strategy planning in addition to opportunity identification, market intelligence gathering and NPD management techniques. Laforet and Tann (2006) conclude that the most innovative SMEs had a higher commitment to innovation than the less innovative companies. Mosey et al. (2002) demonstrated that the small companies with aggressive growth ambitions who repeatedly introduced innovative new products that opened up new market niches were also the best performing companies. Other studies show the extent to which small businesses innovate successfully depends upon their capacity to plan ahead, to have a clear strategy and a wiliness to learn and take risks (Salavou et al. 2004, Beaver and Prince 2002).

Huang et al. (2004), basing their study on the measures proposed by Griffin and Page (1996) demonstrated that the most frequently used success measures were that of 'customer acceptance' and 'customer satisfaction'. This supports previous findings that

customer based measures are the most commonly utilised measures (Griffin and Page 1996, Sorescu et al. 2003). Further research by Ledwith and O' Dwyer (2009) demonstrated that SMEs do tend to focus on customer based measures and meeting performance and specification measures over other success measures, however, none of the measures SMEs focus on are significant in predicting organisational performance.

To summarise, company size has a significant effect on innovation involvement. With regards radical innovation it is to be expected that SMEs will be able to leverage on their advantages to overcome the disadvantages that they may experience. Not all SMEs are interested in engaging in radical innovation but the SMEs that do engage in successful radical innovation are the best performing companies.

2.2.6. Section Summary

This section summarises much of the literature relating to innovation at a high level. A definition for radical innovation was offered as follows 'a radical innovation can turn an industry on its head, creating new bases of performance, new competitors and new business models'. The concept of exploitive innovation vs. explorative innovation was introduced. The measurement of innovation success was explained and discussion around SMEs involvement in radical innovation added. The next section of this chapter discusses how innovation can be managed in varying contexts.

2.3. MANAGING RADICAL INNOVATION: THE FUZZY FRONT END

This section of the chapter outlines how innovation is managed in a company. The fuzzy front end is introduced and expanded upon. Two models for characterising the fuzzy front end and the entire innovation process are discussed; the Discovery, Incubation, Acceleration model by O Connor and DeMartino (2006) and the Search, Select, Implement and Capture model from Tidd and Bessant (2009).

2.3.1. Managing Incremental Innovation

Managing incremental innovation is a relatively easy task. Processes such as Stage-gate, Figure 2.3, set down an easily followed guide with different development stages and gates representing progress review points.

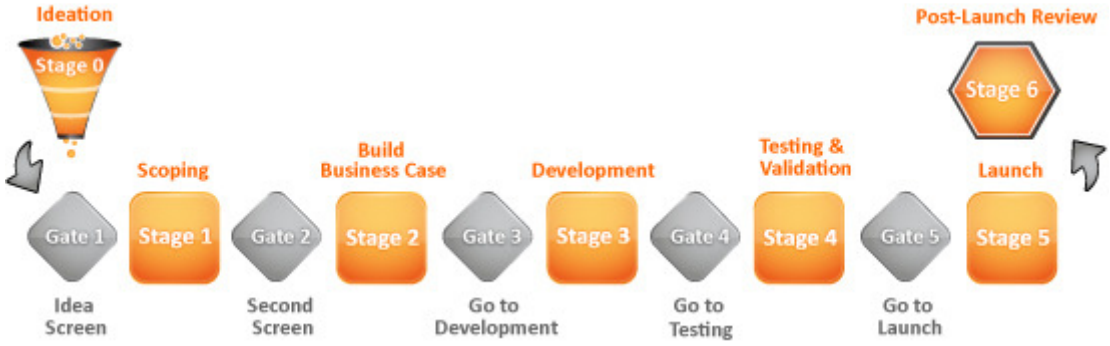


Figure 2.3 The Stage Gate Process.

A stage-gate controlled process can struggle to deal with radical innovation although efforts have been made to make it more flexible (Cooper 2008, Cooper 2013). Problems arise at the review 'gates' as these are in place as a means of risk control. Review gates effectively terminate projects that are risky thus limiting the company exposure to expensive failures. The caveat to this effective protection is that these review gates also limit the company from radical innovation and the massive growth potential that may arise if successful. As the innovations move towards the radical end of the spectrum the information required at these gates is often not available or reliable so ideas are rejected and cultural and political company influences on selection decisions increase in importance (Bessant et al. 2010).

2.3.2. The Fuzzy Front End of Innovation

The fuzzy front-end (FFE) is the 'fuzzy' area of activity that occurs in the period between when a new product idea is identified and a quantifiable amount of development is completed on the idea. It is described as 'fuzzy' because work and activities at this point can often be experimental and chaotic. Many ideas may be proposed at this stage which much be filtered down to allow the best ideas progress to full development (Figure 2.4).

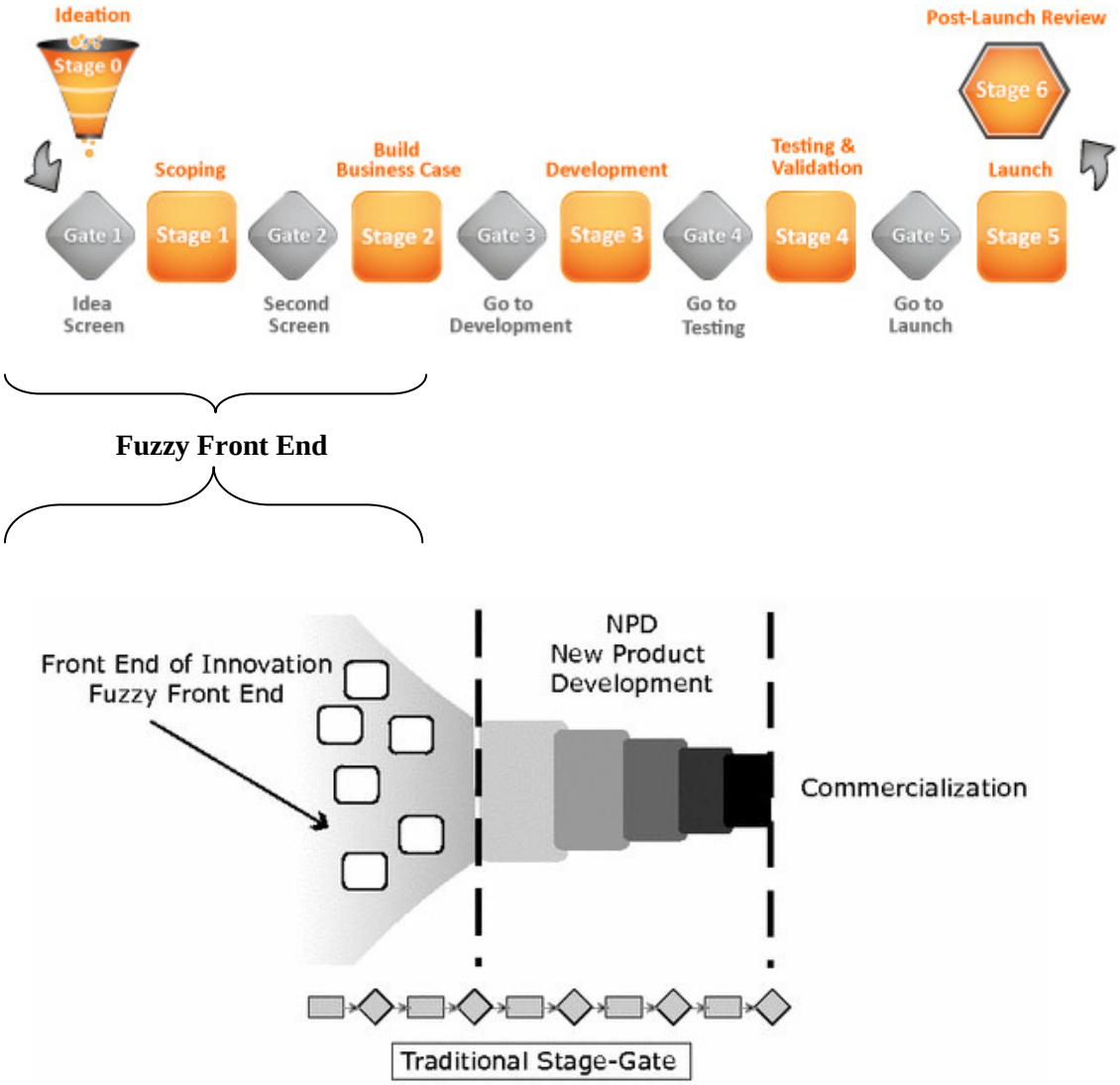


Figure 2.4 The fuzzy front end

Importance of fuzzy front end

Successful innovations originate from ideas (Boeddrich 2004). Incremental ideas generally come from ongoing interaction between a company and its customer. For radical innovation ideas are much more likely to result from the synthesis of new and non-obvious insights from a disparate repertoire of technical information (Leifer et al. 2000). These ideas are formulated during the very early stages of the innovation process, i.e. the fuzzy front end (Smith and Reinertsen 1991, Koen et al. 2001, Reid and De Brentani 2004).

The term fuzzy front end was first popularised by Smith and Reinertsen (1991) and adopted by various other authors. Other authors and researchers developed various other names for this product development phase:

- The ‘fuzzy front end’ (Smith and Reinertsen 1991, Boeddrich 2004, Khurana and Rosenthal 1997, Reid and De Brentani 2004, Koen et al. 2001, Cooper 2008, Verworn et al. 2008).
- The ‘front end of innovation’ (Khurana and Rosenthal 1998, Bröring and Leker 2007, Bröring et al. 2006, Poskela and Martinsuo 2009).

This phase of the development process represents the phase between the first consideration of an opportunity and when it is judged ready to enter the structured development process (Kim and Wilemon 2003, Koen et al. 2001). It includes work such as: technical feasibility demonstrations, early market research, financial viability analysis, business model development, and business plan preparation (Markham et al. 2010). Cohen and Levinthal (1990) define it as the territory leading up to organisational-level absorption of the innovation process.

It is identified as a phase that is critical for new product success (Cooper and Kleinschmidt 1996, Cooper and Kleinschmidt 1995, Markham 2013) and is thought to be the root of success for firms involved with radical new product innovation (Reid and De Brentani 2004). Verworn (2009) clarifies the ‘leverage effect’, which suggests that the front end has an indirect impact on project execution and hence new product development success. The activities and decisions that are undertaken during the fuzzy front end represent the starting point for the entire NPD development process. Decisions made at this stage determine the direction of the development, consequently a clearer understanding of the activities potential impact could ultimately result in a competitive advantage. Few companies understand the importance of the fuzzy front end despite the considerable impact this phase can have on innovation performance (Kim and Wilemon 2002). The fuzzy front-end phase of innovation projects is critical for as the foundation for success or failure is often established before a new concept enters the subsequent ‘formal’ development process (Frishammar et al. 2011).

The search for new ideas to create a stream of potential new products is an important step in the innovation process; one which is relatively low cost compared to the cost of actually implementing any one idea (Urban and Hauser 1993). Several studies have provided evidence of a link between new product performance and time spent on fuzzy front end activities (Cooper and Kleinschmidt 1995, Urban and Hauser 1993). Radical new innovations have the highest level of uncertainty during the fuzzy front end because the development of products resulting from such innovations entails the a lack of understanding and the fewest strategies for effective management (Brentani and Reid 2012). Research has been completed on the radical innovation process though it does not exclusively focus on the fuzzy front end (O'Connor and Rice 2001, O'Connor et al. 2008, Tidd and Bessant 2009).

Kahn et al. (2003) see the fuzzy front end as an important issue in future research on product development management. How companies manage the fuzzy front end can become an important source of competitive advantage and a core competency in accomplishing their innovation strategies and targets (Kim and Wilemon 2002). Veryzer (1998) suggested that a major difference between the NPD processes of incremental and radical products lies in the fuzzy front end and suggest activities associated with the development of incremental products might be rarely possible and even counterproductive during the fuzzy front end of radical innovation e.g. concept testing and business assessment might discourage radical innovation. These type of activities are very difficult in any case when dealing with radical innovation (Verworn et al. 2008).

Pioneering radically new products is a risky strategy. At the early stages of the development of a new product/innovation the new performance and features that will be valued by the users are not always clear to the developers or even the users themselves. Valued features may be added through further development through a process of trial and error by the users and developers. New features that are valued by the users in a product can then be recognised by competitors and incorporated into further products. Thus the early stages of development can be extremely volatile and pioneers can be displaced by new entrants (Steffens 1993). Success goes to ‘early entrants’ with the vision, patience and flexibility to establish a mass consumer market (Tellis and Golder 1996).

The fuzzy front end of the innovation process for radical innovation is widely accepted as being crucial, however, there is here is little empirical evidence to support the assertions that the front end has an impact on product performance or which front-end activities have positive or negative impact on performance (Verworn et al. 2008). The wrong choice of projects at this stage could potentially have fatal implications for a company. Often selection systems are too effective at reducing risk for the company, at detecting and subsequently rejecting projects that have a high chance of failure. Thus companies face a double challenge of finding radical ideas and then actually getting them into the development process.

2.3.3 Managing the Fuzzy Front End

This research is based around the fuzzy front end of the innovation process for radical type innovations.

Cooper (1988) distinguishes four phases of the fuzzy front end:

1. The generation of an idea;
2. Initial screening;
3. Preliminary evaluation;
4. Concept evaluation.

Cooper and Kleinschmidt (1986) and Cooper and Edgett (2008) affirm that vital predevelopment activities include:

1. **Preliminary market assessment**: A quick assessment of the market to determine market size and potential, customer interest, initial insights into customer needs, requirements and value, and the competitive situation.
2. **Technical assessment**: A pre-development assessment of the technical challenge, identifying the probable technical solution, the development route, technical challenges, risks and potential ‘showstoppers,’ etc.
3. **Source-of-supply assessment**: An initial appraisal of source of product supply, including operating requirements, probable materials and equipment needs, and possible outsourcing needs, suppliers and partners or alliances.

4. **Market research**: A more in-depth market investigation, involving the project team doing voice of customer research.
5. **Concept testing**: This is a different type of customer input, where the proposed product, perhaps as a model, concept or virtual prototype, is presented to customers, and feedback is sought. Interest and purchase intent are established.
6. **Value-to-the-customer assessment**: A value-in-use analysis, whereby the product's value is quantified.
7. **Product definition**: The entire project team integrating the acquired information into a product definition.
8. **Business and financial analysis**: Integrating the data obtained in the homework stage into a business case, which features a full financial and business analysis.

Khurana and Rosenthal (1998) designated the following front-end activities:

1. Product strategy formulation and communication;
2. Opportunity identification and assessment;
3. Idea generation;
4. Product definition;
5. Project planning;
6. Executive reviews.

These models of the front end of innovation are characterised by multiple stages requiring specific information e.g. technical assessment, market assessment etc. For radical innovation this type of information is rarely available and assessments would be of the qualitative nature when they do exist. Veryzer (1998) suggests that radical new product should at some stage of the development process enter into the conventional new product process; however, at the early stages i.e. during the fuzzy front end, the process must be flexible enough to extend to the wide range of uncertainties possible for different innovations. As mentioned, research suggests that activities associated with the development of incremental products may be counterproductive during the fuzzy front end of radical innovation (Veryzer 1998). The above models of the fuzzy front end have too many stages requiring specific information input which for radical innovation projects would not be available (Verworn et al. 2008) resulting in excessive bureaucracy and the stifling of innovation and creativity which is vital in the early stages of radical innovation.

2.3.4 Managing Radical Innovation and the Fuzzy Front End.

Innovation often fails due to unrealistic expectations from management. The time horizons and the level of investment needed for radical innovation to be successful can make radical innovation an unattractive option. It may take a long time and a large investment to nurture a portfolio of promising prospects to become commercial successes. A number of models have emerged in recent years designed to manage the entire radical innovation process including the fuzzy front end. The following section describes two of the models; the *Discovery, Incubation, Acceleration* model developed by O Connor and DeMartino (2006) and *Search, Select, Implement, Capture* model by Tidd and Beassnt (2009).

Innovation model 1: The Discovery, Incubation, Acceleration Model

O Connor and DeMartino (2006) model, further refined by O Connor, Leifer et al. (2008), for managing innovation comprises of three distinct building blocks that interface with one another and with the rest of the organisation. (O'Connor et al. 2008).

These three building blocks are:

1. Discovery (D);
2. Incubation; (N)
3. Acceleration (A).

O' Connor et al. (2008) uses the acronym DNA to represent these three building blocks which describe a model for radical innovation within an organisation.

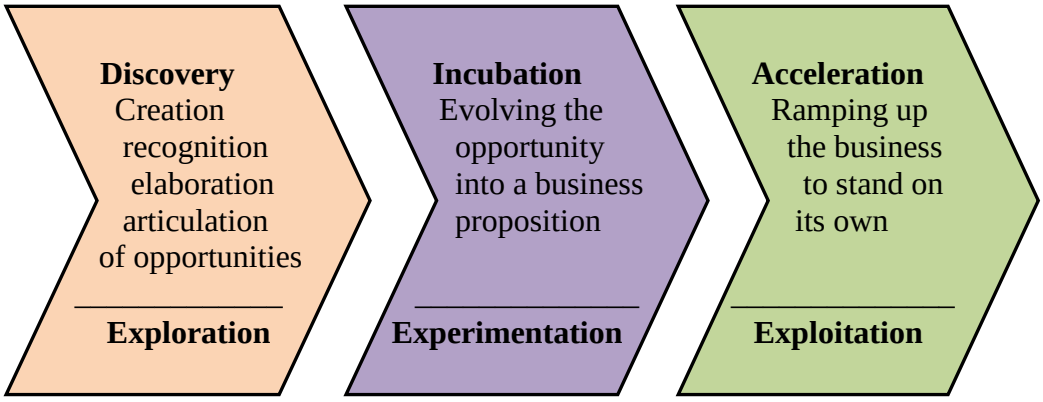


Figure 2.5 DNA innovation system (O Connor and DeMartino 2006)

Discovery represents the early stage of the innovation process where ideas are identified, concept are developed and proposed for further development.

Incubation represents the nurturing of the portfolio of opportunities identified in the discovery phase that may have uncertain outcomes. Incubation involves testing the opportunities in multiple market spaces to develop the strategic path forward for each opportunity.

Acceleration is 'the building of the business's critical mass'. Acceleration ramps up a young business to the point where the business can operate relative to more mature business platforms within the company.

These three steps need to be managed together as a system for the radical potential of the portfolio to be realised. The interfaces between the blocks have to be monitored. This requires moving individual projects and business ideas from discovery to incubation and finally to acceleration. It can be difficult for the organisation to absorb the output of the process or the organisation requires more than the system is producing. These problems stem from the organisations changing capacity for innovation. Capacity levels for innovation are not constant. O' Connor et al. (2008) sees a need for an '*orchestration*' role to manage the relationship between the DNA innovation system and the mainstream organisation. Clearly the discovery phase aligns closely with the fuzzy front end of the development process. The following section discusses 'discovery' in more detail.

Discovery

The first building block is the 'discovery' capability. Being competent at discovery corresponds to the ability to 'create and identify opportunities that may have major impact in the market place through the delivery of new performance benefits, greatly improved performance benefits, or new ways of doing business' (O'Connor et al. 2008). These ideas can come from inside the organisation or from outside sources. Discovery is not equal to invention. The 'invention' may have occurred outside of the organisation and then be adapted for the organisation e.g. Tesco entering the insurance and banking industry. Discovery comprises of much more than the initial idea. A full discovery capability comprises of three activities relating to:

- Seeking out and developing foundation knowledge.

  This step is the invention stage. New ideas and technologies are developed. This is often quite a technical step and the most obvious step of discovery. Alternatively the discovery may not be an actual new technology but a new application of old knowledge.

- Opportunity Generation

  The second of the three discovery activities is the work involved in finding potential business opportunities on the basis of the discovered knowledge. The organisation must be proactive here and engage with external partners necessary to generate the potential break through opportunities.

- Opportunity Articulation

  The third and final activity associated with discovery is opportunity articulation. This represents the ability to clarify opportunities in a manner that energises management. Business opportunities can be identified and generated but if their linkages to the company's future, the company's renewal or their strategic intent cannot be demonstrated then they will not succeed.

Innovation model 2: The Search, Select, Implement, Capture Model

Tidd and Beassnt (2009) advocate a four stage process for managing innovation.

1. **Search** relates to the techniques used by a company to search for radical innovation opportunities.
2. **Select** relates to the techniques used by a company when selecting ideas for radical innovation and what metrics are used to monitor radical projects.
3. **Implement** relates to how the company takes the idea from the initial concept to the finished product.
4. **Capture** relates to how companies can best capture value from their innovations and minimise the drawbacks of change.

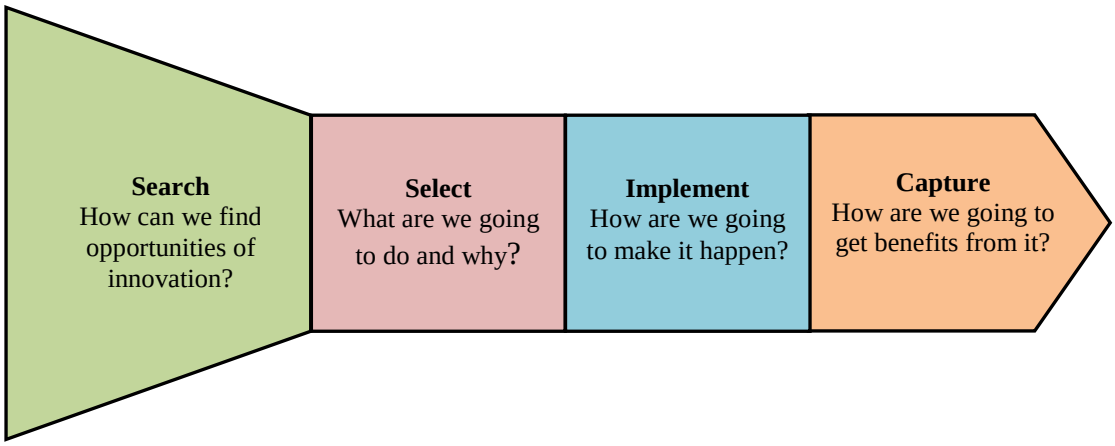


Figure 2.6 Search, Select, Implement and Capture Innovation System (Tidd and Bessant 2009)

The search and select phases align closely with the fuzzy front end of the development process.

Search relates to the techniques used by a company to search for radical innovation opportunities, what sources are used for ideas, how ideation is managed etc. There are many different sources of innovative ideas. Innovation is a process of taking ideas forward, revising and refining them. Triggering that process is not solely about flashes of inspiration and 'eureka' moments. To manage innovation effectively a company must be aware of all the potential sources of innovative ideas. Figure 2.7 represents the wide range of stimuli that exist that may trigger the innovation process.

Bessant and Von Stamm (2007) identified 12 search strategies which have the potential to increase radical search capacity.

1. Sending out scouts;
2. Exploring multiple futures;
3. Using the web;
4. Working with active users;
5. Deep diving;
6. Probe and learn;
7. Mobilise the mainstream;
8. Corporate venturing;
9. Corporate entrepreneuring;
10. Use brokers and bridges;
11. Deliberate diversity;
12. Idea generators.

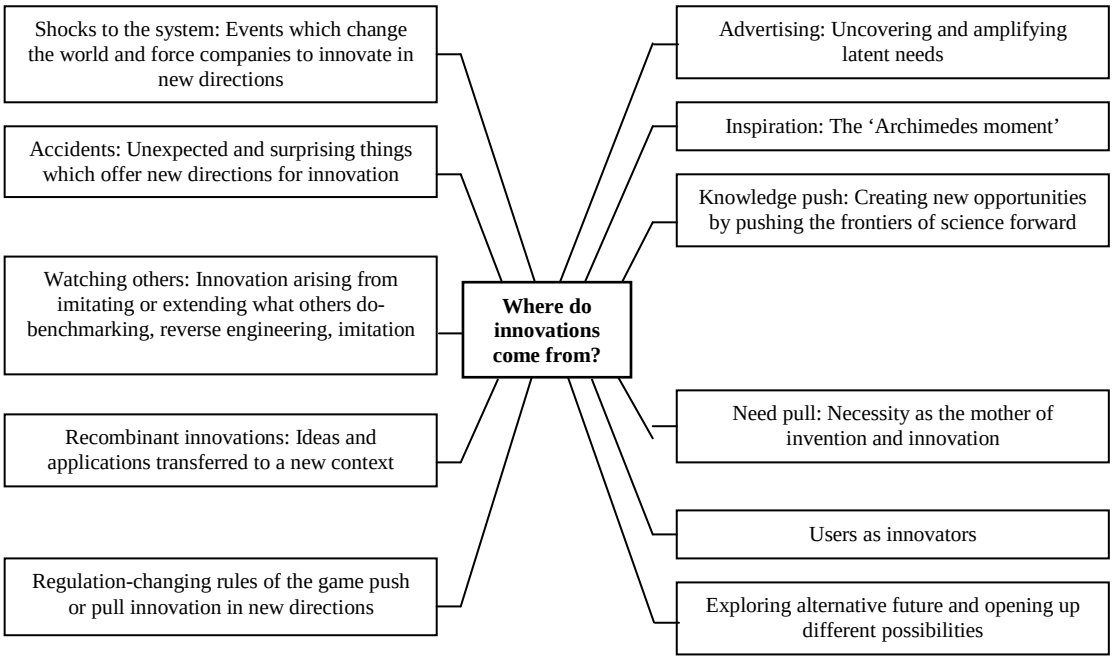


Figure 2.7 Potential Sources of Innovation (Tidd and Bessant 2009)

Select relates to the techniques used by a company when selecting ideas for radical innovation and what metrics are used to monitor radical projects. When searching for radical innovations many opportunities may materialise. Obviously no firm has the resources to pursue every project so decisions have to be made regarding which opportunities to pursue? Many routine selection processes exist including - decision rules and criteria, portfolio techniques, stage gate review systems etc. Given the emergence of a radical new technology or the emergence of a new market, or a shift in the regulatory framework – established companies often face major challenges regarding project selection.

Heuristics and internal rules for resource allocation are unhelpful and may actively militate against placing bets on the new options because they are far outside the firm's 'normal' framework thus the company need a system place to ensure all radical opportunities are not rejected by the companies 'immune' system. It is important to note that selection is not a single event. Over the course of development each innovation will face constant evaluation. Each evaluation represents a selection decision: whether or not to continue to devote resources to the project or to terminate.

Bessant et al. (2010) identified 9 selection strategies which have the potential to increase radical search capacity.

1. Building alternative visions;
2. Bridge-building to/from outside the box;
3. Probe and learn methods;
4. Using alternative evaluation and measurement criteria;
5. Mobilising sponsorship and championship;
6. Using alternative decision-making pathways;
7. Deploying alternative funding structures;
8. Using alternative implementation structures;
9. Mobilising entrepreneurship inside and outside the firm.

2.3.5 A Model for this Research

Examining the two models it can be seen that the Discovery phase in the O Connor and DeMartino (2006) model and the Search and Select phases of the Tidd and Bessant (2009) model aligns with the fuzzy front end of innovation. The Search, Select, Implement, Capture model is a more suitable starting point for this research given the DNA was developed primarily for larger organisations. The companies studied for the DNA model included 3M, Air Products, Albany International, Corning, Dupont, GE, IBM, J&J Consumer, Kodak and Shell Chemicals etc. These companies are all extremely large companies so the applicability of the model may be questioned when applied to a wide range of companies particularly in a country like Ireland with a large percentage of SMEs in operation. It is also an extremely complex model e.g. the model has defined roles as ‘Orchestrators’ who are required as process managers etc.

The search, select, implement, capture model can be viewed as a more simplistic approach to managing radical innovation. The model was developed using a broad range of firms with input from many different countries. This model of radical innovation can be applied in an uncomplicated manner to a wide context of companies. The development of the model consisted of an exploration into the different phases of the radical innovation process. The development involved a mixture of experience-sharing workshops coupled with in-depth case research of DI experiences, surveys and experiments in the participating firms. Furthermore, subsequent work on the search

(Bessant and Von Stamm 2007) and selection (Bessant et al. 2010) phases identified potential practices companies can use during these phases. These practices have not been examined in published research which also identifies a research gap in current literature.

2.3.6 Section Summary

This section outlined how innovation can be managed. Two models for characterising the fuzzy front end and the entire innovation process were discussed. The Tidd and Beassnt (2009) model for managing innovation was adopted as part of the starting point for this body of research. The search/select phases align with the fuzzy front end of the radical innovation process and are useful in structuring the research accordingly. The following sections outline in detail the challenges companies face in the search/selection phases of radical innovation.

2.4 THE FUZZY FRONT FND: RADICAL SEARCH

This section discusses the search aspect of the fuzzy front end of innovation. Two dimensions of search behaviour are discussed in detail; exploitation i.e. incremental innovation and exploration i.e. radical innovation. Problems companies experience when dealing with innovation search and attempting to balance between exploitation and exploration are examined. Finally, search practices are discussed that previous literature identified as having the potential to increase radical innovation search capacity.

2.4.1 Introduction

The radical innovation process can be characterised according to four key elements – search, selection, implementation and capture. The challenge in managing innovation is to find a method of carrying out these activities– and over time to embed these patterns of behaviour so that they become ‘routinised’ in the structures and processes within the company. This can be problematic because different degrees of novelty require different solutions for search and selection. Trying to manage these different degrees of novelty simultaneously, developing ‘ambidexterity’, sets up tensions across an organisation (Tushman and O'Reilly 1996).

2.4.2 Searching for Ideas

Exploitation vs Exploration

As previously mentioned (Section 2.2), there are two broad dimensions of search behaviour, exploitation and exploration. It is widely accepted that companies require both exploration and exploitation type activities to be success over extended periods of time (Ancona et al. 2001, Benner and Tushman 2002, Eisenhardt and Martin 2000, Feinberg and Gupta 2004, March 1991, March 1996, March 2006). Companies have a choice on how to invest their limited resources. Choices must be made between gaining new information about alternative technologies and improving future returns and using the currently available technologies to improve present returns (March 1991).

Pursuing one or other strategy exclusively may lead to long-term problems. Knott (2002) concluded that exploitation and exploration type actives can co-exist in product development and the two activates complement each other. Other authors support this and have modelled exploration and exploitation as activities that positively interact (He and Wong 2004, Jansen et al. 2006, Katila and Ahuja 2002, Lubatkin et al. 2006, Nerkar 2003). Feinberg and Gupta (2004) offered empirical evidence of the positive effect of ambidexterity in their survey of 573 companies. The positive relationship between innovation ambidexterity and business performance was further explored in terms of revenues, profits, and productivity growth relative to companies' competitors by Lin et al (2012).

Creating a balance between these two very different kinds of activity depending on the current company requirement seems to represent a route to success for most companies (He and Wong 2004, Benner and Tushman 2003). Typically companies treat radical innovation as a single event. The commitment is not sustained long enough to develop and embed a competency (O'Connor and Rice 2013). It is a significant challenge for companies to embed radical innovation as a function with the company and build up an innovation capability over time (O'Connor and Ayers 2005).

Exploration activities, focusing on radical innovation, are fraught with uncertainty and unfamiliarity. The process is non-linear, stochastic, highly explorative and experimental, involving probing and learning rather than targeting and developing (Rice

et al., 1998). The organisational culture and adherence to process following found in firms tends to push efforts towards low risk incremental innovation (Dougherty and Heller, 1994, Koberg et al. 2003). Less is known about effective management of the development process for radical innovation than for incremental innovation (McDermott 1999). Rather than being a predictable process, developing radical innovations involves considerable risk and requires insight and foresight (O'Connor and Veryzer, 2001).

Exploitive Search vs Explorative Search

Exploitation, represents incremental innovation; building on existing capabilities, whilst exploration represents radical innovation; building new capabilities (Benner and Tushman 2003, Tushman and O'Reilly 1996). The different nature of these two search activities requires very different mechanisms – routines – to enable them (Von Stamm 2008). Exploit behaviour uses routines designed to improve current products or develop new products using a variation of current technologies ensuring that existing customers are satisfied. Explore behaviour uses routines designed to open up new markets for a company (which could then be potentially exploited) using either existing products or technologies repositioned (e.g. Ryanair) or new products with different technologies than are currently utilised. Typically more open search strategies are a viable option for explorative NPD projects that seek to develop novel products or services. Exploitative projects aiming at incremental improvements of existing offerings, in contrast, have little if anything to gain from search openness (Salge et al 2013). For companies that focus on incremental innovation projects, a relatively closed approach to innovation is most beneficial in terms of innovation performance (Pullen et al. 2012).

These search dimensions can be mapped as in Figure 2.8. The vertical axis refers to shallow or deep search behaviour and could be likened to a simple technology continuum (see Figure 2.1). The horizontal axis relates to the nature of the frame. This is narrow or broad search where narrow represents a comfortable innovation space for a company, one which they are used to operating, and broad represents new innovation spaces, when companies attempt to move outside their current areas of competency.

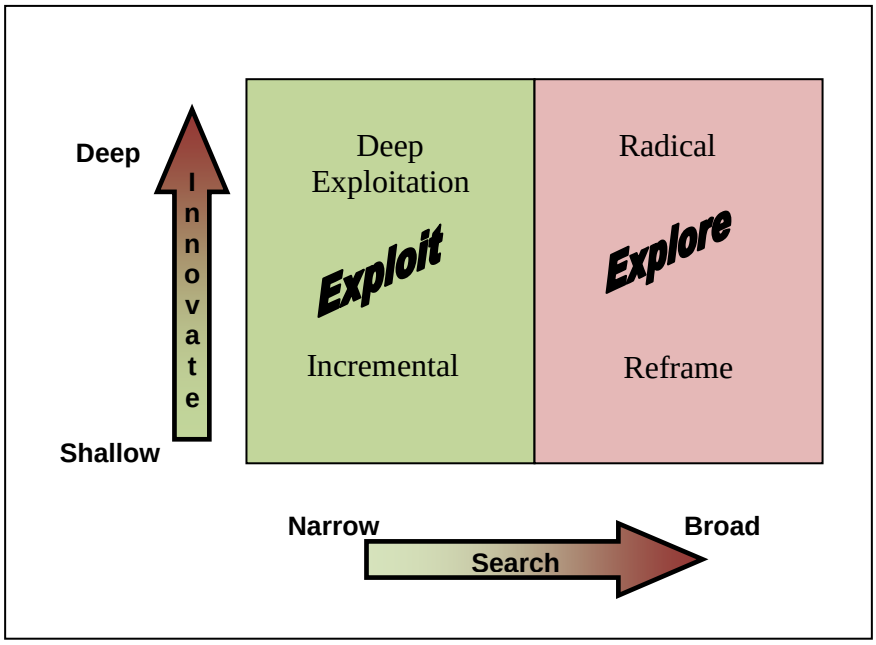


Figure 2.8 Innovation Search Space (adapted from Tidd and Bessant 2009).

Transitioning from exploitation to exploration

One of the most critical front-end activities is determining market and customer needs (Markham et al 2010). Established firms develop strengths in exploiting existing capabilities and embed these operations as routines to a high degree of sophistication (Christensen 1997, Tushman and O'Reilly 1996, Hwang and Christensen 2008, Koberg et al. 2003). For example electronics firms commit extensive resources to R&D but regardless of the actual market needs their innovations are still largely guided by Moore's Law (Lundstrom 2003, Thompson and Parthasarathy 2006).

These companies appear adept at managing innovation yet when radical changes occur due to new entrants to the market or changing consumer needs then these companies can experience difficulties adapting. Christensen's (1997) original theory of disruptive innovation highlights this – radical innovations create new markets emerging at the fringes of an existing market, serving different customers with a different value proposition.

This radical way of doing things is typically in conflict with the established dominant game (Charitou and Markides 2012). As activity at this fringe, which is of little interest or perceived relevance to the established companies, increases, the radical innovation

migrate towards mainstream markets and disrupt them, as seen in Figure 2.9 (Christensen 1997, Druehl and Schmidt 2008, Schmidt and Druehl 2008, Gilbert 2003). Both incremental and radical innovations can be disruptive to a firm if they introduce new knowledge that may supplant or make obsolete prior knowledge (Plowman et al. 2007).

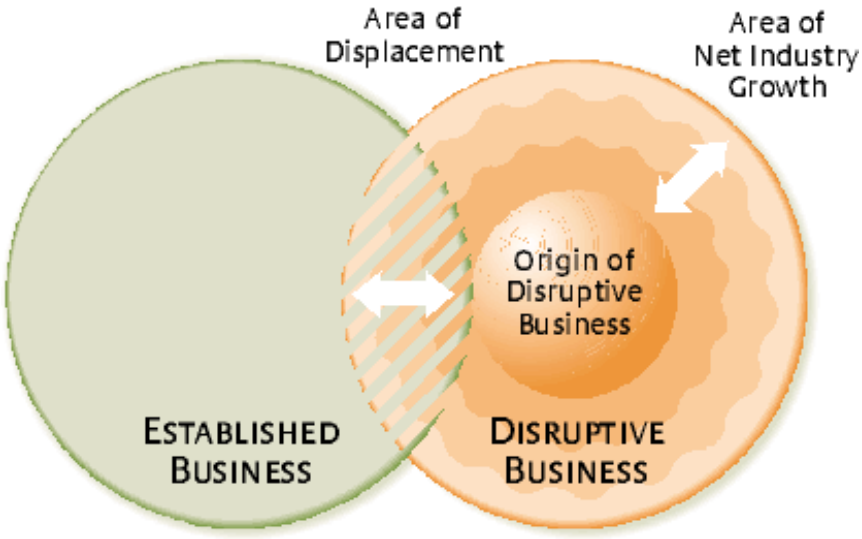


Figure 2.9 Disruptive business migrating to established market (Gilbert 2003)

Companies have a choice of where they wish to search and focus their resources. Established companies can become overly reliant on the systems and procedures that have brought them success via exploitation. They become locked in to these behaviours and reliant on following systems that have worked successfully in the past (Bate 1994, Christensen 1997, Leonard-Barton 1995). Polaroid, for example, experienced difficulty in adapting to digital imaging. During this period the 'senior managers strongly discouraged search and development efforts that were not consistent with the traditional business model' (Tripsas and Gavetti 2000).

Another potential problem is 'technology overshoot' (Christensen and Raynor 2003). This is not a lack of search activity but rather a problem of direction – maintaining balance between exploitation and exploration. Companies can selectively influence their innovation performance depending on targeted search for external knowledge and their sectoral trajectories (Köhler et al. 2012). The effective design of knowledge search strategies at the ideation stage of innovation projects has the potential to improve innovation success and organisational performance (Salge et al. 2013). Mature firms

must develop radical innovations as a basis for building and dominating fundamentally new markets (O'Connor and Rice 2013).

Search Best Practice

Research indicates that certain factors or best practices are more likely to create an environment where innovation can flourish (Kanter 1988). For radical innovation, 'order and clarity' (generally accepted to support incremental innovation) may be detrimental (Veyser 1998). Management must learn to loosen control and become less risk averse in order to develop an environment that favors radical innovation (Ekvall 1996).

Camp (1989) defined 'best practice' as a technique, method, process or activity that is more effective at delivering a particular outcome than any other technique, method, process or activity within that domain. Adapting this definition, explorative search best practice can be defined as practices that promote greater success in identifying ideas for radically new products and services. While acknowledging that 'order and clarity' may be detrimental to radical innovation, certain companies, e.g., Hewlett Packard, Johnson and Johnson, 3M and Sony are innovative in a regular and repetitive manner (Tushman and O'Reilly III, 1996; Zien and Buckler, 1997; Gundling, 2000). Firms differ in how they search and these variations can lead to variations in performance (Katila and Ahuja 2002). For example recent research demonstrates that the best performing companies use formally planned activities for idea generation (Markham and Lee 2013). This suggests that there are certain practices that a company can engage in to increase their capabilities of success. The effective design of knowledge search strategies at the ideation stage of innovation projects has the potential to improve innovation success and organisational performance (Salge et al. 2013).

The following section discusses radical innovation search practice. These practices have the potential to increase a company's radical innovation search capacity. While all the search practices identified are proposed as been applicable for exploratory search many of the practices may also be appropriate for exploitive search.

2.4.3 Categorising Radical Search Best Practice

'Search' relates to companies using practices that both enable companies to be the 'creators of change' in their industry, proactively trying to develop radically new ideas, as well as searching for existing ideas that may impact the company in the future. From the literature different approaches can be identified which may be linked with increased success when looking to source ideas for potential radical innovation.

When categorising search practice, a choice must be made regarding the category breakdown. An option would be to attempt to breakdown the search phase into a process with a number of steps and allocate best practice accordingly. However, given the uncertainty during the fuzzy front end it is difficult to identify an exact process for radical innovation. As an alternative four key practice areas are selected to generally categorise search practice. While they do not form a linear process they are broad enough to encapsulate most potential search best practices. Given the broad nature of the categories there is room for overlap between them and in some cases a best practice could be discussed under several of the categories. However, the aim of the categories is to provide some structure for the literature on search best practice rather than to provide mutually exclusive groups.

The four categories that have been identified are;

1. Learning about markets for radical innovation;
2. Managing radical idea generation;
3. People Management for radical innovation;
4. Openness to external sources for radical innovation.

The following sections discuss identified best practices across the 4 categories.

Learning about markets for radical innovation

This subsection outlines some of the practices companies can engage in to increase their ability to learn about and identify new markets to target using either products and technologies or new products and technologies.

For a product or technology to have a radical effect on the market place it doesn't always have to utilise a vastly 'new' technology but often a new unthought-of application of an existing technology can send shock waves through a market. Choosing market applications unfamiliar to the firm obviously presents challenges in itself, however, it over comes several barriers also including less risk to existing business though the cannibalising of existing markets and less pressure regarding the need for consumers to adopt your technology (McDermott and O'Connor 2002). O Connor and Rice (2001) describe Analog Devices development of a micro-electro-mechanical (MEMS) accelerometer, a small microchip that can measure changes in speed. Initially, this technology was used to replace electro-mechanical airbag sensors, however, the application possibilities are nearly endless e.g. virtual reality games, medical applications to detect changes in the rate of heart pulse etc. resulting in a powerful source of radical innovation for the developing company. Future growth of a company can depend to a great extent on its ability to apply technology to develop new products and improve existing products, as well as to expand market applications for its existing products (Gjerde et al. 2002).

The ideas and insights of lead users can provide the starting point for ideation and help create new markets, products and services. Lead users become particularly important in a radical innovation context because very often the challenge is to find the things which no-one has yet noticed, or the markets which do not yet exist. Von Hippel (1986) was one of the pioneers of 'lead users' as a source of product development. His research explored how lead users can be systematically identified, and how their perceptions and preferences can be incorporated to identify emerging needs for new products, processes and services. Further research has also indicated the value lead users present to companies (Franke and Shah 2003, Herstatt and Von Hippel 1992, Lilien et al. 2002, Jeppesen and Molin 2003). Lilien et al. (2002) found that lead user projects had

significantly higher novelty, addressed more original customer needs, and also had significantly higher forecasted sales than other projects.

Development teams can work in tandem with customers in order to successfully establish the voice of the customer and translate that value into the product concept and proposed product solution (Cormican and O'Sullivan 2004). Increased customer involvement has been proven to improve the effectiveness of the development projects (Shepherd and Ahmed 2000, Leonard-Barton and Sensiper 1998, Griffin and Hauser 1996).

Rothwell (1992) identified a set of key factors underpinning successful innovation which includes; building a strong market orientation; emphasising user-needs; building customer linkages and involving users in the development process. Latent needs can exist that the customer and developers have not identified. Ahmed (1997) found that the companies best at innovation were those that had frequent interaction with customers. Rather than asking consumers and customers what they might like, researchers observe the everyday life of real people, capturing the experiences of people as and when they occur. Ahmed (1997) found that the best performing companies encouraged their engineers to make external visits in order to better understand market needs and use these insights to solve new customer problems.

Ethnography allow for deep insights into user needs, including those not clearly articulated (Bessant and Maher 2009). Customers are especially important for feedback to the firm on ideas for new innovation or improvements to existing innovations (Kumar et al. 2010). Of course research exists that counters' this view, over the short-term, the required orientation of business actions towards the wishes of customers may be entirely correct. However, in the medium- to long-term companies in the high-tech sector, in particular, run the risk of failing to notice relevant technological changes because customers cannot assess these or reject them at first glance(Rosenbusch et al. 2011) . Furthermore only gathering information on mainstream customers' needs and responding to such needs is detrimental to radical and disruptive innovations, whereas orientation towards small but emerging customer segments enhances the development of disruptive innovations (Yu and Hang 2010).

Barczak et al. (2009) found the best performing companies in their sample used techniques such as beta testing, customer site visits, voice of the customer and ethnography to gain a connection with their end user, more than the other worse performing companies in the sample. To be an effective innovator, a company must know their customers' customers and competitors as well as or better than their immediate customers (Bohlmann et al. 2012). Schmidt et al. (2007), and Hagberg-Andersson (2006) demonstrate that many companies only innovate in response to customer requests and are reluctant to exercise pro-activity. This lack of pro-activity can undermine customer loyalty and result in feelings of provider complacency (Beverland et al. 2004). Research shows the need for ongoing adaptation toward customers' requests (Mukherji and Francis 2008) and that proactive customer orientation is the most consistent driver of customer value (Blocker et al. 2011).

One source of ideas about possible innovation triggers is to imagine alternative futures, especially those which do not necessarily follow the current trajectory (Heinonen and Ruotsalainen 2013, Bessant and Stamm 2007). An effective way of creating and exploring such futures is through scenario-based approaches. Organisations have come to realise that while predicting possible futures is useful, they can also take action to help shape and influence emergent alternatives. These activities may involve building links with different sets of stakeholders and being a part of a future which co-evolves out of those interactions. Howard et al. (2002) found using scenarios to 'provoke innovation' and enable design engineers 'walk the imaginary line between current experience and expectations of the future'.

To summarise some of the keys issues to emerge from the literature are:

- The innovative use of existing/new technology to new markets (McDermott and O'Connor 2002, O Connor and Rice 2001, Gjerde et al. 2002).
- Identification of latent needs (Barczak et al. 2009, Blocker et al. 2011, Bessant and Maher 2009, Rothwell 1992, Ahmed 1997).
- Use of lead users (Von Hippel 1986, Franke and Shah 2003, Herstatt and Von Hippel 1992, Lilien et al. 2002, Jeppesen and Molin 2003, Yu and Hang 2010).
- Use of futures studies (Heinonen and Ruotsalainen 2013, Bessant and Von Stamm 2007, Howard et al. 2002).

- Deep diving/connecting with end consumers (Bohlmann 2012, Kumar 2010, Shepherd and Ahmed 2000, Leonard-Barton and Sensiper 1998, Griffin and Hauser 1996).

Managing radical idea generation

This subsection outlines some of the practices companies can engage in to increase their ability to manage and enable the ideation process.

Success in radical innovation is influenced by developing the capability to scan for signals about potential change and having a readiness to move into new areas and let go of old ones if required (Tidd et al. 2001). A willingness to cannibalise current products and markets in the pursuit of experimentation is often suggested as a means to facilitate radical innovation (Chandy and Tellis 1998, Cravens et al. 2002). The willingness of those responsible to abandon existing knowledge, collective experience and actual investments are a central determinant in the creation of radical innovations (Rosenbusch et al 2011).

O'Connor and DeMartino (2006) found many companies successful at innovation adopted an idea generator approach. The idea generators group were established with the mandate of overseeing the development of radical innovation projects. In addition to this the idea generators educated company members about the companies radical innovation mission and to assist appropriate skill development throughout the organisation by conducting workshops and ideation sessions (O'Connor and DeMartino 2006). Bessant and von Stamm (2007) also advocate idea generators (internal and external) to facilitate radical innovation ideation.

Barczak et al. (2009) found ‘creativity sessions’ was one of the techniques the best performing companies were using in their innovation efforts. The best firms in their sample also developed better project teams by using multiple organisational processes related to improving team effectiveness and cross functional cooperation.

The manner that the personnel charged with the task of innovation are organised can influence the success of product development. The use of cross-functional teams has been supported by extensive research (Cooper and Kleinschmidt 1995, Brown and Eisenhardt 1995, Page 1993, Griffin 1997, Cooper et al. 2004a). Members from different areas of expertise make different contributions to the development as well as fostering interdepartmental communication.

Working in tandem with the team initiative is the idea of innovation 'scouts/hunters'. The role of an innovation hunter is to search actively for new ideas to trigger the innovation process. It is the task of these idea hunters to recognise and anticipate connections between currently unconnected fields. O Connor and De Martino (2006) found successfully innovating companies were those who were sending internal staff members searching outside the firm for new ideas. Poolton and Barclay (1998) and Pitta and Franzak (1997) found the presence of a 'gatekeeper'; someone who scans the organisational boundaries and collects information and disperses it to those inside, is essential for successful product innovation. Furthermore market gatekeepers must possess competence in the application of technology to potential new markets (Burgelman 1983).

According to Rothwell (1992) a key factor underpinning successful radical innovation is a willingness to accept and adopt 'external' ideas. Identifying the opportunity represents only a step in the development process; the company actually accepting and being open to ideas (which may contradict the company's current direction) is an important factor. Research suggests managers should be active, not passive, in influencing innovation within their organisations (DeTienne and Koberg 2002). Organisations successful in radical innovation make themselves more hospitable people with different ideas (Leavy 2005).

Providing adequate resources to these ideas supports radical innovation. 3M, a company renowned for its innovation have interventions in place to facilitate radical innovation (Gundling and Porras 2000). A key intervention is having some 'slack' in resources to assist experimentation and learning. This slack enables 'bootleg innovation', where employees embark on covert action in which they decide to pursue their own innovation ideas. Bootleg innovation is of particular interest to companies for radical innovation as

it is a technological trial and error learning process with no management control to inhibit creative freedom (Augsdorfer 2005). Resent research suggests the encouragement and rewarding of 'skunkworks' groups and intrapreneurial ventures enables innovation (Brentani and Reid 2012). Slack resources, on an ongoing basis, without significant disruptions promote innovation (Judge et al. 1997). Access to abundant, high quality resources increases an organisation's chances of coping with change (Christensen and Overdorf 2000). Christensen (1997) suggests that radical innovation projects that obtain funding are more likely to succeed.

Employees are an important source of innovation thus having the systems in place to support their innovative function is extremely important. Companies need to have the systems in place to harness creativity, capture ideas and apply those to relevant problems and opportunities and ultimate convert them to successful, innovations. Employee suggestion systems are a means of facilitating the process of motivating employees to think creatively, share their creative thoughts and convert them in to innovative ideas (Fairbank and Williams 2001). Employees suggestion systems are characteristics of prospector type companies (Laforet 2009), those that are at the fore front of radical innovation (Miles and Snow 1978, 2003).

To summarise some of the keys issues to emerge from the literature are:

- The use of innovation 'scouts' (O'Connor and DeMartino 2006, Poolton and Barclay 1998, Pitta and Franzak 1997).
- Using 'idea generators' (O'Connor and DeMartino 2006, Bessant and von Stamm 2007, Barczak et al. 2009).
- Using an idea management system (Fairbank and Williams 2001, Laforet 2009).
- Creating 'active' teams (Aagaard and Gertsen 2011, Cooper and Kleinschmidt 1995, Brown and Eisenhardt 1995, Page 1993, Griffin 1997, Cooper et al. 2004a).
- Providing adequate resources (Brentani and Reid 2012, Gundling and Porras 2000, Judge et al. 1997, Christensen and Overdorf 2000, Christensen 1997).

People Management for radical innovation;

This subsection outlines some of the practices companies can engage in to more effectively manage the personnel charged with innovation search.

The hiring of appropriate people will facilitate the continuous challenging of the status quo (Leonard-Barton 1992). In 3M, a company renounced for its innovation, particular emphasis is placed on recruiting innovative people and supporting the innovation process (Gundling, 2000). Radical innovation will not happen without the right personnel in place so companies should carefully prescreen new hires based on individual characteristics (Brentani and Reid 2012).

Lateral relationships and a widening of task boundaries within organisations create an environment favorable to innovation (Brown and Eisenhardt 1997). 3M have a process of circulating people and ideas to encourage the transfer of knowledge. This works in conjunction with the allocation of time to experiment, thus facilitating idea gathering (Gundling, 2000). Intrafirm linkages are a positive predictor for incremental and radical innovation (Koberg et al. 2003). Radical innovation often involves synthesising and reusing existing knowledge and information. Access to this knowledge is a key barrier to success. Skills and knowledge that are created during the design and development process are often lost after the project is finished. Consequently, similar mistakes are repeated and companies spend scarce resources reinventing solutions that have been previously resolved. Many organisations face difficulties in transferring this knowledge and information from one organisational unit to another (Cormican and O'Sullivan 2004). Communication is a fundamental and basic requirement for product innovation particularly in the case of geographically distributed team members (Cormican and O'Sullivan 2004).

Communication between the people and departments involved in NPD effects product success (Keller 1986, Mossholder et al. 1998, Cooper and Kleinschmidt 1995). Voss et al. (1998) found the best small NPD performers were the ones who were ‘more open internally, paying attention to employee communication.’ Cooper and Kleinschmidt (1995) demonstrate that high quality development teams have frequent meetings for efficient decisions and co-ordination. Griffin and Hauser (1996) examined the impact of

communication, co-operation and inter-functional harmony and found that their usage strongly correlate with project success. Rothwell (1992) identifies internal and external communication as being one of the key factors underpinning successful innovation. Verworn (2009) demonstrated project success is dependant the quality of communication during the actual project execution which is positively affected by quality communication during the fuzzy front end.

McDermott and O'Connor (2002) suggest successful radical development teams rely on the existence of large informal networks of individuals both inside and outside the company, which can be utilised as required. These informal networks also help long-term survival of projects when budgets restrictions are in place (McDermott 1999). In large companies in particular the knowledge needed for development may be companywide. A system in place to enable quick communication between company experts enables innovation. A company having aligned and easy-to-use IT systems and networks is key for radical innovation (Aagaard and Gertsen 2011).

Ahmed (1997) found successfully innovating companies fuel innovation by building synergy between research and commercial development. Differing perspectives among functional departments are encouraged, with a view that the intellectual competition sharpens and improves the end product. Design and development teams are deliberately staffed with individuals from peripheral disciplines who are unfamiliar with the core products or technology under development. These types of measures are taken to ensure that projects are approached from different and innovative perspectives, and that conventional wisdom and 'status quo' is constantly challenged and tested. One key perceived advantage of bringing perspectives from a number of disciplines is that often it helps in making significant breakthroughs that would never have happened if research laboratories alone or functional divisions were simply aligned with individual business interests (Ahmed 1997).

To summarise some of the keys issues to emerge from the literature are:

- Internal communication (Cormican and O'Sullivan 2004, Griffin and Hauser 1996, Rothwell 1992, Verworn 2009);

- Internal networks of support (Ahmed 1997, Brown and Eisenhardt 1997, Koberg et al. 2003, McDermott and O'Connor 2002, McDermott 1999);
- Encouraging diversity (Ahmed 1997, Brentani and Reid 2012, Gundling, 2000, Leonard-Barton 1992).

Openness to external sources for radical innovation

This subsection outlines some of the practices companies can engage in to become more open to external sources of innovation.

Much innovation happens at the boundary between one knowledge set and another. The scope for transferring ideas from one sector/business to another is a powerful source of innovation. Companies should encourage boundary spanners to attend industry conferences and, occasionally, conferences that are tangential to their disciplines (Brentani and Reid 2012). Increasingly organisations are looking outside their normal knowledge zones, as they begin to pursue open innovation strategies. Radical innovation in particular needs external input and thrives on informal networks, both internal and external to the company (O'Connor and McDermott 2004). Mosey (2005) argues that cross-functional teams who can learn from external sources is especially important for a small companies facilitating radical innovation. Employees learn more during innovative projects; radical innovations can broaden an employees or a firms competencies (Zirger 1997). Learning capability has an indirect impact on business performance by facilitating innovation ambidexterity that in turn fosters business performance (Lin at al 2012).

Whilst organising and empowering internal teams and staff represents a powerful source of innovative ideas this can stretch existing resources. A helpful way to amplify the search capacity of a company is to make better or different use of the existing resources i.e. to mobilise the mainstream players in new or additional roles (Bessant and Stamm 2007). Pfeffer (1996) identifies the effective use of employees as a key factor in gaining competitive advantage and discusses the benefits of cross utilisation and multiskilling of employees. Innovation is influenced by organisation and attitude rather than nurturing

solitary genius (Hargadon and Sutton 2000) so mobilising the mainstream can be a useful method to increase search capacity.

The innovation process is knowledge intensive (Kanter 1988). Often the knowledge required for incremental innovation is local knowledge that can be sourced within the company (Jelinek and Schoonhaven 1991). Typically, radical development projects require more competencies and skills to realise a product concept than the available competencies and skills of the employees of the company (Verworn et al. 2008). For a radical innovation, much of the required knowledge will be new to the firm, and may result in the value of the previously accumulated R&D knowledge of the firm to be diminished (Hill and Rothaermel 2003). Companies should not limit themselves to their own industry in terms of learning potential. There are advantages in developing network positions that connect different technology areas (Elfring and Hulsink 2003, Hargadon 2003). A wider and more diverse search strategy moving across industry boundaries is capable of creating more opportunities (Helfat 1994, Katila 2002). Knowledge brokering is a key process for sustaining foresight and predicting future innovations by making connections between different industries or projects (Hargadon and Sutton 1997, Andriopoulos and Gotsi 2006). Bae and Chung (2001) advise firms to consider technological alliances, particularly when operating in competitive environments.

Companies are increasingly recognising the power of the internet as a platform for co-creating value with customers (Sawhney et al. 2005). As firms increasingly adopt open innovation, social media becomes critical to gather external ideas (Barczak 2012). The internet represents a hive of potential information for any company. It is a passive information resource and an additional space into which the firm sends its scouts to identify trends and trigger the innovation process. The internet also enhances the ability of companies to contact and engage their existing customers in the product innovation process (Dahan and Hauser 2002). The internet is an open, cost-effective and ubiquitous network (Afuah 2003). Internet platforms offer companies means to gain a very clear picture of customers needs at a much lower cost than through traditional market research (Rohrbeck et al. 2010). Creating virtual environments overcomes many barriers associated with more traditional forms of market research. The internet enables a continuous two way dialogue of interaction in which consumers have the opportunity to become active players in the innovation process (Sawhney et al. 2005). Virtual

environments also enhance the firm's capacity to tap into the social dimension of customer knowledge, by enabling the creation of virtual communities of consumption (Kozinets 1999). Mechanisms that are useful at the early stages of the NPD process include suggestion boxes (see Figure 2.10) where customers can contribute their own innovative ideas (Sawhney et al. 2005). Information technology use throughout NPD process , including the front end, has a positive long-term impact on the performance of new products (Barczak et al. 2007).

Incentives for contributors can also be added and have been found to improve collaborative idea generation (Toubia 2006). Bessant and Stamm (2007) cite case examples regarding internet usage for radical innovation e.g. using the web as a multi-directional information marketplace like Eli Lilly's 'www.innocentive.com' connecting those with scientific problems with those being able to offer solutions. The best firms gather information during the fuzzy front end by using discussion forums, blogs, branded social network, innovation hubs, wikis etc significantly more than the other companies (Markham and Lee 2013).

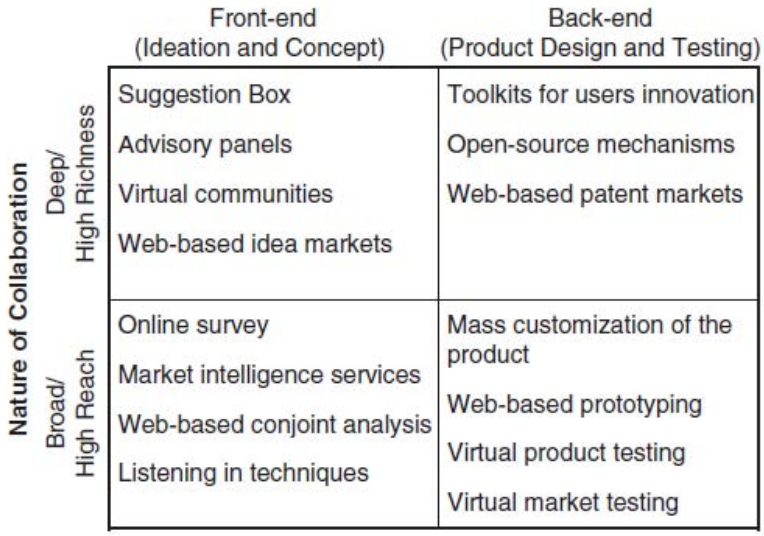


Figure 2.10 Internet based collaborations based on nature of collaboration and stage of NPD process (Sawhney et al. 2005)

Collaboration is the basis for bringing together knowledge, experience and skills from multiple external sources to contribute to the development of a new product more effectively than individual team members performing alone. Many companies have reorganised, outsourced and shifted their knowledge creation and capture activities, including R&D, into alliances that span across a wide range of different organisations.

Chesbrough (2003) refers to this process as the shift from ‘closed’ to ‘open’ innovation. These new models of ‘open’ innovation provide firms with the opportunity to draw in expertise and experience from outside the organisation (Christensen and Maskell 2003). Research by Chiang and Hung (2010) suggests that ‘open search breadth’ i.e. search that utilises many external channels from which the innovating company accesses knowledge is positively related to radical innovation performance. Huiznigh (2011) predicts that open innovation will become fully integrated in innovation management practice rather than a separate topic. Too much search openness at the ideation stage can also be detrimental to new product outcomes. More specifically, they reveal that explorative NPD projects have more to gain from search openness at the ideation stage than their exploitative counterpart (Salge et al. 2013).

Firms adopting a science-driven or supplier-driven knowledge search have a good chance to create new-to-market innovations (Köhler et al. 2012). Many countries have recognised the potential and have made great efforts to enhance the collaboration between industry and academia (Etzkowitz and Leydesdorff 2000). Guan (2005) found that the higher the level of collaboration with universities and research institutes the more novel resultant technologies were. According to Rothwell (1992) establishing effective linkages with external institutions and bodies of technical know-how is a key factor underpinning successful innovation. Formal links with suppliers are very important to the product innovation process (Griffin and Hauser 1996). Huang and Mak (2000) found that significant benefits can be achieved if suppliers are involved in the early stages of the product innovation process. Increasing the diversity of a firm’s innovation partners and respective innovation stimuli, in turn, improves the capability of firms to identify more advanced innovations. Research has shown that collaboration with non-business systems are more important than the customers of an company for the introduction of products which are new to the market (Kaufmann and Tödtling 2001).

Barczak et al. (2009) found that given the complexity of radical projects, more than 50% of such projects involve collaboration with partner organisations. They also found that when the best performing companies in the sample collaborate, they are more likely to put in place formal mechanisms that both support the joint endeavor and increase its probability of success such as having interlocking concurrent development processes;

using shared websites/groupware and having both formal sub-contract and technology licensing agreements in place.

To summarise some of the keys issues to emerge from the literature are:

- Open innovation (O'Connor and McDermott 2004, Mosey 2005, Bae and Chung 2001, Chesbrough 2003, Christensen and Maskell 2003, Chiang and Hung 2010, Huiznigh 2011, Köhler et al. 2012, Barczak et al. 2009, Salge 2013).
- Collaboration with unusual partners areas (Kaufmann and Tödtling 2001, Elfring and Hulsink 2003, Hargadon 2003, Helfat 1994, Katila 2002, Hargadon and Sutton 1997, Andriopoulos and Gotsi 2006).
- Using online initiatives (Sawhney et al. 2005, Dahan and Hauser 2002, Afuah 2003, Kozinets 1999, Bessant and Stamm 2007, Markham 2013, Rohrbeck 2010, Barczak 2012).
- Mobilising 'main stream' staff (Bessant and Stamm 2007, Pfeffer 1996).

2.4.4 Categorising Radical Search Best Practice

In this relatively new area of research attempts have been recently made to map the factors underlying the fuzzy front end. Whilst research is relatively scarce regarding the underlying selection factors research has been completed on the search phase (Aloini et al 2013, Ledwith et al 2012). The research these papers are based upon was largely conducted in Italy and focuses on the practices and techniques that can be used at the front end of innovation to search for radical or discontinuous new product ideas with the end goal being the identification of underlying factors that represent the dimensions of searching for radical new ideas. The practices this research focuses on reflects the previously presented literature review on radical search best practices.

The Ledwith et al. (2012) paper focuses on practices to enable internal and external search and creativity. Aloini et al (2013) research focus on practices around four key search areas of:

1. Customers and users
2. External collaboration
3. Employees and culture
4. Market and idea management

They also map the 12 identified search strategies (Bessant and Von Stamm 2007) onto these key areas. The four key search areas identified by Aloini et al (2013) map closely align with the four categories under which search best practice was discussed in the previous section confirming the breath and validity of the literature review.

Both Ledwith et al (2012) and Aloini et al (2013) identified 5 underlying search factors characterising search practice as follows:

1. Internal networking
2. Market awareness
3. Idea management
4. Open environment
5. Connecting with customers/Listening to customers.

While these papers have attempted to characterise and model the underlying factors at the front end of radical innovation, the identified factors impact on innovation performance is ignored. This research will therefore extend the previously published research in identifying and clarifying the underlying factors but also assessing their utility for improved innovation performance. While the identification of the underlying factors controlling the fuzzy front end of the radical innovation process is a valuable contribution, the consideration and assessment of their utility in controlling innovation performance would represent a significant contribution to innovation management knowledge.

2.4.5 Section Summary

This section discussed the search aspect of the fuzzy front end of innovation. Two dimensions of search behaviour were discussed in detail:

1. Exploitation i.e. incremental innovation;
2. Exploration i.e. radical innovation.

The problems incumbent companies' experiences, when attempting to balance between exploitation and exploration activities were discussed. Finally search practices were discussed in relation to previous literature identified as having the potential to increase radical innovation search capacity.

2.5. THE FUZZY FRONT END: RADICAL SELECTION

2.5.1 Introduction

The following sections discuss the selection aspect of the fuzzy front end of innovation. Project selection is discussed in relation to radical innovation and also the typical selection behaviour that companies exhibit when attempting to avoid selecting radical innovations is discussed. Problems established companies face when selecting radical innovations are identified, in particular having selection systems which are 'too effective'. Finally innovation selection practices are discussed in relation to previous literature identified as having the potential to increase radical innovation selection capacity.

2.5.2 Project Selection

The selection of new ideas is not as simple as selecting a portfolio of projects with varying degrees of risk. The process involves choosing from all the potential innovation directions a company can take. These decisions with regard to radical innovation may have serious implications for a company as they can determine the direction the company intends to move in the medium to long-term (Chandy et al. 2003). If a company does not have a method of managing this selection process then this carries a high risk of failure particularly in multi-project firms (Cooper 2001). Managers must understand that managing strategic planning and generating NPD project ideas are beneficial to the ultimate outcome of firm performance (Song et al. 2011).

When the innovation decision relates to incremental innovation, there is relatively little difficulty. Existing selection tools are very effective in terms of risk control for companies (Bessant et al. 2010). Over the course of development each innovation will face constant evaluation. Each evaluation represents a selection decision: whether or not to continue to devote resources to the project or to terminate. The aim of selection is to effectively terminate projects that are risky thus limiting the company exposure to expensive failures. The caveat to this effective protection is that these selection systems also limited the company from radical innovation and the massive growth potential that may arise if successful. Management practices that are effective in established

businesses are often ineffective and even destructive when applied to radical innovation projects because of higher levels of uncertainty inherent in the latter (O'Connor and Rice 2013). More flexible strategic plans that accommodate improvisation may be needed in NPD management since innovation activities cannot be planned precisely due to the unexpected jolts and contingencies of the NPD process (Song et al 2011).
Existing techniques for project selection and portfolio management include;

- Decision rules and criteria (Kahraman et al. 2007);
- Portfolio techniques (Cooper et al. 2002b, Cooper and Edgett 2010);
- Stage gate review systems (Cooper 2008);
- Fuzzy front end tools for early stage selection (Koen et al. 2001);
- Fast track routines for small projects (Cooper 2008).

Radical Product Selection

The above tools are very useful when dealing with incremental innovation. Many of them rely on detailed information (for example sales and supply chain forecasts.) for project progression. When dealing with incremental innovation this information is readily available. A business case can be assembled for an innovation and the real and achievable benefits to the company can be argued. However, Cooper (2011) found that companies that focus on financial returns underperform firms with a balanced approach to portfolio management. As the innovations move towards the radical end of the spectrum financial information is often not available or reliable and cultural and political company influences on selection decisions increase in importance (Bessant et al. 2010). Decisions must frequently be made with-out having all relevant information at hand, this idea assessment is a necessary step in the innovation process; however, it is accompanied by a high degree of uncertainty (Verworn 2009).

There are a large number of reasons that companies can use to justify the rejection of radical ideas that are perceived to be of little benefit to the organisation (Table 2.1).

Table 2.1 Justification for non-adoption radical ideas (adapted Bessant et al. 2010)

Argument	Explanation
'It's not our business'	Recognition of an interesting new business idea but rejection because it lies far from the core competence of the firm.
'It's not big enough for us'	Emergent market size is too small to meet growth targets of large established firm.
'Not invented here'	Recognition of interesting idea with potential but reject it – often by finding flaws or mismatch to current internal trajectories.
'We're not cannibals'	Recognition of potential for impact on current markets and reluctance to adopt potential competing idea.
Existing customers don't want it'	New idea offers little to interest or attract current customers – essentially a different value proposition.
'We've never done it before'	Perception that risks involved are too high along market and technical dimensions.
'We're doing OK as we are'	The success trap – lack of motivation or organisational slack to allow exploration outside of current lines.

As the options move towards the more radical end, the degree of resource commitment and risk rises, and decision making becomes more difficult. Previously mentioned decision rules and criteria, portfolio techniques, stage gate review systems (Kahraman et al. 2007, Cooper et al. 2002b, Cooper and Edgett 2010, Koen et al. 2001) are of little use in a rigid sense, as these systems require information which can be a scarce commodity in the early stages of a radical project e.g. during the fuzzy front of a radical projects it is significantly more difficult to estimate the market size and the price sensitivity of the potential customers (Verworn et al. 2008). If the information is unavailable these systems seem to be inappropriate for selecting a portfolio of R&D projects, as they favour short term projects in relatively certain markets over long term projects in relatively uncertain markets (Carlsson et al. 2007).

Selection Problems

The problem is not that established firms have weak or ineffective selection systems but rather that these are too effective; rejecting ideas that lie too far outside the normal scope of their business as they are not consistent with the decision rules and criteria associated with the framework e.g Polaroid's difficulty in adapting to digital photography when employees were discouraged from development efforts that were not consistent with the traditional business model (Tripsas and Gavetti 2000). Their selection system was not flexible enough to consider certain radical developments.

So firms need to find ways of progressing innovation decisions in such a fashion that they extend an open minded exploration further into the decision chain. The problem is complicated by the potential for radical innovation options to conflict with mainstream projects (for example risking 'cannibalisation' of existing and currently profitable markets) and the need to acquire different resources to those normally available to the firm. To summarise the two major challenges that a company faces when attempting to select radical innovations for further development can be identified as;

1. **Overcoming the existing selection systems and company culture/political influences:**

   Existing selection systems rely on information in order to make selection decisions. If this information is not readily available the embedded selection system rejects innovations which are 'foreign' to the company. Coupled with a prevailing company culture of avoiding risk this represents a major challenge. The company may simply not be interested in certain ideas/innovations due to pre-formed misconceptions and beliefs. The organisational culture and adherence to process following found in firms tends to push efforts towards low risk incremental innovation (Dougherty and Heller, 1994, Koberg et al. 2003). Alternately companies may choose to selectively perceive and interpret the new situation to match or fit their established world views and have trouble adapting and accepting new innovations (Tripsas and Gavetti 2000, Hodgkinson and Sparrow 2002, White and Bessant 2006).

2. **Reducing risk which is inherently high:**

   Due to the nature of radical innovation risk for the company is naturally high. Radical innovation has the highest level of uncertainty during the fuzzy front end (Brentani and Reid 2012). Radical innovation activity will take the company outside of its current areas of competencies in previously uncharted territory. Internal pressures often push innovation efforts toward low risk, immediate reward incremental projects (McDermott and O'Connor 2002). Consequently, reducing project risk is a key issue when deciding which radical innovation to pursue (Turner 2005, McDermott 1999). The decision of which direct to pursue is crucial as in effect the company is mapping out the medium to long-term incremental innovation over the following years (Chandy et al. 2003, Terziovski

2002). Firms have an opportunity to reduce the uncertainties that radical innovation project teams must confront by developing new project management competencies and corporate level organisational structures and processes that can support radical innovation activity (Leifer et al. 2001, O'Connor et al. 2008, O'Connor and Rice 2013).

2.5.3 Categorising Radical Selection Best Practice

By its nature radical innovation involves working with different knowledge components – new technologies, new markets etc. and firms need to develop enhanced absorptive capacity for handling this (Fosfuri and Tribó 2008). Selection relates to companies using practices that enable companies to be open to change and select new innovation/projects that have the potential to take the company into new territory and become 'game changers' if developed fully. From the literature different approaches can be identified which may be linked with increased success when looking to select ideas for potential radical innovation.

When categorising selection practice, a choice must be made regarding the breakdown categories. Similar to search practice it is impossible to identify an exact process that can be followed when selecting for radical innovation as rigid processes inhibit radical innovation creativity. As an alternative three key areas are selected to generally categorise radical selection practice. While they do not form a linear process they are broad enough to encapsulate most potential selection practices. Given the broad nature of the categories there is room for overlap between them and in some cases a best practice could be discussed under several of the categories. However, the aim of the categories is to provide some structure for the literature on selection best practice rather than to provide mutually exclusive groups. The three categories that have been identified are;

1. Supporting early decision making;
2. Culture support system for radical innovation;
3. Measuring Progress for Radical innovation.

The following sections discuss selection best practice across these 3 categories.

Supporting early decision making

This subsection outlines some of the practices companies can engage in to increase their ability to identify radical products early in their development phase.

Innovation by its nature represents a turbulent and changeable environment. In line with this companies need to be flexible to adapt to change. Sharfman and Dean Jr. (1997) note that organisations who intend to survive and have ambitions to flourish and grow in the future require managers capable of overcoming barriers and 'practising flexibility in their strategic choices' and be particularly wary of 'rigidity in their decision processes'. Strategic agility is a keystone to having the ability to transform and renew business models (Doz and Kosonen 2010). Companies that fail to make flexible strategic choices may enter into organisational decline which is the failure to adapt or change to fit with the changing external environment (Weitzel and Jonsson 1989, Christensen 1997). Decision process characterised by openness to novel alternatives, information sources and roles are more like to produce the types of innovative decisions that facilitate organisational adaption (Sharfman and Dean Jr 1997). Managers seeking innovation and new product success need to be responsive to the environmental contexts and to allocate resources to pursue the effective strategic orientations for the specific context (Yang et al 2012).

The concept of a value chain has assumed a dominant position in the strategic analysis of many industries. Many companies assume they occupy a particular position in the value chain and have problems adjusting to a turbulent environment. By adopting a value network perspective where managers recognise they are part of a network or ecosystem and their position can change rapidly enables companies to exploit their position (Peppard and Rylander 2006). Companies should be flexible in their project choice. In turbulent market environments the system of companies is constantly changing so a company need to be open to change and be able to adapt accordingly. Strategic flexibility helps firms with superior technology sustain their exploration (Zhou and Wu 2010) and achieve sustained innovation performance (Kekale et al. 2010). Strategic flexibility promotes the flexible use and coordination of resources to support various technologies and products and thereby enables firms to move readily to new platforms and alleviate lock-in effects (Matthyssens et al. 2005). A flexible organic

structure will play a role in shaping and communicating strategies, and promoting curiosity and seeking behaviour in employees (Davila et al. 2005).

Loosening control is necessary for radical innovation (Ekvall 1996, Tushman and O'Reilly 1996). Companies should be comfortable to enter new markets, consider new business models and new opportunities and be comfortable with letting go of old systems. Entering newer markets can be done in low risk methods. Research shows that high performing innovation companies frequently use small pilot studies conducted by early adopters (Delbecq and Mills 1985). Brown and Eisenhardt (1998) demonstrate that successful innovators are those who are able to improvise and experiment. This experimentation and freedom to experiment is a positive predictor of radical innovation (Koberg et al. 2003). Fundamentally, 'probe and learn' reduces the risks associated with radical innovation into smaller steps with more limited exposure, rather than forcing a single large commitment. This 'buying a look' helps assemble the beginnings of a case for further support and exploration (Cooper et al. 2001, Bessant et al. 2010).

Companies and managers that are risk averse will inhibit radical innovation (Ekvall 1996, Harborne and Johne 2003, Simon et al. 2003). Learning from mistakes is a part of the development process and aids the development of both individual and group skills and experiences (Chatman and Cha 2003, Andriopoulos and Gotsi 2002). Customers can become part of the iterative, prototyping process by companies deepening their major customer relationships and engaging them by engaging them in beta testing programmes for product releases (Hughes and Cosier 2001). Radical innovation is an uncertain process fraught with risk. Prototyping as a probe and learn approach allows companies to reduce risk when deciding which direction to pursue. Verworn et al. (2008) found prototyping during the fuzzy front end enhances top management support and reduces technical and market uncertainty. Valid, earlier customer input on the applications gives firms more confidence in their market prospects (Hende and Schoormans 2012).

Prototyping is going beyond the simplistic and has become far more than a vehicle for exploring user or customer preferences. Prototyping is useful as a demonstration tool—to build bridges in the minds of potential supporters; creating stepping stones that allow people to better understand and shape the idea when it is still in its formative stages

(Bessant et al. 2010). Senior management encouraging early prototyping and being close to the process and exposed to the prototypes at an early stage is a significant index of the company's overall inclination to innovate (Hughes and Cosier 2001). Ulrich and Eppinger (2008) describe the importance of prototyping as a communication and demonstration tool.

It can be difficult to imagine a radically different future. Probing – and learning from the results, even if they represent a failure increases available information regarding what does and doesn't work and so in turn helps build the case for selection (or rejection) or further support and exploration (Bessant et al. 2010). This way, emergent trends, potential designs, etc. can be explored and refined in a continuing learning process. Prototyping as an exploration tool often leads to unforeseen connections being made (Hughes and Cosier 2001).

To summarise some of the keys issues to emerge from the literature are:

- Level of openness to change (Sharfman and Dean Jr. 1997, Weitzel and Jonsson 1989, Christensen 1997, Ekvall 1996, Tushman and O'Reilly 1996, Yang wt al 2012).
- Flexibility in selection (Peppard and Rylander 2006, Zhou and Wu 2010, Matthyssens et al. 2005).
- Prototyping to explore (Bessant et al. 2010, Hughes and Cosier 2001, Koberg et al. 2003, Delbecq and Mills 1985, Brown and Eisenhardt 1998, Hende and Schoormans 2012).

Culture support system for radical innovation

This subsection outlines some of the practices companies can engage into to create a culture conducive to radical innovation project selection.

Visible top-level management support is a factor that is vital for project selection (Brown and Eisenhardt 1995, Cooper and Kleinschmidt 1995, Cooper et al. 2004a, Felekoglu and Moultrie 2014). Brown and Eisenhardt (1995) consider that success is possible only 'with the blessing of senior management.' Cooper and Kleinschmidt (1995) recognised the importance of top-level support and according to their research

success will result if senior management is strongly and visibly committed to the development of new products and devote the necessary resources.

Radical innovations require time to gather the required learning before moving forward. It is important to be culturally receptive to new information and ideas or what Cohen and Levinthal (1990) called having 'an absorptive capacity'**.** Rushing innovation and aiming for shorter development times can lead to higher or lower development costs, for example, and to lower-quality products (Kessler and Chakrabarti 1996). Simultaneously, the faster a firm can develop a new product, the greater the likelihood that it can be the first to market a product and reap 'pioneering' advantages (VanderWerf and Mahon 1997, Kalyanaram et al. 1995). The other side of the coin is that when the pioneer starts a new market with a really new product, it can be a major challenge just to survive (Min et al. 2006).

Hickman and Raia (2002) argue that innovation thrives on disorder, imagination and ambiguity. Tang (1998) suggests that 'innovation thrives on challenge. People are the source of the creativity and individual creativity leads to group creativity which can manifest itself in innovations in the appropriate environment (Kanter 2000, Woodman et al. 1993). An appropriate organisational culture will facilitate this creativity (Tesluk et al. 1997) and the organisation members should be able to operate in a relatively unstructured, open and fluid environment (Amabile et al. 2002).

One of the biggest problems in selecting and carrying out radical innovation in established firms is that they lack individuals with entrepreneurial spirit (Birkinshaw et al. 2007). Innovation must be embraced by the entire organisation by treating innovation as a corporate wide task (Rothwell 1992). Treating innovation as a corporate wide task results in a constant focus on ensuring that innovation is given high priority in day-to-day operations throughout organisations, rather than left as an ad-hoc activity (Ahmed 1997). Johannessen et al. (1999) noted that most innovative organisations are those which are; proactive, risk taking; commitment, and open to change.

Creating a culture of risk-taking within the company should result in more innovative ideas bank to select from. Organic flexible innovative cultures also help in ensuring that ideas flow readily through the organisation (Rosenfeld and Servo 1990). Organisation

cultures that facilitate radical innovation tend to be tolerant of risk taking (Claver et al. 1998). Cooper et al. (2004a) recognised having an innovative climate as one of the important drivers of successful product development. Veryzer (1998) refers to radical innovation as being inherently messy and fraught with uncertainty. Leifer et al. (2001) found that successful radical innovation projects involved people with risk taking propensity, drive, and out-of-the-box thinking. Cooper et al. (2004a) conducted research within certain best practices such as culture and climate and found within the culture aspect of NPD having a supportive, risk averseness climate was conducive to innovation and product development. An informal, open, and inquiring environment that values experimentation, with leaders promoting innovation by creating a shared belief that team members are safe to take interpersonal risks will facilitate radical innovation (Claver et al. 1998, Harborne and Johne 2003, Gudmundson et al. 2003). Encouraging risk taking in selection decisions may uncover new unforeseen connections or potential avenues of innovation.

During the front end of the radical innovation process ideas are not well developed; the usual process for resource allocation and selection decisions are sometimes not suitable. A strategy for dealing with this is to make use of different mechanisms or processes to protect the development. This may be removing the development from the main business or using a third party consultant as a short term environment to allow the idea to grow (Bessant et al. 2010). In a similar vein Leifer et al. (2001) specify the need for innovation 'hubs' that can 'oversee and help nurture projects by reducing uncertainty without increasing bureaucracy'. These types of organisational arrangements are critical and not only protect radical innovation from the company's current business units but result in radical innovation becoming a standalone activity rather than a haphazard and ad hoc activity.

Cooper et al. (2004a) research found the best performing companies were supportive of innovation and had no punishment for failure. Learning from mistakes is a part of the development process and aids the development of both individual and group skills and experiences (Chatman and Cha 2003, Andriopoulos and Gotsi 2002). The learning gained from one development project to the next and the ability to select the appropriate processes for each development type is necessary for the sustained production of new-to-market products (Mosey 2005). Failure must be accepted as part of the innovation

process. Should a radical project be allowed to progress and ultimate end in failure it should not act as a deterrent to future radical project selection.

Much of the literature around radical innovation and the fuzzy front end identifies the roles of various players such as the ‘champion’ and the ‘sponsor’ (Markham 2013). These individuals are important in overcoming existing selection systems and driving radical innovation as a company objective, particularly if they occupy senior management positions. In managing the people side of radical innovation, one of the leadership roles that facilitates innovation is that of a sponsor (McDermott and O'Connor 2002, Dougherty and Heller 1994). Key to the selection phase is developing methods of engaging sponsors in a planned fashion rather than hoping for their emergence (Markham et al. 2010, Bessant et al. 2010).

The presence of a champion on a project team is an asset and important factor leading to project success (Chakrabarti 1974, Cooper and Kleinschmidt 1995, Howell and Sheab 2001, Howell and Boies 2004). Bessant et al. (2010) see the challenge as building champions into the decision-making process, rather than hoping that they will emerge. This may be done by making formal links with senior managers whose remit is to be a sponsor for innovation projects. Radical innovations need careful attention from senior management. Having project champions in senior positions to promote innovation increases the chances of radical iinoivations being selected for development.

Resources within any company are limited. Radical innovation can be an expensive process so rather than drawing from the mainstream R&D budget, which is vital for the day to day innovation research, sometimes alternative funding structures are more appropriate. Rice et al. (2000) found that funding for radical innovation projects in the engineering industry originated from both internal and external sources and whilst it was impossible to formulate hard and fast rules some funding mechanisms appeared to be more effective than others. Funding options can include the conventional R&D budget, a special budget for radical innovation or external partnering with another company or knowledge institution. O'Connor and DeMartino (2006) studied a company which successfully adopted a corporate venturing model.

Providing adequate resources will support radical innovation. A firm's abundant resources, when allocated and deployed for NPD activities, signal the high priority and importance of the NPD activities and thus motivate employees to acquire, collect, and gather customer and technical knowledge, which leads to creating more NPD projects (Song et al 2011). 3M, for example, uses various interventions to facilitate radical innovation (Gundling and Porras 2000). Markham (2013) notes front end success is predicted by having resources available during the early formative stages. Having some slack resources, on an ongoing basis, without significant disruptions or discontinuities promotes innovation (Judge et al. 1997). Access to abundant, high quality resources increases an organisation's chances of coping with change (Christensen and Overdorf 2000). Rothwell (1992) noted the importance of making up-front commitment of resources to screening projects for their successful development. Formally funded front-end activities is becoming the dominant method for managing early stage ideas (Markham and Lee 2013).

To summarise some of the keys issues to emerge from the literature are:

- Visible management support (Brown and Eisenhardt 1995, Cooper and Kleinschmidt 1995, Cooper et al. 2004a, Song et al 2011),
- Senior project champions (McDermott and O'Connor 2002, Dougherty and Heller 1994, Bessant et al. 2010, Markham 2013, Markham et al. 2010).
- Risk taking encouraged (Tesluk et al. 1997, Amabile et al. 2002, Rothwell 1992, Johannessen et al. 1999, Leifer et al. 2001).
- Provision of funding (Rice et al. 2000, Gundling and Porras 2000, Markham 2013, O'Connor and DeMartino 2006, Christensen and Overdorf 2000).
- Protection from parent organisation (Bessant et al. 2010, Leifer et al. 2001).

Measuring Progress for Radical innovation

This subsection outlines some of the practices companies can engage in to assist their effective measurement of project progress for radical projects.

Due to their proactive nature, R&D projects can be difficult to evaluate. Many ideas are still too embryonic to permit evaluation of their future potential (Möller 2010). The information required for evaluation is typically revealed gradually during the

development of the project. Consequently when the opportunity is first identified there are no cash flow estimates available or similar information available that would either justify or invalidate the decision to proceed with the project (Carlsson et al. 2007). For incoming information related to potentially radical or discontinuous projects research suggests that a company use more flexible decision rules. (Brentani and Reid 2012). Within any selection system there is a need for measurement criteria and the general acceptance of these criteria as a basis on which to take selection decisions. Under conditions of high uncertainty normal criteria may not be relevant or only partially effective. When making decisions relating to radical innovations the decision criteria, for example at a stage-gate review, may be too strict and not applicable to the innovation. Alternative review criteria may be utilised as 'learning loops' revealing what is required to be explored further rather than as 'go/no-go' decisions at stage gates (Bessant et al. 2010). These loops can also be linked to resource allocation and have the advantage of allowing further exploration to proceed despite not meeting the typical measurement criteria. Flexibility is key to evaluation. It is very difficult to have a 'standard' set of measurement criteria (Nicholas et al. 2011).

Research suggests that managers should not only pay attention to the immediate product attractiveness with the new concept, but they should also see longer term strategic opportunities when evaluating the ideas and concepts (Martinsuo and Poskela 2011). The systems for idea and concept evaluation need to include evaluation criteria that promote the strategic opportunity that the new product concept can offer, and not only shorter term innovation performance measures (Martinsuo and Poskela 2011).

No two radical innovation projects are identical (Leifer et al. 2000). Radical innovation projects need time to mature before they can move forward. The Product Development and Management Association (PDMA) best practice study (Barczak et al. 2009) revealed new to the world innovations are completed in on average 104 weeks and also on research by Leifer et al. (2000) whose research demonstrates that radical innovation can take up 10 years to complete. Radical innovation therefore need support and nurturing from senior management to allow them develop and should be assessed on longer timescales that continuous innovations. The overall innovation strategy must allow for long term developments (Cooper et al. 2004b).

Due to the longer timelines involved alternate funding arrangement are required than for incremental type innovations (Leifer et al. 2001). Indeed often due to a change in potential funding sources managers may be required to reorient their projects to suit whoever holds the purse strings. The alternate funding arrangements can include external venture capital funds (Kortum and Lerner 2000), internal corporate venturing funds (Rice et al. 2000) or funding collaborations (Czarnitzki et al. 2007). Ensuring adequate resources are available makes an organisation more hospitable to radical innovation and increases chances of project selection.

A radical innovation development may span many years so a project can expect to see its developers and funding sources change several times over that time period. Project leaders must approach a variety of potential funding sources and even reorient their projects to suit whoever in charge of resource allocation (Leifer et al. 2001). Companies may allocate a specific part of their budget exclusively to pursue radical type innovations (Lettice and Thomond 2008). At the time of financial turbulence and stringency, it may be even more difficult to fund higher risk breakthrough opportunities and ideas, unless a specific budget has been ring-fenced (He et al.).

To summarise some of the keys issues to emerge from the literature are:

- Use of alternative measurement criteria (Brentani and Reid 2012, Möller 2010, Carlsson et al. 2007, Bessant et al. 2010, Nicholas et al. 2011).
- Longer timelines of measurement (Martinsuo and Poskela 2011, Cooper et al. 2004b).
- Link funding to timeline (Leifer et al. 2001, Kortum and Lerner 2000, Rice et al. 2000, Czarnitzki et al. 2007).

2.5.4 Section Summary

This section discussed the selection aspect of the fuzzy front end of innovation. Existing systems for selecting projects were discussed in relation to radical innovation and also the typical selection behaviour companies' exhibit when attempting to avoid selecting radical innovations was explained. The concept of companies facing various obstacles when selecting radical innovations, in particular having systems which are 'too effective' at project selection is explored. Finally a selection of innovation selection

practices were discussed that previous literature identified as having the potential to increase radical innovation selection capacity.

2.6 EMERGENT RESEARCH QUESTIONS

From the literature presented and discussed it is clear that the early stage of the radical development process offers much opportunity for a company to influence final project success.

The primary research question to be answered is:

'What are the key success factors in managing the front end of radical innovation?'

This research question can be extended through the review of existing literature in the area of radical innovation management. Research has shown that the continual introduction of 'new to market' innovations represents a route to survival and growth for large and small firms alike (Storey 1994, Cooper 1993, Bessant et al. 2004, Mosey et al. 2002, Leifer et al. 2000, Christensen and Raynor 2003), however, much confusion still exists around best practice in the area (McDermott 1999). Indeed there is little research focusing on how to develop organisational capabilities to turn organisational inertia to radical innovation into core capabilities to sustain radical innovation (Chang et al. 2012). The early stages of radical innovation process, the fuzzy front end, is particularly crucial (Reid and De Brentani 2004). What can a company do during this early stage of the process to increase their chances of final success?

To answer the primary research question a number of sub questions can be identified. Given that this research is examining both the search and selection phases of radical innovation then each sub questions consists of two questions; one addressing search and the second addressing selection. The following summary outlines each sub question to be answered.

A large number of potential best practices have been identified from the literature that may have impact on radical innovation search and selection (Barczak et al. 2009, Bessant et al. 2010, Bessant and von Stamm 2007, Cormican and O'Sullivan 2004, Leifer et al. 2001, Lilien et al. 2002, McDermott and O'Connor 2002, Markham 2013, O'Connor and DeMartino 2006). Given that innovation performance in Ireland is in

need of improvement to maintain competitiveness (Community Innovation Surveys 2004-2006, 2006-2008, The European Innovation Score Card 2009, 2010, 2011) the question arises as to what practices companies in Ireland are currently using. The assessment of the current state of practice within companies in Ireland i.e. the identification of current usage or non-usage of the identified best practice for radical search and selection is key to answering the primary research question.

> *R1a: What practices do companies currently use when **searching** for new ideas during the front end of the radical innovation process?*
>
> *R1b: What practices do companies currently use when **selecting** new ideas during the front end of the radical innovation process?*

The previous questions investigated which practices are used most often by companies. It is important to link the different practices with successful radical innovation; a benchmarking of radical innovation practice to identify gaps in practice usage between the best performing organisations and the rest of the companies. This can be investigated using the two performance measures identified in Section 2.2.4; the number of radical innovations released and market position.

> *R2a: Which **search** practices are linked with increased numbers of radical innovations?*
>
> *R2b: Which **selection** practices are linked with increased numbers of radical innovations?*
>
> *R3a: Which **search** practices are linked with more dominant market positions?*
>
> *R3b: Which **selection** practices are linked with more dominant market positions?*

Given the importance of SMEs in the Irish economy and the differences that exist between SME and large companies (Ghobadian and Gallear 1997; Gray and Mabey 2005, Ledwith 2000, Tidd and Bessant 2009); then the identification of variation of practices in SME and large companies would give insight into improving current practice.

> *R4a: What is the impact of company size on the use of **search** practices for radical innovation?*
>
> *R4b: What is the impact of company size on the use of **selection** practices for radical innovation?*

Having identified through the literature a large number of best practices for radical innovation search and selection it would be expected that some of the practices would be closely related. A single practice is not likely to be of vital importance for success but rather groups of practices that collectively and cumulatively impact innovation (Dooley et al. 2002). The identification of factors to clarify practice in this emergent topic is crucial for the answering of the primary research question.

> *R5a: What are the underlying factors that can be used to categorise radical **search** practices?*
>
> *R5b: What are the underlying factors that can be used to categorise radical **selection** practices?*

Having identified if there are underlying factors comprising of individual practices characterising radical search and selection it is important to link the factors with successful radical innovation. This can be investigated using the two performance measures identified in Section 2.2.4; the number of radical innovations released and market position.

> *R6a: Which of the identified **search** factors are linked with increased numbers of radical innovations?*
>
> *R6b: Which of the identified **selection** factors are linked with increased numbers of radical innovations?*
>
> *R7a: Which of the identified **search** factors are linked with more dominant market positions?*
>
> *R7b: Which of the identified **selection** factors are linked with more dominant market positions?*

The research question is visually demonstrated in Figures 2.11 and 2.12. A separate model is presented to examine the search and selection phases of radical innovation. The model is split across three levels depicting best practices, underlying factors and radical innovation success.

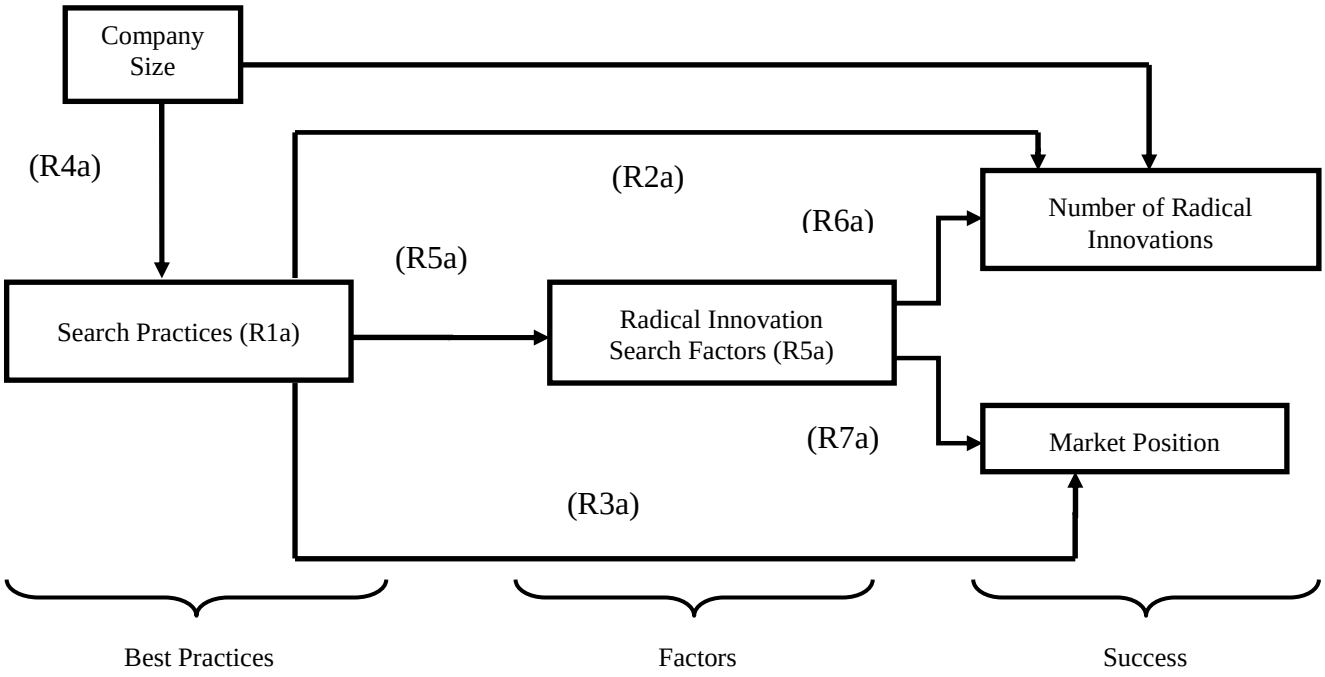


Figure 2.11 Extended research question: Search

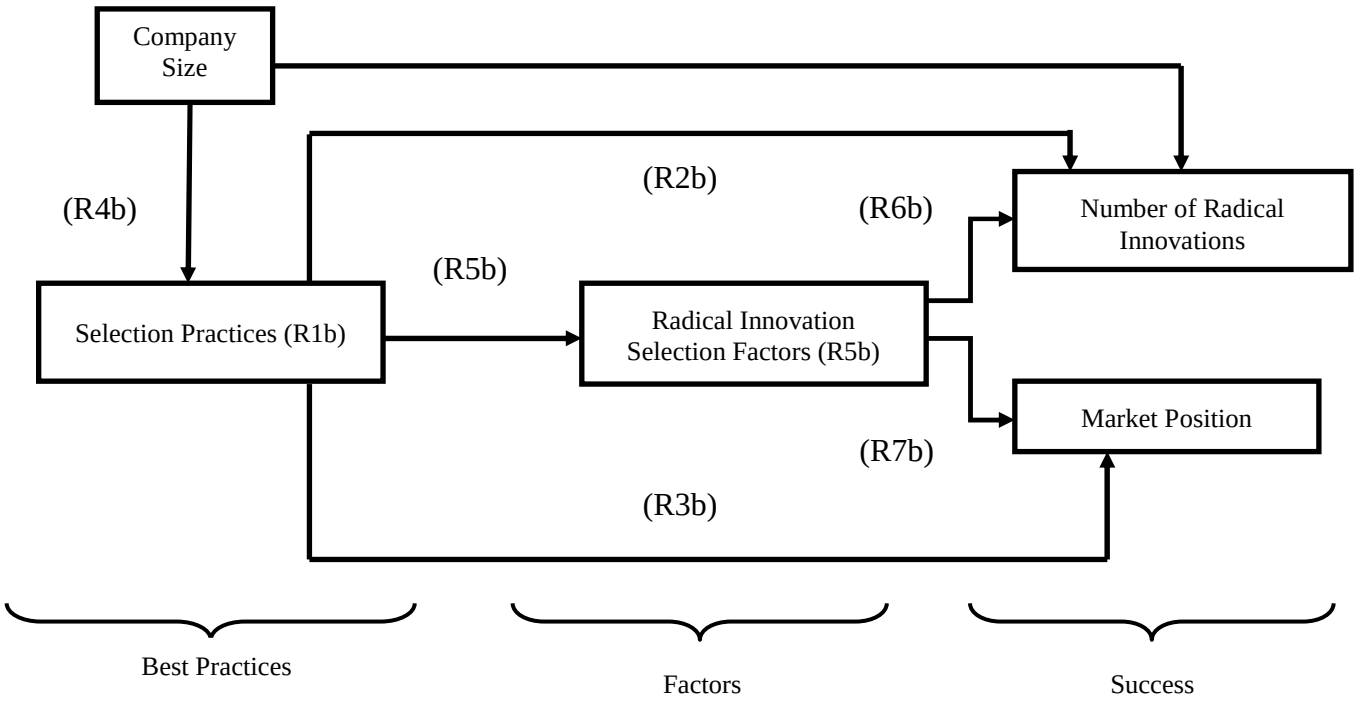


Figure 2.12 Extended research question: Selection

2.7 CHAPTER SUMMARY

The purpose of this chapter was to present a review of the literature on innovation as it is related to the research question posed in Chapter 1:

The research question is formulated as

> *'What are the key success factors in managing the front end of radical innovation?'*

In Section 2.2 definitions were offered for some of the key concepts involved in the study. Innovation and radical innovation in relation this piece of research is expanded upon and defined. Measuring innovation success in the context of this research was discussed and some key differences between SME and large companies highlighted.

Section 2.3 of the chapter outlined how innovation can be managed in a company. Some historical approaches to innovation were discussed before the concept of the fuzzy front end was introduced. Several models for characterising the fuzzy front end and the entire innovation process were discussed. The Search, Select, Implement and Capture model from Tidd and Bessant was selected with the focus for the research to be on the early stages of the process: Search and Selection for radical innovation.

Section 2.4 discussed the search aspect of the fuzzy front end of innovation. Two dimensions of search behaviour were discussed in detail-exploitation i.e. incremental innovation and exploration i.e. radical innovation. Balance between exploitation and exploration type activities was examined. Finally a selection of innovation search practices were discussed in relation to previous literature identified as having the potential to increase radical innovation search capacity.

Section 2.5 discussed the selection aspect of the fuzzy front end of innovation. Existing systems for selecting projects were discussed in relation to radical innovation and also the typical selection behaviour companies' exhibit when attempting to avoid selecting radical innovations. Problems companies face when selecting radical innovations was discussed, in particular having systems which are 'too effective'. A selection of

innovation search practices were discussed in relation to previous literature identified as having the potential to increase radical innovation selection capacity

Finally seven sets of research questions were identified to guide the research. The following chapter outlines the research plan and methodology that will guide the rest of the thesis.

Chapter Three Research Methodology

3.1 INTRODUCTION

The previous chapter identified the importance of the fuzzy front end of the radical innovation process. Identifying the search and selection capabilities of innovating companies and developing a deeper understanding into the relationships which exists between innovation search and selection practices and innovation performance would contribute significantly to radical innovation knowledge.

In this chapter the relevant philosophical perspectives and their implications in the context of the objectives of the research are reviewed. A research design consistent with the adopted philosophical approach and overall research objectives of the project is then developed. Finally three phases of empirical research, data collection and analysis are outlined.

3.2 RESEARCH OBJECTIVES

The primary research question to be answered is:

> *'What are the key success factors in managing the front end of radical innovation?'*

The research question has been extended by developing the following sub research questions relating to radical search and radical selection practices and their underlying factors.

Search

Practice questions

*R1a: What practices do companies currently use when **searching** for new ideas during the front end of the radical innovation process?*

*R2a: Which **search** practices are linked with increased numbers of radical innovations?*

*R3a: Which **search** practices are linked with more dominant market positions?*

*R4a: What is the impact of company size on the use of **search** practices for radical innovation?*

Factors Questions

*R5a: What are the underlying factors that can be used to categorize radical **search** practices?*

*R6a: Which of the identified **search** factors are linked with increased numbers of radical innovations?*

*R7a: Which of the identified **search** factors are linked with more dominant market positions?*

Selection

Practice Questions

*R1b: What practices do companies currently use when **selecting** new ideas during the front end of the radical innovation process?*

*R2b: Which **selection** practices are linked with increased numbers of radical innovations?*

*R3b: Which **selection** practices are linked with more dominant market positions?*

Factor Questions

*R4b: What is the impact of company size on the use of **selection** practices for radical innovation?*

*R5b: What are the underlying factors that can be used to categorise radical **selection** practices?*

*R6b: Which of the identified **selection** factors are linked with increased numbers of radical innovations?*

*R7b: Which of the identified **selection** factors are linked with more dominant market positions?*

The front end of the radical innovation process was characterised in Chapter 2, Section 2.3 and the 'search' and 'select' phases of the Tidd and Bessant (2009) model selected as a starting point for this research. A review of the literature identified various practices companies can use to increase their search and selection capabilities for radical innovation.

The principal focus of this research is, therefore, to develop a framework outlining radical innovation search and selection using these identified practices and to consider its utility in the context of innovation performance.

3.3 RESEARCH PHILOSOPHY

3.3.1 Theory

Characterising the link between theory and research is a complicated matter. Theory and research are equally important facets to the process of accumulating knowledge (Bryman and Bell 2007). Theory may be defined as 'the explanation of observed regularities' (Bryman and Bell 2007). There are two forms of theory development;

- Deductive theory
- Inductive theory

Deductive theory

Deductive theory represents the commonest view of the relationship between theory and research. Deduction entails the development of conceptual and theoretical structure e.g. hypothesis prior to its testing through empirical observation (Gill and Johnson 2002).

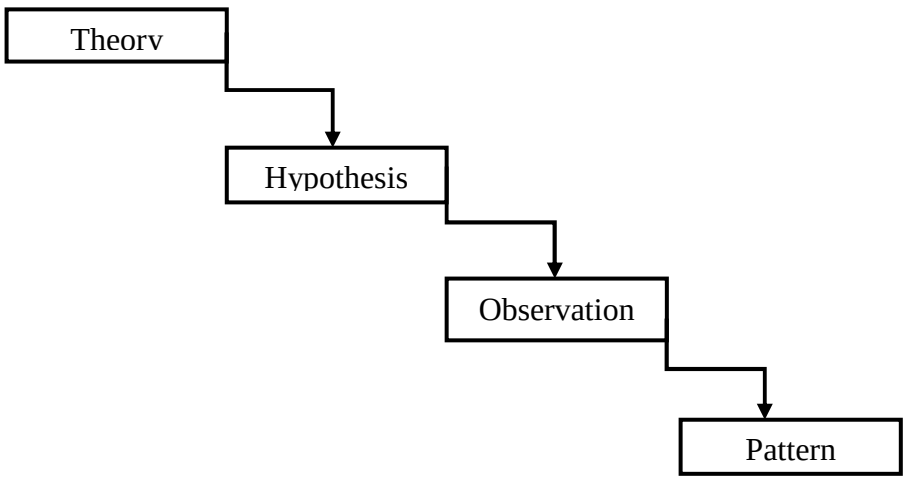


Figure 3.1 Deductive Theory

Inductive theory

Inductive theory represents the reversal of the deductive theory process. In inductive theory, one begins with specific observations and measures which result in the detection of patterns and regularities allowing the formation of tentative hypotheses that can explored to develop theories.

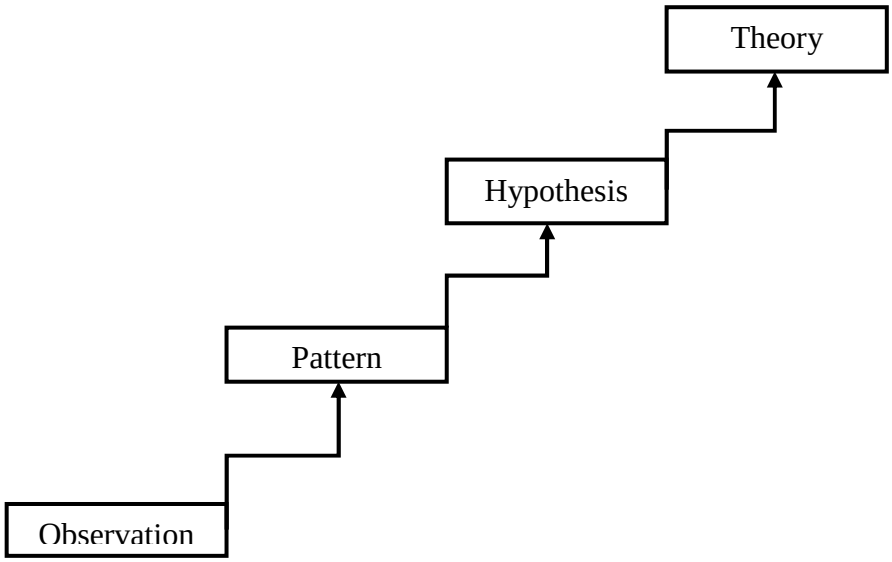


Figure 3.2 Inductive Theory

Deduction and induction processes are related. The research process can originate at different positions as seen in Figure 3.3. The process may begin with some form of preliminary theory and then using deductive processes hypotheses can be generated that can subsequently be evaluated and verified through research and the results of which produce decisions about the theory (e.g. supported, rejected, revision needed). Alternatively utilising a inductive method, specific observations may be used for the development and exploration of principles that are developed into a general theory and subsequently used to guide research that develop hypotheses and theory.

Thus there exists a symbiotic relationship between theory and practical research. Theory is used to guide the research process and research results arbitrate an evaluation of the appropriateness of the theory.

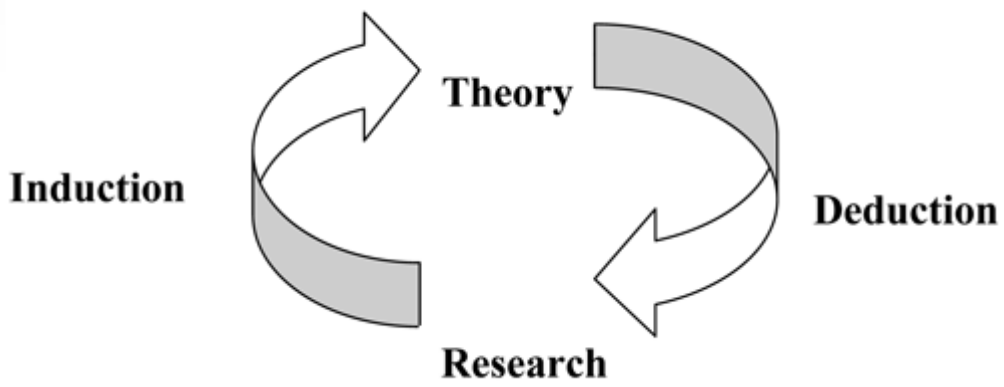


Figure 3.3 Induction-Deduction Relationship

3.3.2 Ontology and Epistemology in Management Research

Explorations of philosophical perspectives usually tend to begin with a review of positivism.

Some of the guiding principles of positivism include:

- Only knowledge confirmed by the senses can be warranted as knowledge;
- The purpose of theory is to generate hypotheses than can be tested (deductive theory);
- Knowledge is arrived at through the gathering of facts that provide the basis of laws (inductive theory);
- Science must be conducted objectively;
- There is clear distinction between scientific statements and normative statements.

Positivism can entail elements of both inductive and deductive strategy and specifies a clear distinction between the roles of theory and research. According to the positivist perspective knowledge is treated objectively i.e. social practices and behaviours are defined and quantified as specific variables. These variables can be studied independently from each other and give opportunity for theory to be developed to predict their effect on future performance. The researcher is objective; neither affecting nor being affected by the research in question (Saunders et al. 2011). Human actions are reduced to automatic responses to external stimuli (Tiernan, 1995). At positivisms core is the aim of understanding causal relationships in natural phenomena and to

explain and predict events. Similarly, in the field of organisational and management enquiry, the objective of positivism is the discovery of the fundamental laws which govern organisations operations (Johnson and Duberley 2000).

Positivism relies on structured research methods that can be easily replicated and produces data that are suitable for statistical analysis (Gill and Johnson 2002). The research approach generally taken by positivists is to develop a theory and attempt to prove it using quantitative methods.

Positivism has often becomes the 'default' position for which justification for considering alternatives must be given. The temporal primacy and longevity which positivism possesses has established the place of the positivistic scientific method as the 'superior' process for generating high quality knowledge. Other competing perspectives have emerged, which rejects some or all of the doctrines of positivism. These perspectives are classically represented along a continuum extending from positivism at one end to constructivism at the other.

Constructivism, the alternate to positivism, conceives of a world that is socially constructed in which meanings are produced by people; 'It take the meanings and interpretations, the motives and intentions, which people use in their everyday lives, and which direct their behaviour – and elevates them to the central place in social theory and research' (Blaikie 1993, pg 176). Reality is a product of social interactions, and consequently there is no single definable reality but multiple realities constructed in multiple contexts. For research this means there is no objective reality that can be discovered by researchers. This view is a radical departure from the detached positivist perspective. It privileges subjectivity as the observer/researcher is concerned with how social objects are made meaningful by actors in the 'life world' (Holstein and Gubrium 1994).

Between the polar opposites of positivism and constructivism, perspectives that do not wholly reject all the tenets and doctrines of each perspective exist. These perspectives attack positivism's adherence to the view that reality is objective and external, arguing instead, that reality is socially constructed and given meaning by people (Easterby-Smith et al. 2008, Guba and Lincoln 1994, Denzin and Lincoln 1994). Simultaneously,

the perspectives challenge the notion of only a socially-constructed reality (Johnson and Duberley 2000). Table 3.1 illustrates the extremes of this continuum and suggests implications for management research.

Table 3.1 Positivism vs Constructivism

	Characteristics of positivism	Characteristics of social constructivism
Ontological position: The nature of reality	• External and independent of the observer • Objective and ordered • Single reality • Belief in laws, uniformity and generalisability of knowledge • Reductionist and deterministic	• Reality is socially constructed • Interpretive: socially and experientially based • Changing realities • A product of human minds and has no independent status of its own, • Reality is determined by meanings
Epistemological position: Acquiring knowledge of reality	• Value free acquisition of sense data accessible by the scientific process which is the only reliable foundation for knowledge • Neutrality • Dualism: researcher remains objective and exterior to the subject. • Reduction of the natural world • Nomothetic (law giving) generalisations • Direct experience • Sense data • Empirical verification	• There is no neutral ground for knowledge since all observation is value laden • Observer becomes part of what is observed • Getting close to the subject • Adopting a holistic view of social phenomena • View social phenomena in their natural environments • Idiographic (relating to individuals) generalisations
Aim of the research	• Suited to the study of 'It' beings to generate causal and fundamental laws of human behaviour • Explanation, prediction, control	• Suited to the study of human beings • Those metaphysical things that positivism discounts or cannot access through empirical facts, such as values • Understanding, exploration, emancipation
Attitude of the researcher	• Detached, independent, impartial	• Involved, interacts with the subject in order to gain understanding of the phenomenon.
Methods	• Natural sciences methods • Measuring operationalised concepts • Use of large samples • Manipulation and control of isolated variables for the measurement of their relationships with others • Uniformity and generalisability of knowledge	• Multiple methods to establish different views of the same phenomena • Small samples investigated in depth over time • Social constructions can be elicited and refined through interaction between the researcher and the respondent

Adams (2003) citing Blaikie (2007), Denzin and Lincoln (1994), Easterby-Smith et al. (2008) and Johnson and Duberley (2000).

3.3.3 Qualitative vs Quantitative Research

Both qualitative and quantitative approaches have long traditions associated with them making it difficult to develop a concise definitions (Yin 2009). They may be simply differentiated by the quantitative emphasis on numeric data and the latter's on nonnumeric data in the form of words. Denzin and Lincoln (1994) develop this and suggest that quantitative studies emphasise the measurement and analysis of causal relationships between variables. On the other hand, qualitative research stresses the socially constructed nature of reality.

Qualitative research can be construed as a research strategy that emphasis words rather than quantification. Qualitative researchers aim to gather an in-depth understanding of human behaviour and the reasons that govern such behaviour. The qualitative method investigates the why and how of decision making, not just what, where, when. In the conventional view, qualitative methods produce information only on the particular cases studied, and any more general conclusions are only propositions (informed assertions). They do, however, tend to be limited in the conclusions and inferences that can be drawn from typically small samples but are, useful for supplementing, validating, explaining or illuminating quantitative data (Miles and Huberman 1994).

In the social sciences, quantitative research refers to the systematic empirical investigation of social phenomena via statistical, mathematical or computational techniques. The process of measurement is central to quantitative research because it provides the fundamental connection between empirical observation and mathematical expression of quantitative relationships. Quantitative studies, on the other hand, offer greater opportunity for generalisation as the research tends to involve a larger number of individuals (items, entities, instances of the phenomena and so on), drawn from a wider, or even the whole, population. Quantitative methods can be fast and economical, provide wide coverage of the range of situations, and can be of considerable relevance to policy makers when statistics are aggregated. But they can be inflexible and artificial, and may not be very effective in understanding the processes or the meanings that people attach to events or incidents (Easterby-Smith et al. 2008).

3.3.4 Impact on this Research

Having thus circumscribed the philosophical field, delimited by positivism and social constructivism, it is necessary to outline wherein the current research is located. Examining Table 3.1 it is clear that this research is situated towards the positivist perspective for the following reasons:

- The ontological and epistemological positions of the research and indeed one of the underlying assumptions for the entire piece of research is that there are specific practices companies can undertake to search for and select radical innovations;
- These search practices can be observed and are not dependent on the researcher to interact with them;
- These practices can be extended to form 'laws' or best practice that can be generalised and applied in a wide number of contexts;
- The positivistic approach is suited to the study of 'it' and the explanation, prediction and control of 'it'. In the case of this research 'it' refers to definable practice and it is expected that these practices exhibit some form of prediction and control over radical innovation outcome.

While innovation research, is often grounded in the perceptions of individuals and is unlikely to comfortably fit in a wholly positivist tradition clearly the overall research questions favours a positivist approach. Typically a positivistic research approach relies on highly structured research methods that are easily replicated and produces data that are suitable for statistical analysis (Gill and Johnson 2002, Gartrell and Gartrell 1996). In keeping with the positivist perspective and to fulfil the objectives of the research a quantitative approach was selected comprising of a survey methodology.

3.4 RESEARCH DESIGN

This section outlines the research design. Three phases of research are described. The development, implementation and subsequent analysis of the chosen survey methodology are discussed.

3.4.1 Research Phases

Table 3.2 outlines three distinct phases of research designed to fulfil the research objectives of this study.

Table 3.2 Research Phases

	Phase I	Phase II	Phase III
Data/Duration	October 2008-October 2009	December 2009-January 2011	February 2011-February 2012
Data Collection Method	Analysis of literature	1. Search Survey (SearchQ1) 2. Selection Survey (SelectQ2)	1. Search and Selection Survey (SearchSelectQ3)

Phase I

Phase 1 of the research consisted of an analysis of the literature. The review of the literature identified various practices companies can use to increase their search and selection capabilities for radical innovation. The literature review is presented in Chapter 2 and formed the basis for following phases of research.

Phase II

This phase lasted approximately 14 months and consisted of the development, testing, implementation and analysis of two exploratory radical innovation surveys. The development of the surveys is discussed in Section 3.4.2.

- The 1st survey explored the 'search' aspect of the fuzzy front end and is from this point on referred to as the **SearchQ1 survey** (Appendix C)
- The 2nd survey explored the 'selection' aspect of the fuzzy front end and is from this point on referred to as the **SelectQ2 survey** (Appendix D).

Phase III

The primary output from Phase II was the identification of 5 underlying search factors and 4 underlying selection factors (as detailed in Chapter 5). In order to confirm the existence of these underlying factor characterising search and selection a 3rd survey was developed and implemented. This survey covered both the 'search' and 'selection' aspects of the fuzzy front end. The format replicated that exactly of the surveys used in Phase 2.

- The 3rd survey covered both the 'search' and 'selection' aspect of the fuzzy front end and is from this point on referred to as the **SearchSelectQ3** (Appendix E) survey.

Figure 3.5 details the research phases and subsequent analysis performed on the data.

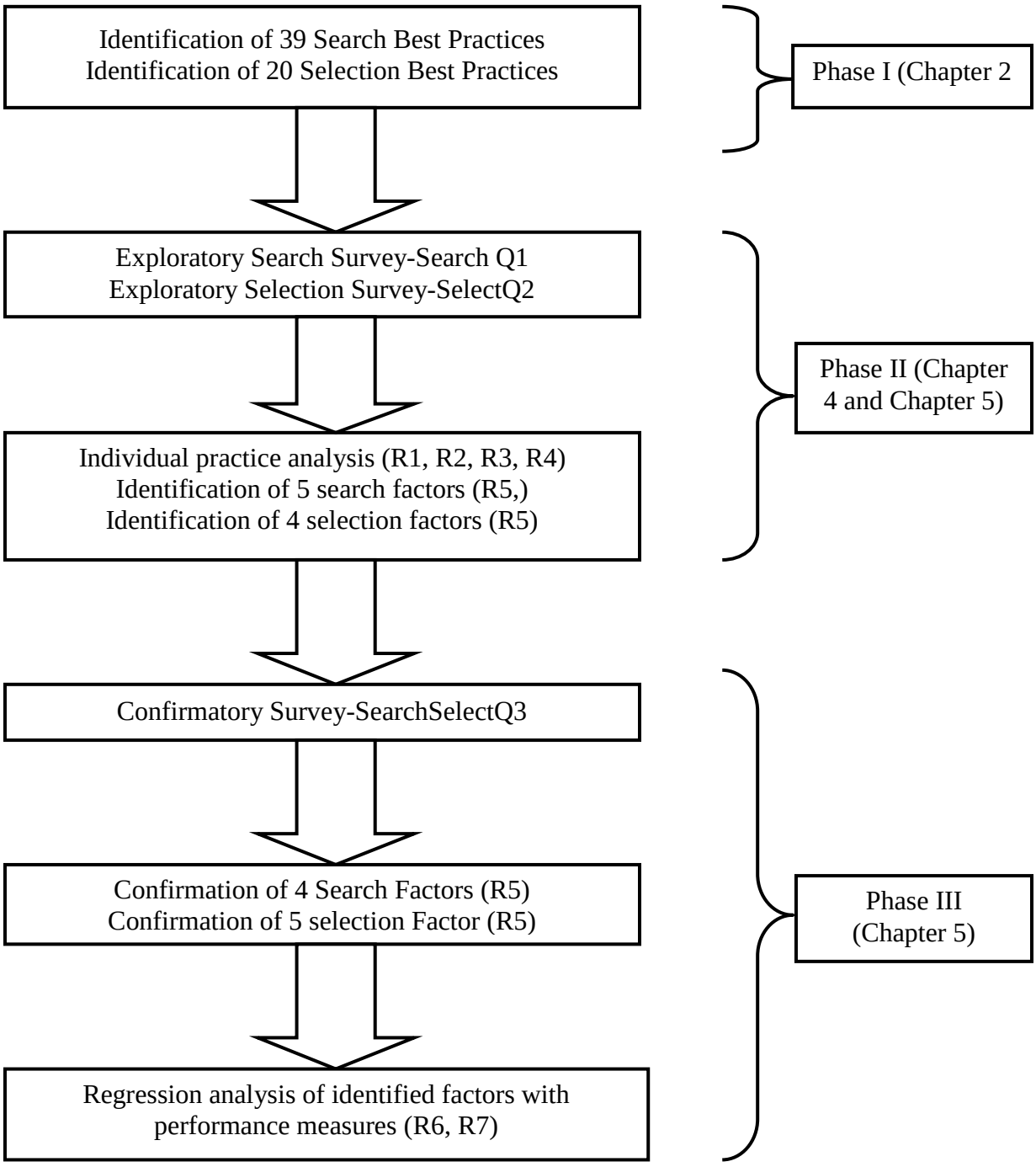


Figure 3.4 Research Phases

3.4.2 Survey Development

The three innovation surveys were structured similarly;

- Section 1 of each survey gathered demographic and performance data for the respondent companies.

- Section 2 of each survey gathered data relating to each of the identified search and selection practices.

The structure of the survey instrument is expanded upon below.

Survey Section 1

Section 1, for each of the three surveys, was designed to gathered demographic and performance data from the respondent companies. The following data was requested:

- Respondent name (optional);

- Company name (optional);

- Primary Industry sector;
  - Pharmaceutical;
  - Software and ICT;
  - Electrics and Electronics;
  - Medical Devices;
  - Other Technologies;
  - Other.

- Number of employees in company (To establish large company/SME status);

- Number of incremental/substantial/radical innovations developed and released over the previous 5 years;

- Current market position given choice of 5 market positions outlined below;
    - Dominant;
    - Strong;
    - Favorable;
    - Viable/Tenable;
    - Weak.

Survey Section 2

The analysis of the literature identified key issues surrounding best practice; subsequently 'questions' relating to the key issues were developed to examine best practice in respondent companies. The questions for the exploratory search survey, SearchQ1, and the exploratory selection survey, SelectQ2, were developed from a number of sources. A large number of questions were desired given the ultimate aim was to identify underlying factors. It is not unusual to begin with as many as three to four times the number of items/practices ultimately desired in the final scale/factor (DeVellis, 1991) with unwanted items eliminated as desired. The sources of questions used were as follows:

1. The key literature areas identified through the review of the literature surrounding best practice for search and selection as discussed in Sections 2.4.2 and 2.5.3;

2. Two separate reports outlining potential search and selection practices (Bessant and Stamm 2007, Bessant et al. 2010);

3. A previously conducted innovation survey in Company X[1] (This survey was never used in published research but is viewable in Appendix B).

[1] Company name withheld for confidentiality reasons.

3.4.3 Search Practice Questions

The question sections in the SearchQ1 survey were structured in a similar way as the literature review best practice discussion. The following tables outline the survey questions developed in response to the key literature issues that emerged from the literature review. 39 practices/questions in total were identified across the 4 categories.

1. Learning about markets for radical innovation;
2. Managing radical idea generation;
3. People Management for radical innovation;
4. Openness to external sources for radical innovation.

Table 3.3 Search Survey Questions Section 1

Learning about markets for radical innovation	
Key Literature Issues	**Best Practice Survey Questions**
• The innovative application of existing/new technology to new markets • Identification of latent needs • Use of lead users • Use of futures studies • Deep diving	1. When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets. 2. To learn about unfamiliar markets, we rely on a set of unconventional market research tools to identify latent, yet unarticulated needs among different customer groups. 3. We have a dedicated group of people (e.g. from marketing, sales, R&D) that explores new ways to apply our existing technology to new industries and new customers. 4. We actively try to find those lead users who are innovating to solve problems present at the leading edge of a trend and seek to 'co-evolve' new products and services together with them. 5. We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need. 6. We systematically seek out and learn from firms - within and in particular outside our industry that are known to have well-functioning innovation practices in order to improve our own innovation system. 7. We make use of some form of futures study in order to create and explore alternative futures especially those which do not necessarily follow our current trajectory. 8. We develop and use scenarios to help understand and influence our organisation's future. 9. Our organisation looks deeply at how people actually use our products, as opposed to how people say they use our products. 10. We ensure that our engineers and technical people get a chance to observe the use of our products and services in real life situations. 11. Our organisation often conducts pilot-scale testing before moving into a main stream market. 12. We frequently use prototypes when presenting new ideas as a means of learning and refining an idea.

Table 3.4 Search Survey Questions Section 2

Managing radical idea generation	
Key Literature Issues	**Best Practice Survey Questions**
• The use of innovation 'scouts' • Using 'idea generators' • Using an idea management system • Creating 'active' teams • Providing adequate resources	1. We have people (part-time or full-time) officially charged with scouting for new ideas, finding new sources of potential radical ideas and looking for trends and developments that might have implications for organisation's future. 2. Senior management is interested and receptive to such insights and new ideas. 3. In our organisation, we try to stimulate radical innovation by periodically commissioning teams to generate ideas around major platforms or themes that are strategically relevant to us. 4. In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback. 5. We have a team of people with responsibility for our idea management system. 6. We encourage people to come forward with ideas, even if they have only a vague idea of the potential market applications for the idea. 7. Our organisation operates some form of creative idea generation to support Discontinuous Innovation. 8. We access external sources that can help us to scan for ideas for future products and markets. 9. Our organisation operates venture capital funds that can be used for the development of internally or externally generated ideas. 10. Our organisation sets up teams to actively search out and implement new ideas that will take our business in new directions. 11. Our organisation supports corporate intrapreneurship as part of our Discontinuous Innovation efforts. 12. We have a dedicated, ring-fenced budget available to fund intrapreneurs.

Table 3.5 Search Survey Questions Section 3

People Management for radical innovation	
Key Literature Issues	**Best Practice Survey Questions**
• Internal communication • Internal networks of support • Encouraging diversity	1. In our organisation, we have 'network ambassadors' who can help radical innovation teams connect with other people company-wide when new knowledge or insight is needed. 2. In our organisation, teams engaged in radical innovation projects can locate experts in various disciplines of radical innovation when needed through accessing a database on our intranet. 3. In our organisation, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm. 4. Our organisation operates some form of brokering/bridge-building that involves bringing together people for different knowledge sets, backgrounds or functions in order to support Discontinuous Innovation. 5. Our organisation deliberately encourages diversity in terms of mind-sets and thinking in order to support Discontinuous Innovation.

Table 3.6 Search Survey Questions Section 4

Openness to external sources for radical innovation	
Key Literature Issues	**Best Practice Survey Questions**
• Open innovation • Collaboration with unusual partners • Using online initiatives • Mobilising 'main stream' staff	1. We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions. 2. We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services. 3. We use some form of web-based exploration in order to identify future trends in technologies and markets that may impact on our business. 4. We openly share many of our patented technologies with a network of research partners in order to license-in and license-out new technology. 5. Instead of doing all R&D ourselves we are moving towards open innovation by increasingly using external sources as input to our innovation process. 6. We have implemented an open and collaborative research environment with e.g. universities, research centres and specialised agencies. 7. Alongside our usual long-term strategic alliances, we develop short term technology-focused partnerships with other companies. 8. Our organisation mobilises its mainstream resources, including staff and other organisations with which we work, to support Discontinuous Innovation/Radical Innovation. 9. We currently have systems or procedures in place that ensure insights from mainstream staff who have the opportunity to gather information from external sources are being collected systematically. 10. We actively encourage people to go to events/conferences/courses that are outside their current realms of experience.

3.4.4 Selection Practice Questions

The question sections in the SelectQ2 survey were structured in a similar way as the literature review best practice discussion. The following tables outline the survey questions developed in response to the key literature issues that emerged from the literature review. 20 practices/questions in total were identified across the 3 categories

1. Supporting early decision making;
2. Culture support system for radical innovation;
3. Measuring Progress for Radical innovation.

Table 3.7 Selection Survey Questions Section 1

Supporting early decision making	
Key Literature Issues	**Best Practice Survey Questions**
• Level of openness to change; • Flexibility in selection; • Prototyping to explore • Prototyping to demonstrate.	1. Our company engages in creative thinking about the future and we consider ways to take our business into new markets or new ways of competing. 2. We remain open to re-consider our future position in our industry value chain and make shifts if we have to. 3. When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market. 4. We use prototypes to build bridges in the selection process. By using prototypes we 'build bridges' in the minds of potential supporters (e.g. senior management, investors etc.) between the current state of affairs and what might be if this project is given opportunity to develop. 5. We use prototyping to reduce uncertainty when making selection decisions i.e. we often 'buy a look' before deciding whether or not proceeding. 6. We use prototyping to 'take a small step' in a few different directions before committing to a large step in one direction.

Table 3.8 Selection Survey Questions Section 2

Culture support system for radical innovation	
Key Literature Issues	**Best Practice Survey Questions**
• Visible management support • Senior project champions • Risk taking encouraged • Provision of funding • Protection from parent organisation	1. In the company there are identifiable project champions in senior positions within the company who promote the development of radical and discontinuous projects. 2. When identifying a promising radical innovation project, we develop it through a different and more flexible process than the traditional stage-gate system. 3. Our firm funds radical innovation project development differently than they fund incremental innovation projects. 4. We are increasingly using external sources to fund our R&D projects within innovation through partnerships and alliances with other firms/universities/state bodies etc. 5. The process for accessing and leveraging resources (funding, personnel, capital equipment, and other organisational resources) for radical innovation projects in our firms is clear. 6. If a radical product idea doesn't fit our current trajectory we use alternative implementation structures (e.g. satellite SMEs, third party consultants, venture arms, partnership with other firms etc) to allow the idea to develop away from the mainstream business. 7. There is an atmosphere in our organisation which encourages everyone to take part in innovation. 8. We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs. 9. In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.

Table 3.9 Selection Survey Questions Section 3

Measuring Progress for Radical innovation	
Key Literature Issues	**Best Practice Survey Questions**
• Use of alternative measurement criteria • Longer timelines of measurement • Link funding to timeline • Immediate profitability not key focus	1. When evaluating radical opportunities we use alternative measurement and evaluation criteria to the ones used for non-radical opportunities. 2. Our senior managers understand that it takes times for radical innovation projects to acquire the necessary learning experience before they can move forward. 3. Instead of a preoccupation with profitability potential, we often assess the promise of radical projects by their potential to open up new territory and thereby provide opportunities for learning about technologies and markets. 4. Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and proven themselves. 5. When making decisions about the success of radical innovation in our organisation, we look at our ability to manage a portfolio of radical innovation projects at various stages of development rather than on the success or failure of one single radical project.

The confirmatory survey, SearchSelectQ3, consisted of a subset of questions identified through the exploratory factor analysis of the first two surveys, SearchQ1 and SelectQ2.

3.4.5 Question structure

The second section of the survey was designed to gather information relating to the use and importance of search or selection practices for radical innovation. For each question respondents were asked to indicate on a Likert scale (ranging from 'strongly disagree' to 'strongly agree') the extent to which their firm makes use of such a practice for radical innovation and their opinion relating to the importance of the practice for radical innovation search or selection. Figure 3.6 details a sample question to demonstrate how each question was presented to each respondent of the survey.

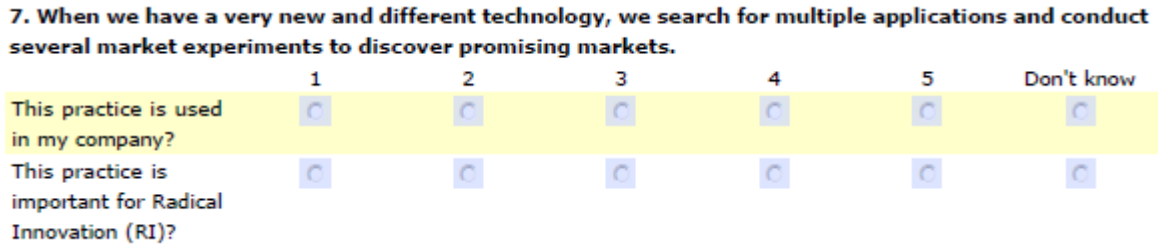


Figure 3.5 Sample question from Exploratory Search survey

3.4.5 Survey Administration

Each of the three surveys was targeted at senior managers, within the respondent companies, with responsibility for developing new products. In the case of many of the smaller companies the owners/managing directors were targeted as respondents. Each survey was completed on a self reporting basis similar to other innovation and product development based surveys such as Barczak et al. (2009) and Koberg et al. (2003). The survey was distributed electronically using SurveyMonkey.com©.

Firms were broad-based across several high-tech industries including medical devices, software development, pharmaceuticals and electronics. A cross-industry sample such as this was chosen to increase the generalizability of the findings. The companies were chosen on a number of criteria. First, they had to be established in their industry as this research is concerned with either creating radical innovations or searching for existing emerging innovations that start-up companies may have developed. Second, they had to be engaged in some form of product/service innovation. Companies were selected based on these criteria from a number of databases including databases provided by the Irish Development Agency (IDA), Enterprise Ireland (EI), the Enterprise Research Centre (ERC located in the University of Limerick) and the Irish Management Institute (IMI).

The following actions were taken to promote response and minimise bias:

- The survey and cover letter was pre-tested with a group of target respondents (n=4) with similar responsibilities as the sample population in addition to work colleagues (n=4). Pre-testing ensured that the survey questions were clear and convenient to answer and that the relevance of survey participation was evident;
- The survey included a personalised cover letter that introduced the study, identified it as an academic study, and highlighted its potential value to the respondent and the importance of their participation in the study. Participants were assured that their responses were confidential;
- A follow-up email was sent ten days after the initial mailing to remind the respondents of the request for their participation again highlighting the relevance of the study.

Table 3.10 shows the sample sizes, no of respondents and response rate for each of the surveys. The top reasons for non-participation included ‘no time’, ‘we’re not appropriate’.

Table 3.10 Sample sizes and Response Rates

	Sample Size	Number of Respondents	Response Rate
SearchQ1	580	87	15%
SelectQ2	610	94	15.4%
SearchSelectQ3	566	88	15.5%

3.4.6 Survey Analysis

There were a number of stages to analysing the data. Preliminary analysis was performed followed by exploratory factor analysis, standard multiple regression and confirmatory factor analysis.

Content Validity

To ensure content validity of the statements, the practice questions used were shown to experts in the field of innovation. This resulted in minor modification of the statements. As mentioned, as part of the research strategy, the survey was pre-tested;

- The pretesting used 4 target respondents and 4 co-researchers;
- Pretesting respondents were asked;
    - If the cover letter provided adequate information;
    - If the instructions were clear and accurate;
    - If the questions were clear and error free;
    - If there were any problems in understanding what answers were required;
    - If the administration method was effective and glitch free.

This pre-testing further ensured that the survey questions were clear and convenient to answer and that the relevance of survey participation was evident (Forza 2002).

Non Response Bias

To test for non-response bias, wave analysis techniques were employed by comparing the responses of the early wave respondents and late wave respondents to the surveys. This method is based on the assumption that the opinions of late respondents are representative of the opinions of non-respondents (Rogelberg and Stanton 2007). Significant testing yielded no statistically significant differences between the early (first 20% of respondents) and late wave groups (last 20% of respondents), indicating that non-response bias was not a problem. Table 3.11 and 3.12 demonstrates some of this analysis.

Table 3.11 SearchQ1 Early wave vs. Late wave respondents

Survey Question Code	Early wave vs Late wave*
MRIGQ1USE	-.808
MRIGQ2USE	-.829
MRIGQ3USE	-1.295
MRIGQ4USE	-.320
MRIGQ5USE	-.225
MRIGQ6USE	-.520
MRIGQ7USE	-.500
MRIGQ8USE	-.480
* Mann Whitney U	

Table 3.12 SelectQ2 Early wave vs Late wave respondents

Survey Question Code	Early wave vs Late wave*
Q1USE	-.877
Q2USE	-.182
Q3USE	-.762
Q4USE	-.192
Q5USE	-.631
Q6USE	-.725
Q7USE	-1.316
Q8USE	-.478
* Mann Whitney U	

Preliminary analysis

Analysis of the data includes the reporting of descriptive data relating to industry sector, company size, market position and involvement in radical innovation over the previous 5 years. Mann–Whitney U, a non-parametric statistical hypothesis test for assessing whether one of two samples of independent observations tends to have larger values than the other was used to assess differences between different segments of the sample e.g. SME vs. large companies, innovator companies vs. non-innovator companies. The Wilcoxon signed-rank test, a non-parametric statistical hypothesis test for comparing two related samples, matched samples, or repeated measurements on a single sample to assess whether their population mean ranks differ, was used to compare usage of practices and the perceived importance of practices within a group e.g usage and importance within the SME segment of the sample.

Common Method Variance

Given that all the data are self-reported and drawn from a single respondent in the organisation, the impact of common method variance had to be considered. Common method variance is variance that is attributed to the measurement method rather than the constructs of interest that may cause systematic measurement error and further bias the estimates of the true relationship among theoretical constructs. The test for checking common method variance used in this study was the Harman single-factor test (Podsakoff and Organ 1986, Stam and Elfring 2008, Carr and Kaynak 2007, Darnall et al. 2010). All practices were loaded into an exploratory factor analysis, using un-rotated principal components factor analysis to determine the number of factors that are necessary to account for the variance in the variables.

If a substantial amount of common method variance is present, either;

1. A single factor will emerge from the factor analysis
2. One general factor will account for the majority of the covariance among the variables (Podsakoff and Organ 1986, Krishnan et al. 2006, Steensma et al. 2005, Aulakh and Gencturk 2000, Schriesheim 1980).

Neither of the above conditions was present. Furthermore if common method variance is largely responsible for the relationship among the variables, the one-factor CFA

model should fit the data well (Korsgaard and Roberson 1995, Mossholder et al. 1998). However, only 30.6 % variance was extracted for the one factor model using the Exploratory Search survey data and only 44.0% variance was extracted for the one factor model using the Exploratory Selection survey. The practices also suffered from poor factor loadings. The confirmatory factor analysis confirmed that the single-factor model did not fit the data well for each of the exploratory surveys as below. Table 3.13 shows the fit indices for the SearchQ1 and SelectQ2 surveys and confirms that the one factor model is a poor fit for the data of each survey.

Table 3.13 Model fit indices for search and select one factor models

Index	SearchQ1	SelectQ2	Recommended values for very good fit	Sources
χ^2	180.05(p-value .00)	606.37 (p value .00)	-	-
RMSEA	.166	.28	< .05	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
NFI	0.57	.48	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
N-NFI or TLI	0.6	.5	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
CFI	0.67	.57	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
χ^2/df	3.33	7.87	>1 and <3	(Bollen 1989, McIver and Carmines 1981, Hair et al. 1998, Jöreskog 1969)

RMSEA= root mean square error of approximation, NFI= normed fit index, N-NFI= non-normed fit index, TLI= Tucker-Lewis index, CFI=comparative fit index

While the results of these analyses do not preclude the possibility of common method variance, they do suggest that common method variance is not of great concern and thus is unlikely to confound the interpretations of results.

Exploratory Factor Analysis

To reveal any latent variables or factors within the SearchQ1 and SelectQ2 surveys exploratory factor analysis was used in line with recommendations of Costello and Osborne (2005) and Pallant (2010) utilizing SPSS (Version 18). The Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and the Bartlett Test of Sphericity (BTS) were conducted on the data. This preliminary analysis confirmed that the data

distribution satisfied the psychometric criteria for the factor analysis to be performed. Principal component analysis (PCA) was selected as the factor extraction method and oblique rotation - Direct Oblimin - was employed because of the possibility that the extracted factors may be correlated. Kaiser criterion, variance accounted for greater than 70% and interpretability criteria were all used in order to decide the number of meaningful factors to be extracted. A set of rules were established and used to interpret the results of the factor analysis. In particular, a practice was retained using the following criteria:

- If it loads primarily on one factor;
- When loading on multiple factors, the difference between the higher loading and all the other loadings (related to different factors) should be greater than or equal to 0.2;
- The practice loading allows for an interpretable solution.

Search

Exploratory factor analysis on the SearchQ1 survey resulted in the practice list being reduced from 39 practices to 12 practices. Practices were eliminated in an iterative process according to the above mentioned decisions rules for retaining practices. This was a complex process given the number of practices initially included in the exploratory factor analysis. This process is outlined in Appendix F-G.

Selection

Exploratory factor analysis on the SelectQ2 survey resulted in the practice list being reduced from 20 practices to 14 practices. Practices were eliminated in an iterative process according to the above mentioned decisions rules for retaining practices. This process is outlined in Appendix H-I.

Standard Multiple Regression

Regression analysis enables the prediction of future outcomes based on values of predictive variables. Standard Multiple Regression was used subsequently to the exploratory factor analysis in order is assess the predictive value that the identified factors have on the performance measures. This was completed on the data in line with Pallant (2010).

The sample size is adequate for multiple regression analysis according to criteria set down by Stevens (2009) and Tabachnick and Fidell (2007). Stevens (2009) recommends 15 cases per predictor for a reliable regression. Data was checked to ensure that the assumption of mulitcollineraity was not violated by having variables that were too closely related to each other by checking Pearson Correlation coefficients, tolerances and variance inflation factors (VIF). Scatter plots and normaility plots indicated that some variables were skewed so care was taken when interpreting regression data. Any outliers in the data are not having an undue influence on the results of the model as indicated by the values for Cooks distance in the Residual statistics tables (Appendix J and K). A value of above 1 for Cooks distance indicates that the outliers are a potential problem (Tabachnick et al. 2001) and may need elimination.

Confirmatory factor analysis

Following Netemeyer, et al. (2003), the psychometric properties of the measurement scale were examined through confirmatory factor analysis (CFA).

- SPSS was used to perform factor analysis on the data from the SearchSelectQ3 survey to assess if the same factors once again emerged from the data set as had done in the previous surveys, SearchQ1 and SelectQ2 (Appendix M).
- Lisrel was used to assess if the identified 5 factor search model and 4 factor selection models are a good fit for the data (Appendix N).

This important step ensures any potential bias when eliminating practices at the exploratory stage is reduced.

Convergent Validity

Convergent validity refers to the degree to which two measures of constructs that theoretically should be related are in fact related. Convergent validity is ensured by examining the indicator loadings of the factor analysis for statistical significance (Kenny and Kashy 1992). To have convergent validity, the resulting factorial structure should be clear and well defined thus indicating that a significant relationship between each practice and its respective factor: the factor loadings of each construct should be significantly high (Dunn et al. 1994). The Cronbach's alpha of the subscales should also

achieve values of at least 0.7 to demonstrate internal consistency and adequate reliability (Hair et al. 1998). Pearson correlations and Spearman-Brown are shown for two item measures in line with Eisinga et al. (2013).

Discriminant Validity

Discriminant validity tests whether the concept/measurements that are thought to be unrelated are unrelated i.e the emergent factors are significantly different from each other and are not measuring the same construct. For evidence of discriminant validity both analyses of the factor loadings and the inter-factor correlations are conducted. In particular, each item should present high loading only on one specific factor and significantly lower loadings on all the other factors (Straub 1989). Whenever there are high construct inter-correlations, there is a need to further assess discriminant validity, in order to have confidence in subsequent research findings (Saunders et al. 2011). Correlation coefficients for all possible pairs of latent constructs are examined to verify that correlations are not above the recommended level of 0.65 (Tabachnick and Fidell 1996).

3.5 CHAPTER SUMMARY

This chapter has provided an overview of the research plan to be used in this research. The relevant philosophical perspectives and their implications in the context of the objectives of the research were reviewed and concluded with the selection of a positivist approach. A research design consistent with the adopted philosophical approach and overall research objectives of the project was developed. To this end a research strategy was selected incorporating a number of separate innovation surveys based around the two stages of the fuzzy front end of radical innovation. The first two surveys are to explore search and selection practices companies are using to search and select radically new ideas and utilised exploratory factor analysis to identify ‘factors’ used to search and select radical innovations. The third survey replicates the previous surveys and used confirmatory factor analysis in order to confirm the identified ‘factors’.

Chapter Four

Radical Innovation Practice: Search and Selection

4.1 INTRODUCTION

This chapter presents the individual item results of the Exploratory Search survey (SearchQ1) and the Exploratory Selection survey (SelectQ2). Results for search and selection practice are presented comparing usage for the entire sample, the innovator and non-innovator companies, the market leader and market followers companies and according to company size.

The chapter is structured as follows:

- Section 4.2 presents the results of the SearchQ1 survey;
  - Demographics of the sample including company size and industry sector;
  - Correlations between company size and the performance measures of radical innovation involvement over the previous 5 years and market position;
  - The individual practice results are presented including;
    - Usage and importance of each search practice (Question R1a);
    - Usage and importance of each search practice in innovator companies vs. non-innovator companies (Question R2a);
    - Usage and importance of each search practice in market leaders vs. market followers (Question R3a);
    - Usage and importance of each search practice in SME companies vs. large companies (Question R4a).

- Section 4.3 presents the results of the SelectQ2 survey;
  - Demographics of the sample including company size and industry sector;
  - Correlations between company size and the performance measures of radical innovation involvement over the previous 5 years and market position;
  - The individual practice results are presented including;
    - Usage and importance of each selection practice (Question R1b);
    - Usage and importance of each selection practice in innovator companies vs. non-innovator companies (Question R2b);
    - Usage and importance of each selection practice in market leaders vs. market followers (Question R3b);
    - Usage and importance of each selection practice in SME companies vs. large companies (Question R4b).

4.2 SEARCH PRACTICE RESULTS

As described in Section 3.4.6 exploratory factor analysis on the SearchQ1 survey resulted in the practice list being reduced from 39 practices to 12 practices. Practices were eliminated in an iterative process outlined in Appendix F. This section is based around the 12 search practices that comprise the final search factors. The exploratory factor analysis of these 12 practices is presented in Chapter 5.

The 12 retained items are presented in Table 4.1. Each question has been designated a ‘practice name’ to allow for quick reference within tables and text.

Table 4.1 Final retained radical innovation search practices

Question Number*	Survey Best Practice Question (retained items)	Practice Name
Table 3.4/10	1. Our organisation sets up teams to actively search out and implement new ideas that will take our business in new directions.	Create active teams
Table 3.3/1	2. When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.	Seek multiple applications
Table 3.4/1	3. We have people (part-time or full-time) officially charged with scouting for new ideas, finding new sources of potential radical ideas and looking for trends and developments that might have implications for organisation's future.	Employ scouts
Table 3.6/2	4. We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services.	Suggestion website
Table 3.6/1	5. We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions.	CrowdSourcing
Table 3.3/4	6. We actively try to find those lead users who are innovating to solve problems present at the leading edge of a trend and seek to 'co-evolve' new products and services together with them.	Work with lead users
Table 3.3/5	7. We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need.	Connect with end consumers
Table 3.6/9	8. We currently have systems or procedures in place that ensure insights from mainstream staff who have the opportunity to gather information from external sources are being collected systematically.	Mobile mainstream staff
Table 3.6/10	9. We actively encourage people to go to events/conferences/courses that are outside their current realms of experience.	Activity diversity
Table 3.4/4	10. In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback.	Idea management system
Table 3.5/3	11. In our organisation, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm.	Connect people internally
Table 3.5/4	12. Our organisation operates some form of brokering/bridge-building that involves bringing together people from different knowledge sets, backgrounds or functions in order to support Discontinuous Innovation.	Broker knowledge sets

*Refers to Table number/Question number from Section 3.4.3

4.2.1 Search Q1 Demographic Results

Introduction

This section outlines the demographical data of the respondents of the SearchQ1 survey. Company size, primary industry sector, market position and radical innovation involvement over the previous 5 years is presented.

Size, Sector, Market Position, Innovation Involvement

The medical devices sector was the largest sector representing 26% of the sample (23 firms). Other sectors were also well represented in the sample including software development representing 20 % (18 companies) of the sample and pharmaceutical representing 14% (12 companies) of the sample.

The SearchQ1 sample was balanced in terms of size with 52% of the sample representing SME's and the remaining 48% representing large organisations (based on the European definition of an SME having fewer than 250 employees).

With regards to radical innovation involvement, 48 companies had no radical innovations, 39 companies had one or more radical innovations over the previous 5 years.

12 companies in the SearchQ1 sample indicated they were in a dominant market position, 44 companies thought they were in a strong market position, 15 companies were in a favourable position, 14 companies were viable and 1 company was in a weak position.

Table 4.2 summarises the data in terms of employee number, industry sector, radical innovation involvement and market position.

Table 4.2 Summary of SearchQ1 Sample

	Company Size (number of employees)				
	0-50	**51-250**	**251-1000**	**1001+**	**Total**
Primary Industry Sector:					
Pharmaceutical	3	4	3	2	12 (14%)
Software and ICT	2	4	4	8	18 (21%)
Electrics and Electronics	4	1	2	3	10 (11%)
Medical Devices	5	5	5	8	23 (26%)
Other Technologies	8	5	2	3	18 (21%)
Other	2	2	2	0	6 (7%)
Market Position:					
Dominant	0	1	5	6	12 (14%)
Strong	6	11	12	15	44 (51%)
Favourable	10	4	1	0	15 (17%)
Viable	6	5	0	3	14 (16%)
Weak	1	0	0	0	1 (1%)
Non Viable	1	0	0	0	1 (1%)
Total	24	21	18	24	87 (100%)

Table 4.3 summarises the data in terms of industry sector and radical innovation involvement. The medical device sector was particularly innovative reflecting the trends in the economy during the time period in which the survey was implemented (Forfas 2008). Pharmaceutical sector innovation was relatively low perhaps reflecting the harsh regulatory and clinical testing cycle new pharmaceutical products have to undergo.

Table 4.3 SearchQ1 Sample

	Number of Radical Innovations						
Number of Radical innovations	**0**		**1**		**2+**		**Total**
Company Size	**SME**	**Large**	**SME**	**Large**	**SME**	**Large**	
Primary Industry Sector							
Pharmaceutical	6	3	1	1	0	1	12
Software and ICT	3	5	3	4	0	3	18
Electrics and Electronics	4	2	0	2	1	1	10
Medical Devices	6	3	2	7	2	3	23
Other Technologies	10	2	2	1	1	2	18
Other	3	1	1	1	0	0	6
Total	32	16	9	16	4	10	87

Company Size vs. Market Position vs. Radical Innovation Involvement

Table 4.4 shows the correlations between company size (no of employees), market position and number of radical innovations developed over the previous 5 years. A correlation ($p<0.01$) exists between company size and market position, the larger a company is the more likely it is to be in a strong or dominant market position. Correlation exists between company size and number of radical innovations developed over previous 5 years ($p<0.05$), the larger a company it is the more likely it is to have had one or more successful radical innovation in the previous 5 years. Finally a correlation exists between market position and number of radical innovations developed over previous 5 years ($p<0.05$), if a company had successful radical innovation in the last 5 years then they were more likely to be in a strong or dominant market position.

Table 4.4 Company size vs market position vs. number of radical innovations

N=87	**Company size**	**Market Position**	**No. of Radical Innovations**
Company size	1	.280**	.269*
Market Position		1	.213*
No. Radical Innovations			1

**p<0.01, *p<0.05

4.2.2 Total Sample Practice Results

This section presents the results to answer research sub question R1a;

> *R1a: What practices do companies currently use when **searching** for new ideas during the front end of the radical innovation process?*

Table 4.5 shows the mean usage and importance results for the 12 retained search practices for the entire SearchQ1 sample. The most used/important are highlighted with arrows. Significant testing, using the Wilcoxon signed-rank test, between usage and importance for the entire sample is also presented. A spider diagram is also presented in Figure 4.1 visually demonstrating the gap that exists between search practice usage and search practice importance for the entire sample.

Table 4.5 Search practices mean usage and mean importance for entire sample

Practice	Use (Scale 1-5)	Importance (Scale 1-5)	Use vs Importance[1] Z value
Create active teams	3.36	4.21	-5.232**
Seek multiple applications	→ 3.39	4.29	-5.741**
Employ scouts	3.37	→ 4.43	-5.825**
Suggestion website.	1.97	3.62	-6.462**
CrowdSourcing	1.78	3.39	-6.478**
Work with lead users.	→ 3.68	→ 4.31	-4.924**
Connect with end consumers.	→ 3.90	→ 4.45	-4.098**
Mobile mainstream staff.	2.79	4.01	-6.462**
Activity diversity.	3.16	4.10	-5.617**
Idea management system.	2.59	4.00	-6.247**
Connect people internally.	2.98	4.09	-5.950**
Broker knowledge sets.	3.13	4.01	-5.330**

**p<0.01, *p<0.05 [1]Based on Wilcoxon signed-rank test, n=87

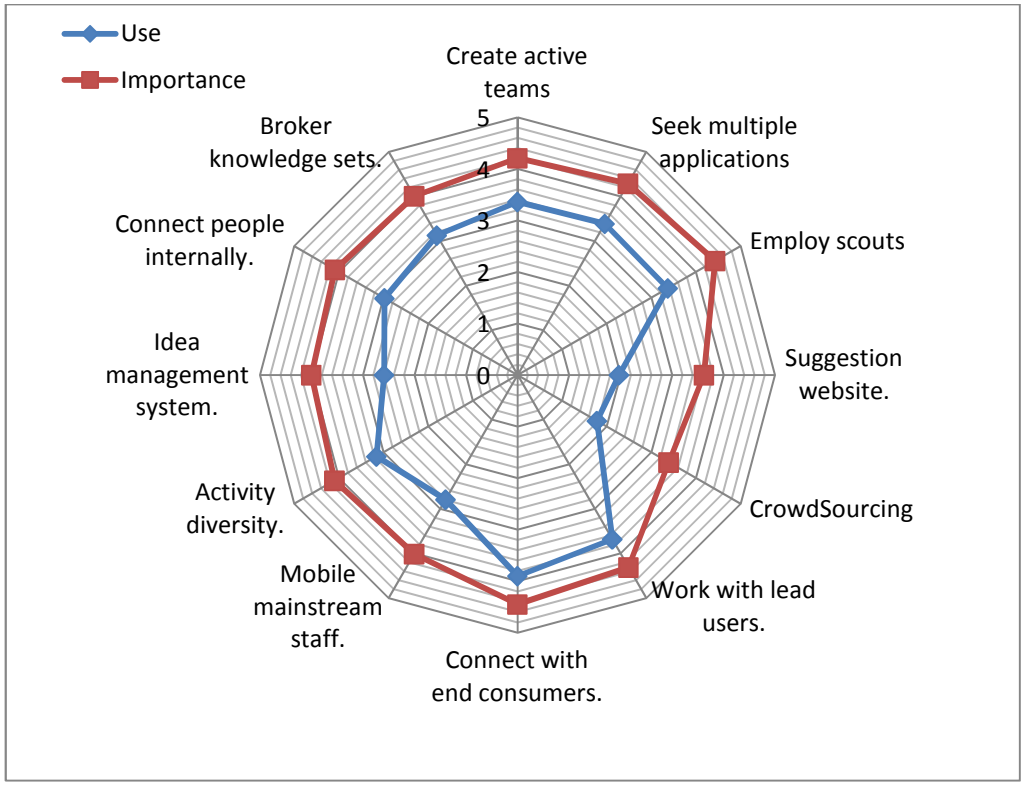


Figure 4.1 Entire Search Q1 Sample: Practice usage vs. Practice Importance

The most used search practices were 'seek multiple applications', 'work with lead users' and 'connect with end consumers'. The most used practices were similar to the most importance practices in particularly the importance of 'work with lead users' and 'connect with end consumers'. A key point to note is the large difference that exists

between usage and the importance of each of the search practices with the importance rating being significantly higher for every practice.

4.2.3 Usage by Performance

A comparison of the usage between the 'innovators' and 'non-innovators' and the 'market leaders' and 'market followers' was completed using the Mann–Whitney U test (also called the Mann–Whitney–Wilcoxon (MWW) or Wilcoxon rank-sum test) which is a non-parametric statistical hypothesis test for assessing whether one of two samples of independent observations tends to have larger values than the other. The 'innovators' in the data set were defined as the companies that had one or more radical innovations over the previous five years. The 'non-innovators' were defined as the companies who had no radical innovations in the previous 5 years. The companies in dominant or strong market positions were seen as the 'market leaders'. All other companies were seen as the 'market followers'.

Innovators v Non innovators

This section presents the results to answer research sub question R2a;

> *R2a: Which **search** practices are linked with increased numbers of radical innovations?*

Table 4.6 shows the mean usage for the innovator and the non-innovator organisations. The most used/important practices are highlighted with arrows. Significance testing reveals some key differences in terms of usage of the search practices by the innovator companies over the non-innovator companies.

A spider diagram is also presented in Figure 4.2 visually demonstrating the gap that exists between search practices usage for the two groups.

Table 4.6 Mean usage of search practices: Innovators vs. Non-innovators

Practice	Innovators Use (Scale 1-5) n=44	Non-Innovators Use (Scale 1-5) n=43	Innovators V Non-innovator Z-Value[1]
Create active teams	3.68	3.05	-2.240*
Seek multiple applications	3.78	3.02	-3.059**
Employ scouts	3.71	3.02	-2.117*
Suggestion website	2.05	1.90	-.372
CrowdSourcing	2.03	1.56	-2.226*
Work with lead users.	3.86	3.16	-1.960*
Connect with end consumers	4.00	3.79	-1.221
Mobile mainstream staff.	3.11	2.50	-2.370*
Activity diversity	3.33	3.00	-1.090
Idea management system	2.67	2.51	-.624
Connect people internally	3.24	2.71	-1.939
Broker knowledge sets	3.36	2.90	-1.698

**p<0.01, *p<0.05, [1] Mann–Whitney–Wilcoxon

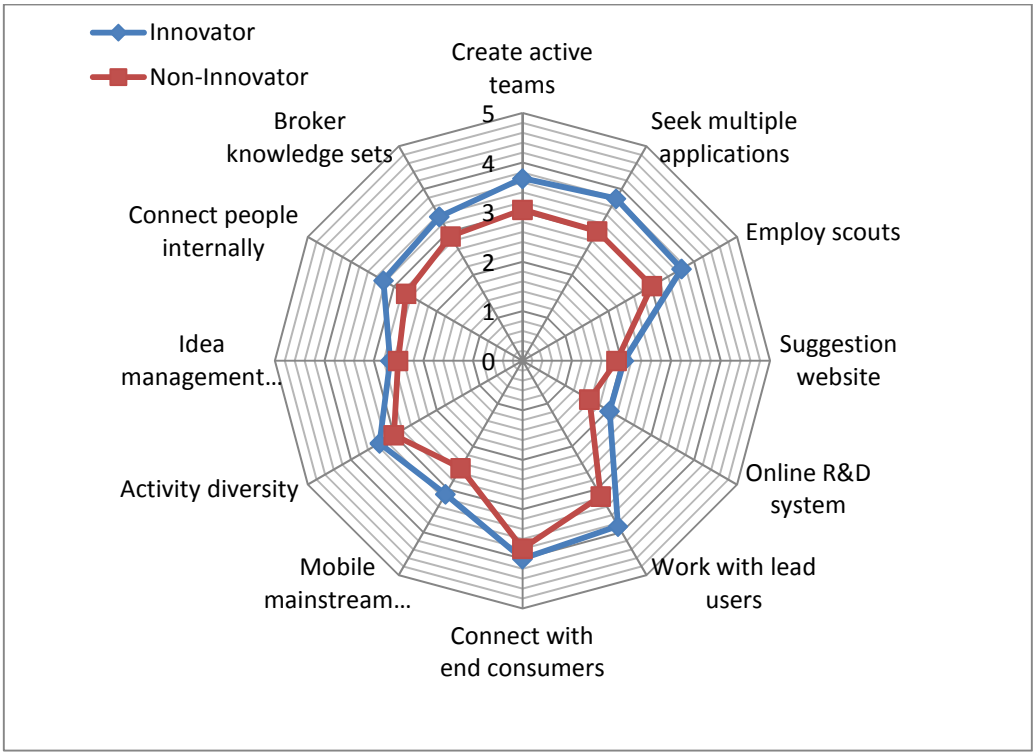


Figure 4.2 Practice mean usage: Innovators vs. Non-Innovators

The most used search practices by the innovator companies were 'seek multiple applications', 'work with lead users' and 'connect with end consumers'. The most used practices by the non-innovator companies were similar; however, level of usage was

lower overall. The innovator companies used every practice more than the non-innovator companies and used ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, ‘crowdsourcing’, ‘work with lead users’ and ‘mobile mainstream staff’ significantly more than the non-innovators.

Table 4.7 shows the mean importance for innovators and the non-innovating organisations. Statistical testing (Mann–Whitney–Wilcoxon) between the perceived importance revealed no significant differences between the two groups. No spider diagram is shown given that the difference between the two groups is negligible. Most important practices were similar between both groups with practices such as ‘employ scouts’ and ‘connect with end consumers’ receiving high ratings.

Table 4.7 Mean importance of search practices: Innovators vs. Non-innovators

Practice	Innovators Importance (Scale 1-5) n=44	Non-Innovators Importance (Scale 1-5) n=43	Innovators V Non-innovator Z-Value[1]
Create active teams	4.21	4.21	-.005
Seek multiple applications	4.36	→ 4.22	-1.111
Employ scouts	→ 4.44	→ 4.43	-.275
Suggestion website	3.38	3.83	-2.069*
CrowdSourcing	3.33	3.44	-.441
Work with lead users.	→ 4.35	4.28	-.951
Connect with end consumers	→ 4.50	→ 4.40	-.772
Mobile mainstream staff.	4.03	4.00	-.053
Activity diversity	4.00	4.19	-1.041
Idea management system	4.00	4.00	-.430
Connect people internally	4.03	4.15	-.693
Broker knowledge sets	4.06	3.98	-.474

**p<0.01, *p<0.05, [1] Mann–Whitney–Wilcoxon

Market Leaders V Market Followers

This section presents the results to answer research sub question R3a;

*R3a: Which **search** practices are linked with more dominant market positions?*

Table 4.8 shows the mean usage for the market leaders and the market followers organisations. The most used/important practices are highlighted with arrows. Significance testing reveals some key differences in terms of usage of the search

practices by the market leaders companies over the market follower companies. A spider diagram is also presented in Figure 4.3 visually demonstrating the gap that exists between search practice usage for the two groups.

Table 4.8 Mean usage of search practices: Market leaders vs. Market followers.

Practice	Market Leaders Use (Scale 1-5) n=56	Market Followers Use (Scale 1-5) n=30	Market leaders v Market Followers Z-Value[1]
Create active teams	3.60	2.93	-2.287*
Seek multiple applications	3.58	3.06	-1.986*
Employ scouts →	3.61	2.93	-2.132*
Suggestion website	1.98	1.96	-.174
CrowdSourcing	1.92	1.55	-1.595
Work with lead users. →	3.74	→ 3.58	-.812
Connect with end consumers →	4.11	→ 3.52	-2.273*
Mobile mainstream staff.	2.88	2.62	-.988
Activity diversity	3.15	3.17	-.129
Idea management system	2.68	2.43	-.785
Connect people internally	2.96	3.00	-.243
Broker knowledge sets	3.08	→ 3.21	-.461

**p<0.01, *p<0.05, [1]Mann–Whitney–Wilcoxon

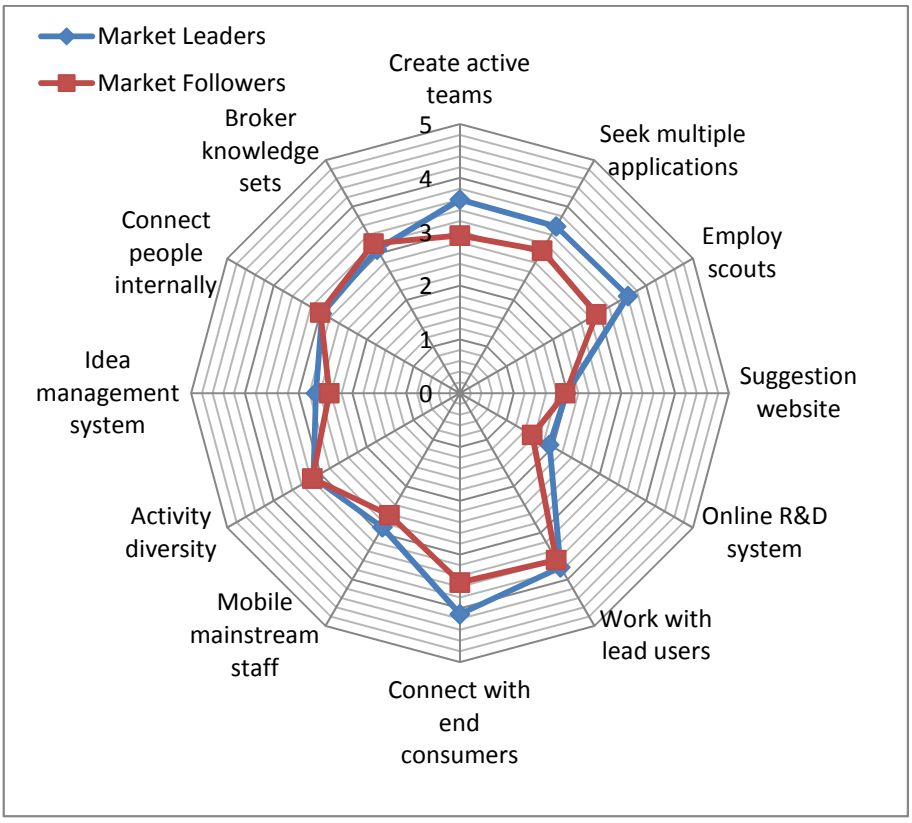


Figure 4.3 Practice mean usage: Market Leaders vs. Market Followers

The most used search practices by the market leaders were 'employ scouts', 'work with lead users' and 'connect with end consumers'. The most used practices by the market follower companies were similar; however, level of usage over many of the practices was lower overall. The market leaders 'create active teams', 'seek multiple applications', 'employ scouts' and 'connect with end consumers' significantly more than the market followers.

Table 4.9 shows the mean importance for Market Leaders v Market Followers. Statistical testing (Mann–Whitney–Wilcoxon) between the perceived importance revealed no significant differences between the two groups and both groups in agreement relating to the most important practices. No spider diagram is shown given that the difference between the two groups is negligible.

Table 4.9 Mean importance search practices: Market leaders vs Market followers

Practice	Market leaders Importance (Scale 1-5) n= 56	Market Followers Importance (Scale 1-5) n=30	Market leaders v Market Followers Z-Value[1]
Create active teams	4.20	4.24	-0.247
Seek multiple applications	4.27	→ 4.33	-0.293
Employ scouts	→ 4.51	→ 4.29	-1.617
Suggestion website	3.64	3.57	-0.297
CrowdSourcing	3.43	3.31	-0.824
Work with lead users.	→ 4.36	4.23	-0.993
Connect with end consumers	→ 4.51	→ 4.34	-0.876
Mobile mainstream staff.	4.04	3.96	-0.016
Activity diversity	4.09	4.11	-0.069
Idea management system	4.06	3.89	-0.715
Connect people internally	4.04	4.19	-0.741
Broker knowledge sets	3.96	4.11	-0.691

**p<0.01, *p<0.05, [1] Mann–Whitney–Wilcoxon

4.2.4 SME vs. Large Organisations

This section presents the results to answer research sub question R4a;

> *R4a: What is the impact of company size on the use of **search** practices for radical innovation?*

Table 4.10 shows the mean usage for SMEs and large organisations. Significance testing reveals some key differences in terms of usage of the search practices. A spider

diagram is also presented in Figure 4.4 visually demonstrating the gap that exists between search practice usage for the two groups.

Table 4.10 Mean usage of search practices: SME vs. Large companies.

Practice	SME (Use) (Scale 1-5) n=55	Large (Use) (Scale 1-5) n=52	SME v Large Z value[1]
Create active teams	2.98	→ 3.85	-3.095**
Seek multiple applications	→ 3.14	3.70	-2.324*
Employ scouts	3.02	3.82	-2.467*
Suggestion website	1.78	2.14	-1.687
CrowdSourcing	1.62	1.97	-2.151*
Work with lead users.	→ 3.51	→ 3.88	-1.607
Connect with end consumers	→ 3.48	→ 4.41	-3.527**
Mobile mainstream staff.	2.63	2.86	-0.953
Activity diversity	3.07	3.21	-0.405
Idea management system	2.72	2.51	-0.627
Connect people internally	2.76	3.21	-1.424
Broker knowledge sets	2.90	3.37	-1.660

**p<0.01, *p<0.05, [1] Mann–Whitney–Wilcoxon

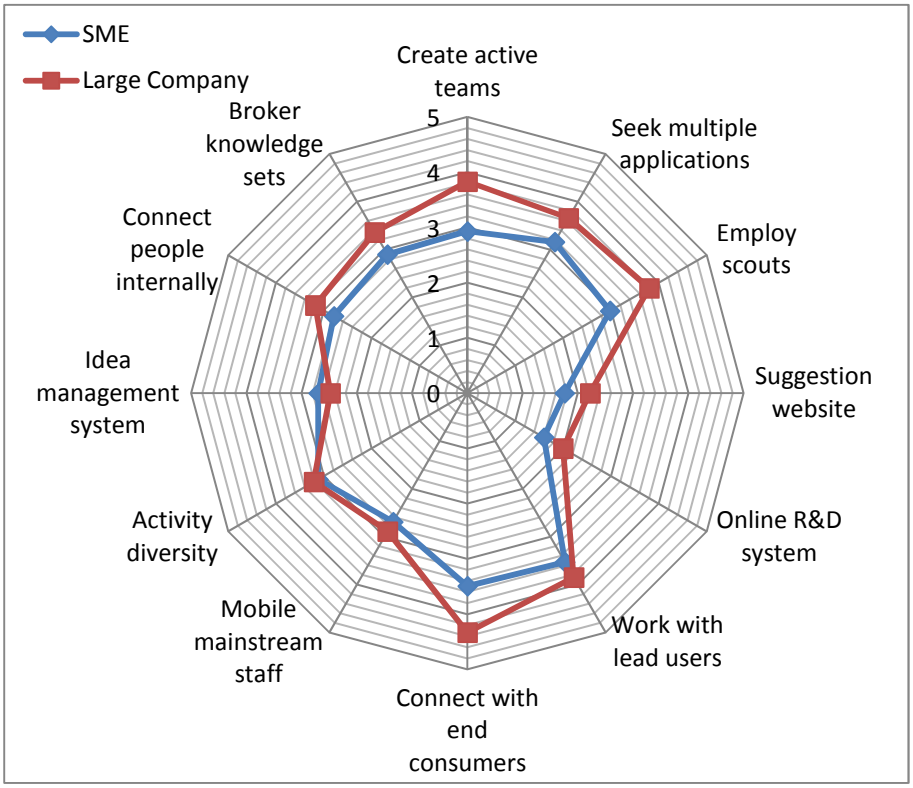


Figure 4.4 Practice usage: SME vs. Large Companies

The most used search practices for both groups were again similar with ‘work with lead users’ and ‘connect with end consumers’ both receiving high ratings. Overall the large companies engaged in the search practices more than the SME companies and the large companies use ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, ‘engage lead users’ and ‘connect with end consumers’ significantly more than the SMEs.

Table 4.11 shows the mean importance for SMEs and large organisations. No spider diagram is presented here as the differences are relatively small. Significance testing reveals two differences in terms of importance of the search practices between large and SME companies with large companies rating ‘engage lead users’ and ‘connect with end consumers’ significantly higher than SMEs.

Table 4.11 Mean importance of search practices: SME vs. Large companies

Practice	SME Importance (Scale 1-5) n=55	Large Importance (Scale 1-5) n=52	SME V Large Z value[1]
Create active teams	4.10	4.35	-1.710
Seek multiple applications	4.16	4.36	-.763
Employ scouts	→ 4.20	→ 4.49	-1.239
Suggestion website	3.62	3.68	-.694
CrowdSourcing	3.35	3.59	-.006
Work with lead users.	→ 4.25	→ 4.51	-1.990*
Connect with end consumers	→ 4.36	→ 4.64	-2.306*
Mobile mainstream staff.	3.91	4.09	-.391
Activity diversity	4.05	4.08	-.907
Idea management system	3.84	4.21	-.203
Connect people internally	3.99	4.24	-.543
Broker knowledge sets	3.95	4.13	-.249

*p<0.05, [1] Mann–Whitney–Wilcoxon

4.2.5 Summary

This section presented the individual item results of the exploratory search survey, SearchQ1. Current usage and importance of the individual practices was presented for the entire sample, the innovators and the non innovators, market leaders and market followers and SME and large companies. The main findings are;

- A relationship exists between company size, market position and radical innovation involvement;
    - The larger a company is the more likely it is to be in a strong or dominant market position;
    - The larger a company is then the more radical innovations they developed over previous 5 years;
    - The stronger the market position of a company is then the more radical innovations they developed over previous 5 years.
- The most used search practices for the entire sample were ‘seek multiple applications’, ‘work with lead users’ and ‘connect with end consumers’.
- A significant difference exists between the usage and importance of each search practices for the entire sample.
- The innovators used many of the search practices more than the non-innovators, in particular, ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, ‘crowdsourcing’, ‘work with lead users’ and ‘mobile mainstream staff’ were used significantly more than the non-innovators.
- The market leaders used many of the search practices more than the market followers, in particular ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’ and ‘connect with end consumers’ significantly more than the market followers.
- The large companies use ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, ‘work with lead users’ and ‘connect with end consumers’ significantly more than the SMEs.

All the results will be discussed in the Chapter 6. The following section presents the results of the exploratory selection survey; SelectQ2.

4.3 SELECTION PRACTICE RESULTS

As described in Section 3.4.6 exploratory factor analysis on the SelectQ2 survey resulted in the practice list being reduced from 20 practices to 14 practices. Practices were eliminated in an iterative process outlined in Appendix H-I. This section is based around the 14 selection practices that comprise the final selection factors. The

exploratory factor analysis of these 14 practices is presented in Chapter 5. The 14 retained items are presented in Table 4.12. Each question has been designated a 'practice name' to allow for quick reference within tables and text.

Table 4.12 Retained Radical Innovation Selection Practices

Question Number*	Survey Best Practice Question (retained items)	Practice Name
Table 3.7/2	1. We remain open to re-consider our future position in our industry value chain and make shifts if we have to.	Strategic flexibility
Table 3.7/3	2. When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market.	Strategic openness
Table 3.4/4	3. We use prototypes to build bridges in the selection process. By using prototypes we 'build bridges' in the minds of potential supporters (e.g. senior management, investors etc.) between the current state of affairs and what might be if this project is given opportunity to develop.	Prototyping to build bridges
Table 3.7/5	4. We use prototyping to reduce uncertainty when making selection decisions i.e. we often 'buy a look' before deciding whether or not proceeding.	Prototyping to reduce risk
Table 3.7/6	5. We use prototyping to 'take a small step' in a few different directions before committing to a large step in one direction.	Prototyping to explore
Table 3.9/1	6. When evaluating radical opportunities we use alternative measurement and evaluation criteria to the ones used for non-radical opportunities.	Alternative measurement.
Table 3.9/2	7. Our senior managers understand that it takes times for radical innovation projects to acquire the necessary learning experience before they can move forward.	Senior management support
Table 3.9/4	8. Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and prove themselves.	Longer time timeline
Table 3.8/1	9. In the company there are identifiable project champions in senior positions within the company who promote the development of radical and discontinuous projects?	Senior champions.
Table 3.8/3	10. Our firm funds radical innovation project development differently than they fund incremental innovation projects.	Alternative funding
Table 3.8/5	11. The process for accessing and leveraging resources (funding, personnel, capital equipment, and other organisational resources) for radical innovation projects in our firms is clear.	Clear ring fenced funding
Table 3.8/7	12. There is an atmosphere in our organisation which encourages everyone to take part in innovation.	Innovation embraced
Table 3.8/8	13. We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs	Risk taking encouraged
Table 3.8/9	14. In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.	Failure accepted

*Refers to Table number/Question number from Section 3.4.4

4.3.1 Select Q2 Demographic Results

Introduction

This section outlines the demographical data of the respondents to the SelectQ2 survey. Company size, industry sector, market position and radical innovation involvement over the previous 5 years is analysed.

Size, Sector, Market Position, Radical Innovation Involvement

The medical devices sector was the largest sector representing 20% of the sample (19 firms). Other sectors were also well represented in the sample including software representing 17 % (16 companies) of the sample and pharmaceutical representing 18% (17 companies) of the sample.

The SelectQ2 survey sample was balanced in terms of size with 46% (43 companies) of the sample representing SME's and the remaining 54% (51 companies) representing large organisations (based on the European definition of an SME having fewer than 250 employees).

With regards to radical innovation involvement, 45 companies had no radical innovations, 49 companies had one or more radical innovations over the previous 5 years.

29 companies in the SelectQ2 sample felt they were in a dominant market position, 28 companies thought they were in a strong market position, 16 companies were in a favourable position, 12 companies were viable and 7 companies felt in a weak position.

Table 4.13 summarises the data in terms of employee number, industry sector, radical innovation involvement and market position. The demographics of the selection survey mirror the demographics of the SearchQ1 survey ensuring similar samples were used for both surveys making the result more generalisable. The comparison of the survey samples are discussed in detail in Section 5.2.

Table 4.13 Summary of SelectQ2 Sample

	Company Size (number of employees)					
	0-50	**51-250**	**251-1000**	**1001+**	**Total (SelectQ2)**	**Total (SearchQ1)**
Industry Sector:						
Pharmaceutical	3	3	4	7	17 (18%)	12 (14%)
Software and ICT	6	5	3	2	16 (17%)	18 (21%)
Electrics and Electronics	1	3	3	3	10 (11%)	10 (11%)
Medical Devices	4	2	7	6	20 (21%)	23 (26%)
Other Technologies	7	2	3	8	19 (20%)	18 (21%)
Other	3	4	2	3	12 (13%)	6 (7%)
Market Position:						
Dominant	3	4	7	15	29 (31%)	12 (14%)
Strong	3	6	10	9	28 (30%)	44 (51%)
Favourable	6	6	3	1	16 (17%)	15 (17%)
Viable	7	2	2	1	12 (13%)	14 (16%)
Weak	2	1	0	4	7 (7%)	1 (1%)
non viable	2	0	0	0	2 (2%)	1 (1%)
Total SelectQ2	24	19	22	29	94 (100%)	
Total Search Q1	24	21	18	24		87 (100%)

Table 4.14 summarises the data in terms of industry sector and radical innovation involvement. These results echoed those of the SearchQ1 survey with the medical device sector again achieving high performance in terms of radical innovation involvement. Pharmaceutical sector innovation was again relatively low perhaps reflecting the harsh regulatory and clinical testing cycle new pharmaceutical products have to undergo. Innovation in the ICT and electronics industries were also performing well in terms of radical innovation involvement indicating companies responding strongly to the never-ending demand for new technology by consumers.

Table 4.14 SelectQ2 Sample

	Number of Radical Innovations						
Number of Radical Innovations	**0**		**1**		**2+**		**Total**
Company Size	**SME**	**Large**	**SME**	**Large**	**SME**	**Large**	
Primary Industry Sector							
Pharmaceutical	6	6	0	3	0	2	17
Software and ICT	5	2	4	0	2	3	16
Electrics and Electronics	2	3	1	2	1	1	10
Medical Devices	4	1	2	4	2	7	20
Other Technologies	5	6	1	2	1	4	19
Other	3	2	2	2	2	1	12
Total	25	20	10	13	8	18	94

Company Size vs Market Position vs Radical Innovation Involvement

Table 4.15 shows the correlations between company size, market position and involvement in radical innovation. A strong correlation ($p<0.01$) exists between company size and market position, the larger a company is the more likely it is to be in a strong or dominant market position. Correlation also exists between company size and No. of radical innovations developed over previous 5 years ($p<0.05$), the larger a company it is the more likely it is to have had one or more successful radical innovation in the previous 5 years. Finally a correlation exists between market position and No. of radical innovations developed over previous 5 years ($p<0.05$), if a company had had 1 or more successful radical innovation in the last 5 years then they were more likely to be in a strong or dominant market position. These results replicate that of the first survey adding to the reliability and validity of the results.

Table 4.15 Company size vs market position vs. number of radical innovations

N=94	**Company size**	**Market Position**	**No. of Radical Innovations**
Company size	1	0.260*	0.286**
Market Position		1	0.384**
No. Radical Innovations			1
**P<0.01, *p<0.05			

4.3.2 Total Sample Practice Results

This section presents the results to answer research sub question R1b;

> *R1b: What practices do companies currently use when **selecting** for new ideas during the front end of the radical innovation process?*

Table 4.16 shows the mean usage and importance results for the 14 selection practices for the entire SelectQ2 sample. Significant testing, using the Wilcoxon signed-rank test, between usage and importance for the entire sample is also presented. The most used/important are highlighted with arrows.

A spider diagram is also presented in Figure 4.5 visually demonstrating the gap that exists between selection practice usage and selection practice importance for the entire sample.

Table 4.16 Selection Practices Mean Use and Importance for Entire Sample

	Use (Scale 1-5)	Importance (Scale 1-5)	Use v Importance Z Value[1]
Failure accepted	3.26	4.28	-5.699**
Risk taking encouraged	3.07	4.32	-6.168**
Innovation embraced	3.52	4.42	-5.597**
Clear ring fenced funding	3.09	3.97	-5.756**
Prototyping to build bridges	3.54	4.15	-4.199**
Prototyping to explore.	3.50	3.92	-3.355**
Prototyping to reduce risk	3.49	3.83	-2.590*
Strategic openness	3.97	4.21	-2.518*
Strategic flexibility	3.95	4.26	-3.173**
Senior champions.	3.46	4.31	-5.534**
Alternative measurement.	3.32	3.85	-3.848**
Alternative funding	3.05	3.78	-3.919**
Longer time timeline	3.33	4.03	-4.851**
Senior management support	3.63	4.17	-4.469**

**p<0.01, *p<0.05, [1] Wilcoxon signed-rank test, N=94

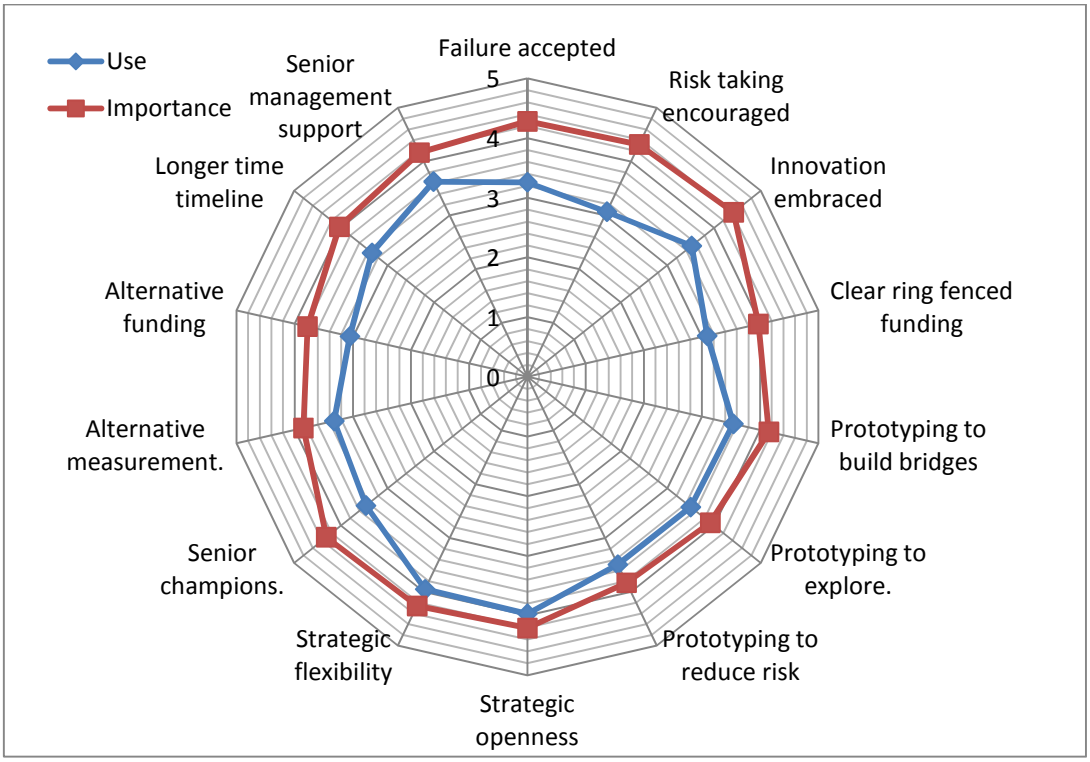


Figure 4.5 Entire Selection Sample: Mean usage vs. Mean importance

The most used practices were ‘strategic openness’, ‘strategic flexibility’ and ‘senior management support’. The most used practices were different to the most importance practices. A key point to note is the large difference that exists between usage and the important of each of the selection practices with the importance rating being significantly higher for every practice.

4.3.3 Usage by Performance

A comparison of the usage between the ‘innovators’ and ‘non-innovators’ and the ‘market leaders’ and ‘market followers’ was completed using the Mann–Whitney U test. The ‘innovators’ in the data set were again defined as the companies that had one more radical innovations over the previous five years. The ‘non-innovators’ were defined as the companies who had no radical innovations in the previous 5 years. The companies in dominant or strong market positions were seen as the ‘market leaders’. All other companies were seen as the ‘market followers’.

Innovators v Non Innovators

This section presents the results to answer research sub question R2b;

> *R2b: Which **selection** practices are linked with increased numbers of radical innovations?*

Table 4.17 shows the mean usage of the selection practices for the innovator and the non-innovator organisations. The most used/important practices are highlighted with arrows. A spider diagram is also presented in Figure 4.6 visually demonstrating the gap that exists between selection practices usage for the two groups.

Table 4.17 Mean usage of selection practices: Innovators vs. Non-innovators

Practice	Non-Innovators Use (Scale 1-5) n=45	Innovators Use (Scale 1-5) n=49	Non-Innovators v innovators Z-Value[1]
Failure accepted	2.79	3.70	-3.591**
Risk taking encouraged	2.60	3.51	-3.533**
Innovation embraced	3.00	4.00	-3.925**
Clear ring fenced funding	2.55	3.60	-3.874**
Prototyping to build bridges	3.27	3.80	-1.824
Prototyping to explore.	3.31	3.68	-1.455
Prototyping to reduce risk	3.14	3.83	-2.696**
Strategic openness	3.73	4.18	-2.453*
Strategic flexibility	3.76	4.12	-1.939
Senior champions.	3.07	3.81	-2.791**
Alternative measurement.	2.75	3.86	-3.945**
Alternative funding	2.35	3.71	-4.585**
Longer time timeline	2.77	3.85	-4.314**
Senior management support	3.29	3.93	-2.717**

**p<0.01, *p<0.05, [1]Mann–Whitney–Wilcoxon

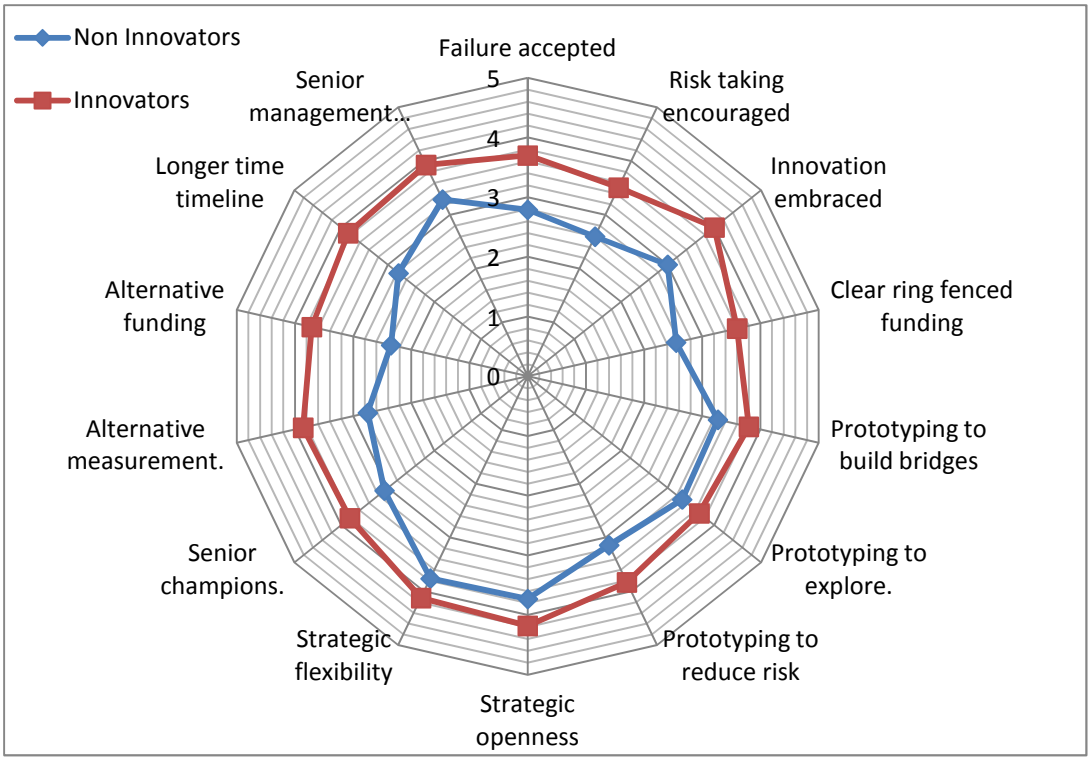


Figure 4.6 Practice usage: Innovator companies vs. Non-Innovator Companies

The most used selection practices by the innovator companies 'strategic openness', 'strategic flexibility' and 'senior management support'. The most used practices by the non-innovator companies were similar, however, level of usage was lower overall. The innovator companies used every selection practice more than the non-innovator companies and used 11 of the 14 practices significantly more than the non-innovator companies.

Table 4.18 compares the mean importance between the innovators and the non-innovating organisations. No spider diagram is shown given that the difference between the two groups is negligible. Three minor differences exist between the importance of the selection practices when comparing the innovators and the non-innovators with the innovators rating 'clear ring fenced funding' 'risk taking encouraged' and 'prototyping to reduce risk' significantly more important than the non-innovators.

Table 4.18 Importance of selection practices: Innovators vs. Non-innovators

Practice	Non-Innovators Importance (Scale 1-5) n==45	Innovators Importance (Scale 1-5) n=49	Non-innovators v innovators Z Value[1]
Failure accepted	4.21 →	4.35	-.622
Risk taking encouraged	4.02 →	4.41	-2.249*
Innovation embraced →	4.30 →	4.53	-1.244
Clear ring fenced funding	3.73	4.18	-2.286*
Prototyping to build bridges	3.95	4.33	-1.551
Prototyping to explore.	3.90	3.93	-.491
Prototyping to reduce risk	3.59	4.04	-2.354*
Strategic openness	4.16	4.26	-.206
Strategic flexibility →	4.25	4.30	-.349
Senior champions. →	4.29	4.34	-.238
Alternative measurement.	3.65	4.05	-1.590
Alternative funding	3.67	3.90	-1.235
Longer time timeline	3.86	4.20	-1.583
Senior management support	4.10	4.25	-.695

**p<0.01, *p<0.05, [1]Mann–Whitney–Wilcoxon

Market Leaders V Market Followers

This section presents the results to answer research sub question R3b;

> *R3b: Which **selection** practices are linked with more dominant market positions?*

Table 4.19 shows the mean usage for the market leaders and the market followers organisations. The most used/important practices are highlighted with arrows. A spider diagram is also presented in Figure 4.7 visually demonstrating the gap that exists between selection practice usage for the two groups.

Table 4.19 Mean usage of selection practices: Market leaders vs. Market followers.

Practice	Market Leaders Use (Scale 1-5) n=57	Market Followers Use (Scale 1-5) n=37	Market leaders v Market Followers Z-Value[1]
Failure accepted	3.25	3.27	-0.027
Risk taking encouraged	3.07	3.06	-0.025
Innovation embraced	→ 3.69	3.23	-2.041*
Clear ring fenced funding	3.16	2.97	-0.750
Prototyping to build bridges	3.66	3.35	-1.168
Prototyping to explore.	3.67	3.23	-1.846
Prototyping to reduce risk	3.65	3.23	-1.737
Strategic openness	3.97	→ 3.92	-0.763
Strategic flexibility	→ 4.03	→ 3.86	-1.082
Senior champions.	3.63	3.18	-1.620
Alternative measurement.	3.51	3.00	-1.829
Alternative funding	3.24	2.76	-1.550
Longer time timeline	3.57	2.91	-2.508*
Senior management support	→ 3.84	→ 3.28	-1.960*

**p<0.01, *p<0.05, [1]Mann–Whitney–Wilcoxon

The market leaders used most of the practices more often than the market followers. Testing reveals three significant differences in terms of usage of the selection practices by the market leaders companies over the market follower companies; ‘innovation embraced’, ‘longer timeline’ and ‘senior management support’.

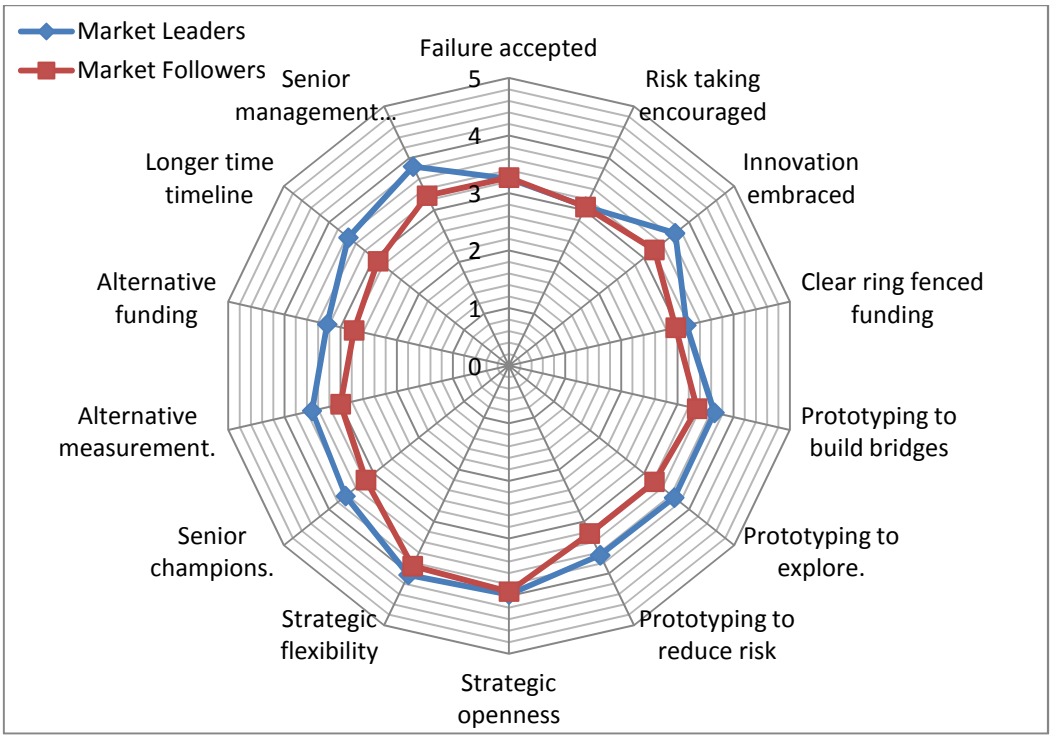


Figure 4.7 Selection practice mean usage: Market Leaders vs. Market Followers

Table 4.20 compares the mean importance between the Market leaders v Market Followers showing a single difference in terms of importance; senior management support. No spider diagram is shown given that the difference between the two groups is negligible.

Table 4.20 Mean importance selection practices: Market leaders vs. Followers

Practice	Market leaders Importance (Scale 1-5) n==57	Market Followers Importance (Scale 1-5) n=37	Market leaders v Market Followers Z-Value[1]
Failure accepted	4.29	→ 4.27	-0.335
Risk taking encouraged	4.16	4.31	-0.632
Innovation embraced	→ 4.45	→ 4.37	-0.625
Clear ring fenced funding	3.89	4.10	-0.481
Prototyping to build bridges	4.26	3.97	-1.410
Prototyping to explore.	3.94	3.88	-0.612
Prototyping to reduce risk	3.87	3.76	-0.663
Strategic openness	→ 4.36	4.14	-1.646
Strategic flexibility	→ 4.35	4.00	-1.618
Senior champions.	4.29	→ 4.36	-0.104
Alternative measurement.	3.96	3.67	-1.680
Alternative funding	3.85	3.69	-0.980
Longer time timeline	4.11	3.91	-1.351
Senior management support	4.32	3.94	-2.125*

*p<0.05, [1]Mann–Whitney–Wilcoxon

4.3.4 SME vs . Large Organisations

This section presents the results to answer research sub question R4b;

> *R4b: What is the impact of company size on the use of **selection** practices for radical innovation?*

Table 4.21 shows the mean usage for SMEs and large organisations. Significance testing reveals some key differences in terms of usage of the selection practices. A spider diagram is also presented in Figure 4.8 visually demonstrating the gap that exists between selection practice usage for the two groups.

Table 4.21 Mean usage: SME vs Large organisation

Practice	SME Use (Scale 1-5) n=43	Large Use (Scale 1-5) n=51	SME Vs Large Z Value[1]
Failure accepted	3.33	3.20	-.481
Risk taking encouraged	3.21	2.94	-1.140
Innovation embraced	3.45	3.57	-.851
Clear ring fenced funding	2.82	3.31	-1.921
Prototyping to build bridges →	3.46	3.61	-.529
Prototyping to explore. →	3.30 →	3.67	-1.629
Prototyping to reduce risk	3.31	3.65	-1.441
Strategic openness →	3.79 →	4.12	-1.840
Strategic flexibility →	3.77 →	4.10	-2.429*
Senior champions.	3.24	3.64	-1.363
Alternative measurement.	3.08	3.52	-1.540
Alternative funding	2.69	3.37	-2.225*
Longer time timeline	3.02	3.58	-2.061*
Senior management support	3.36	3.85	-1.839

*p<0.05, [1]Mann–Whitney–Wilcoxon

The most used selection practices for both groups were again similar with ‘strategic openness’ and ‘strategic flexibility’ both receiving high ratings. Overall the large companies engaged in the selection practices more than the SME companies, however, only three of the practices were used significantly more; ‘strategic flexibility, ‘alternative funding’ and ‘longer timeline’ significantly more than the SMEs.

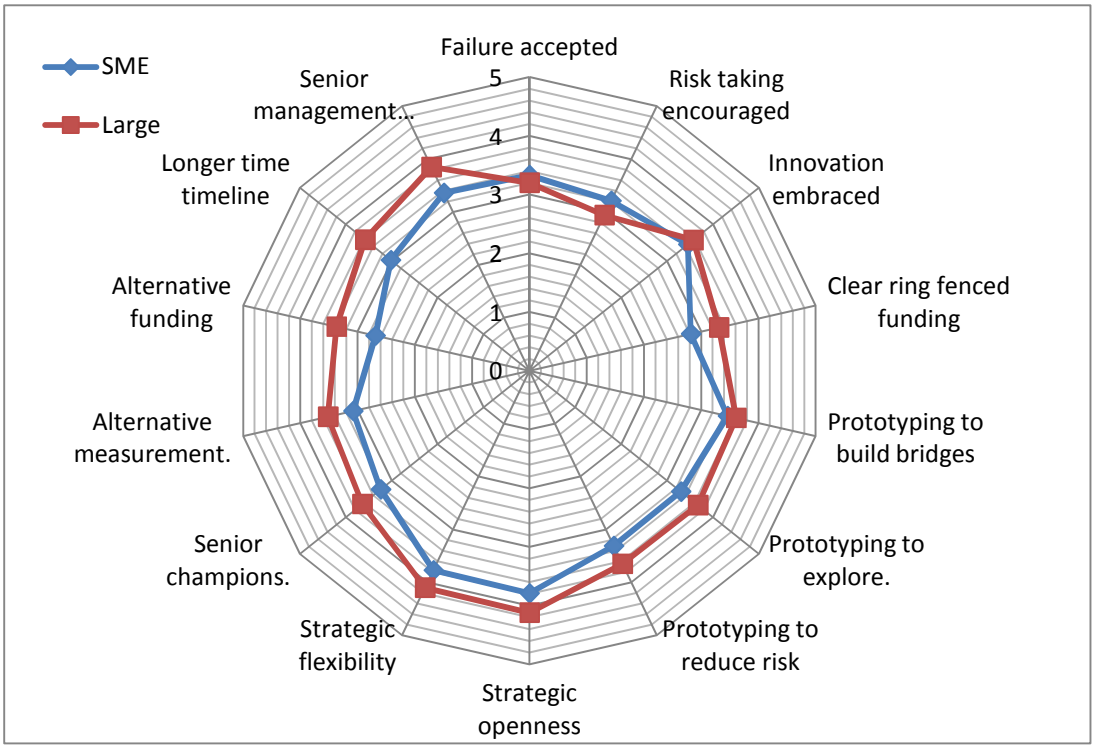


Figure 4.8 Practice usage: SME companies vs. Large Companies

Table 4.22 compares the difference in perceived importance between SMEs and large organisations. No significant differences exist. No spider diagram is presented as the differences are relatively small.

Table 4.22 Mean Importance: SME vs Large organisation

Practice	SME Importance (Scale 1-5) n=43	Large Importance (Scale 1-5) n=51	SME v Large Z Value[1]
Failure accepted	4.30	4.27	-.473
Risk taking encouraged	4.26	4.19	-.631
Innovation embraced	4.31	4.51	-1.085
Clear ring fenced funding	3.97	3.96	-.015
Prototyping to build bridges	4.08	4.21	-.217
Prototyping to explore.	3.85	3.98	-.346
Prototyping to reduce risk	3.70	3.93	-1.280
Strategic openness	4.10	4.31	-.739
Strategic flexibility	4.12	4.42	-1.631
Senior champions.	4.28	4.35	-.865
Alternative measurement.	3.86	3.84	-.263
Alternative funding	3.68	3.88	-1.524
Longer time timeline	3.98	4.09	-.282
Senior management support	4.00	4.32	-1.174

**p<0.01, *p<0.05, [1]Mann–Whitney–Wilcoxon

4.3.5 Summary

This section presented the results of the exploratory selection survey; SelectQ2. Current usage and importance of the individual practices was presented for the entire sample, the innovators and the non innovators, market leaders and market followers and SME and large companies.

- A relationship exists between company size, market position and radical innovation involvement mirroring that of the results of the SearchQ1 survey.
- The most used selection practices for the entire sample were ‘strategic openness’, ‘strategic flexibility’ and ‘senior management support’.
- A significant difference exists between the usage and importance of each selection practice for the entire sample.
- The innovators used 11 of the 14 selection practices; ‘failure accepted’, ‘risk taking encouraged’, ‘innovation embraced’, ‘clear ring fenced funding’, ‘prototyping to reduce risk’, ‘strategic openness’, ‘senior champions’, ‘alternative measurement’, ‘alternate funding’, ‘longer timeline’, and ‘senior management support’ significantly more than the non-innovators.
- The market leaders used three of the selection practices significantly more than the market followers; ‘innovation embraced’, ‘longer timeline’ and ‘senior management support’.
- The large companies use ‘strategic flexibility, ‘alternative funding’ and ‘longer timeline’ significantly more than the SMEs.
- Important ratings were similar with negligible differences regardless of company size, innovator status or market position.

4.4 CHAPTER SUMMARY

This chapter presented the individual practice results for the SearchQ1 and SelectQ2 surveys. The points to note are:

- A relationship exists between radical innovation involvement, market position and company size. The larger a company is the more likely it is to be in a strong or dominant market position, the larger a company is then the more radical innovations they developed over previous 5 years, the stronger the market position of a company is then the more radical innovations they developed over previous 5 years.
- Usage of search and selection practices is significantly lower than the importance attributed to them;
- Innovator companies use 6 of the search practices and 11 of the selection practices significantly more than the non innovators;
- Market leaders use 4 of the search practices and 3 of the selection practices significantly more than the market followers;
- Large companies use 5 of the search practices and 3 of the selection practices significantly more than SME companies;
- Importance ratings are relatively similar albeit with minor differences regardless of company type (innovator v non-innovator, market leader v market follower, SME v large).

Figures 4.9 and Figures 4.10 demonstrate the part of the research question investigated by this chapter. The research questions not investigated during this chapter are in gray scale. Results answering questions R1, R2, R3 and R4 are demonstrated. The search and selection best practices are listed in the model in order of usage in the model. The individual practices that are linked with the release of more radical innovation and more dominant market positions are indicated through the notation ‘RI’ and ‘MP’. Company size appears to have a relatively small effect on individual practice usage so will be excluded at the practice level and its exact effect assessed at the factor and success levels in the following chapter

The next chapter investigates the underlying search and selection factors and their impact on radical innovation success and market position.

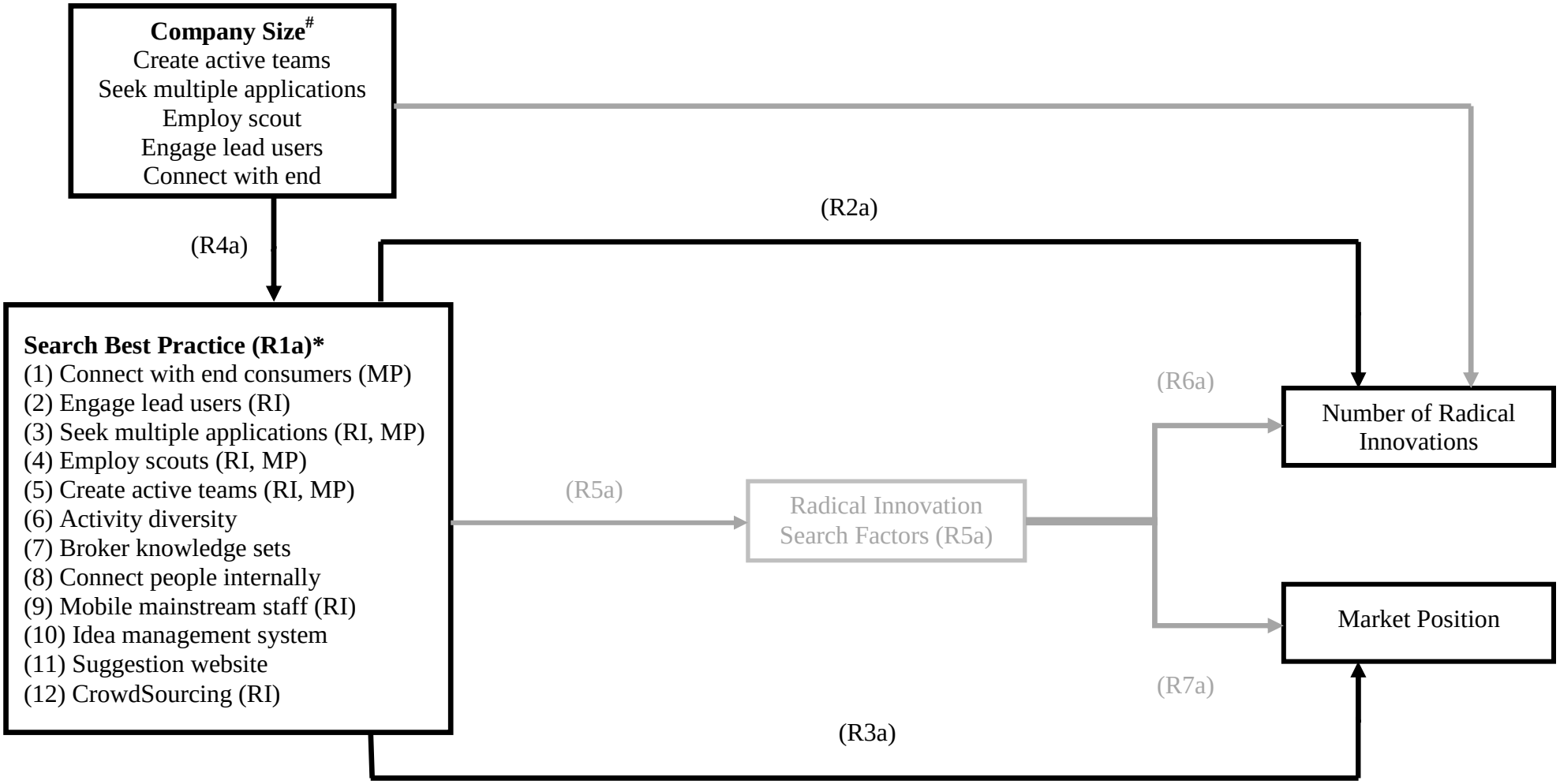


Figure 4.9 Updated Research Model: Search

RI = Usage results in more radical innovations
MP = Usage results in more dominant market positions
* = Practices number in order of highest usage
# = Practices large companies used more often

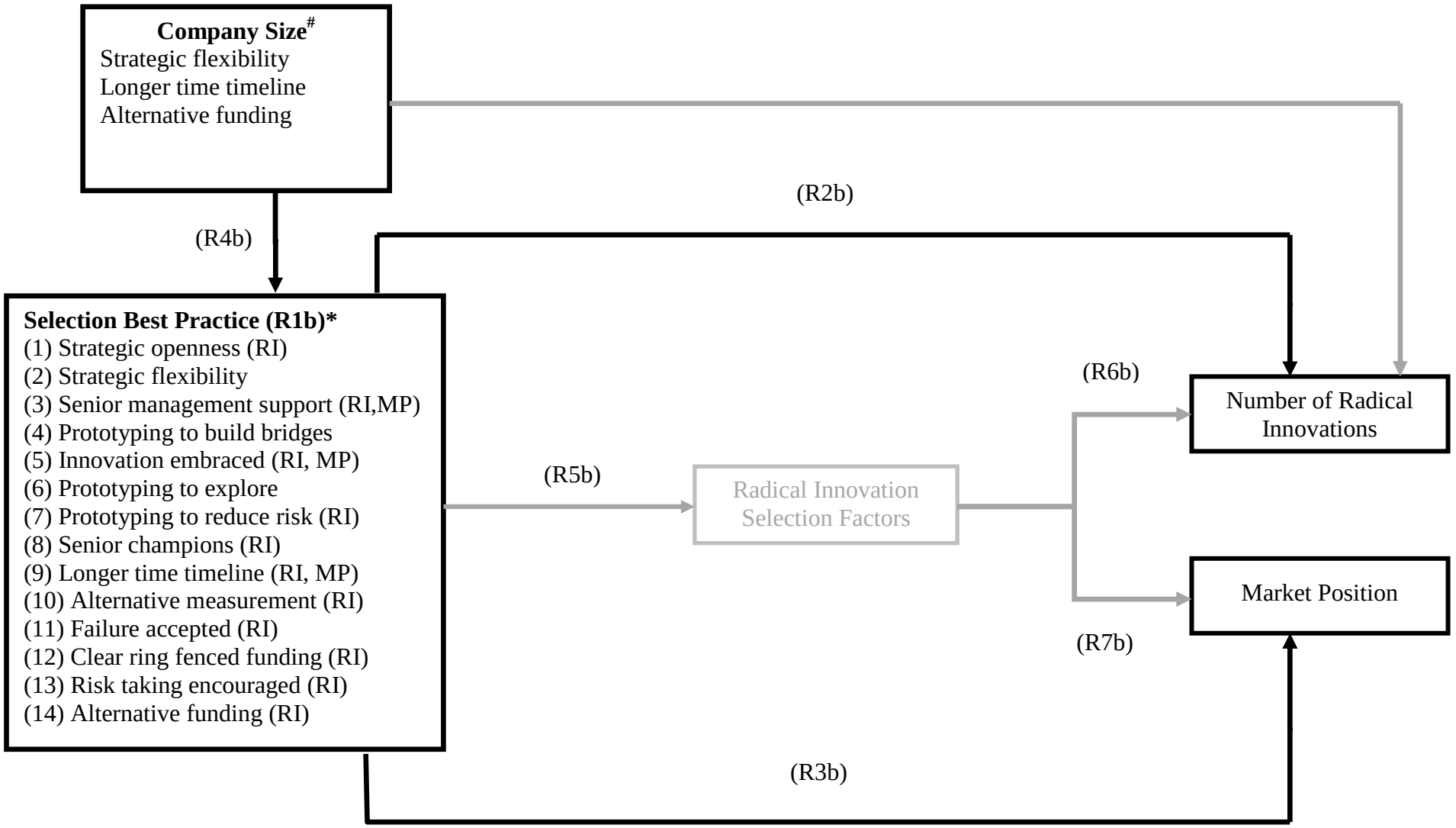


Figure 4.9 Updated Research Model: Selection

RI = Usage results in more radical innovations
MP= Usage results in more dominant market positions
* = Practices number in order of highest usage
# = Practices large companies used more often

Chapter Five
Search and Selection Factors for Radical Innovation

5.1 INTRODUCTION

This chapter presents the results of the exploratory factor analysis conducted on SearchQ1 and SelectQ2 and the confirmatory factor analysis conducted on SearchSelectQ3. Regression analysis is also completed on the performance measures and the identified factors. The primary aim of this chapter is the identification and confirmation of the search factors and selection factors. The identification and confirmation of these factors is the most important contribution of the thesis to knowledge.

The chapter is structured as follows:

- Section 5.2 compares the three survey samples, SearchQ1, SelectQ2 and SearchSelectQ3 in terms of company size, industry sector, and radical innovation involvement.
- Section 5.3 presents the exploratory factor analysis using SPSS to identify search factors for radical innovation (Question R5a).
- Section 5.4 presents the confirmation of the identified search factors for radical innovation using a combination of analysis in SPSS and Lisrel (Question R5a).
- Section 5.5 presents the exploratory factor analysis using SPSS to identify selection factors for radical innovation (Question R5b).
- Section 5.6 presents the confirmation of the identified selection factors for radical innovation using a combination of analysis in SPSS and Lisrel (Question R5b)

- Section 5.7 presents the regression analysis completed to assess the impact of the identified factors on the performance measures (Questions R6a, R6b, R7a, R7b).
- Section 5.8 summarises the results presented in this chapter.

5.2 COMPARISON OF SURVEY SAMPLES

The aim of the SearchSelectQ3 survey is to confirm the identified factors in the SearchQ1 survey and the SelectQ2 survey. To confirm the results the SearchSelectQ3 sample must be comparable to the samples of the previous two surveys.

Table 5.1 compares the 3 samples in terms of respondent company size. The results below show the samples were similar in terms of company size.

Table 5.1 Comparison of survey samples: Company size

	0-50	51-250	251-1000	1001+
SearchQ1	24	21	18	24
SelectQ2	24	19	22	29
SearchSelectQ3	21	20	17	30

Table 5.2 compares the 3 samples in terms of respondent industry sector. The results below show the 3 samples were similar in terms of industry involvement.

Table 5.2 Comparison of survey samples: Industry sector

	Pharmaceutical	Software and ICT	Electrics and Electronics	Medical Devices	Other Technologies	Other
SearchQ1	12	18	10	23	18	6
SelectQ2	17	16	10	20	19	12
SearchSelectQ3	12	19	8	21	18	10

Table 5.3 shows the radical innovation involvement of the respondent companies for each of the three surveys. The innovation involvement of the respondent companies in the three surveys is comparable.

Table 5.3 Comparison of survey samples: Number of radical innovation

	0	1+	Total
SearchQ1	48	39	87
SelectQ2	45	49	94
SearchSelectQ3	50	38	88

Furthermore an analysis of variance was conducted was conducted to ensure that the three samples were similar. The ANOVA revealed no significant differences between the three survey samples in terms of size or radical innovation involvement (Table 5.4, post-hoc tables viewable in Appendix L).

Table 5.4 Analysis of variance between samples: Size and Radical Innovation

		Sum of Squares	df	Mean Square	F	Sig.
Size	Between Groups	1.697	2	.849	.612	.543
	Within Groups	369.135	266	1.388		
	Total	370.833	268			
Radical	Between Groups	.409	2	.204	.814	.444
	Within Groups	66.795	266	.251		
	Total	67.204	268			

Tables 5.1, 5.2, 5.3 and 5.4 demonstrate that the respondents of the three surveys were similar in-terms of company size, industry sector and radical innovation involvement. There is no requirement for radical innovation involvement to be similar across the three surveys as this is variable from company to company over a time period. Given that the three samples are also comparable in terms of size and industry sector indicates that the three samples were similar and market conditions relatively constant over the time period between the surveys, consequently SearchSelectQ3 can be used to confirm the factors identified in the previous surveys.

5.3 IDENTIFICATION OF SEARCH FACTORS

5.3.1 Introduction

The following analysis presents the results of the exploratory factor analysis on the survey data. This allows research question R5a be investigated.

> R5a: *What are the underlying factors that can be used to categorise radical **search** practices?*

The questions used in the survey to describe the practices during the 'search' phase of the radical innovation process were extremely broad in nature. When developing a scale it is not unusual to begin with as many three to four times the number of items (i.e. questions) ultimately desired in the final factors (DeVellis, 1991). Upon analysis items are either discarded or retained and interpreted. Items were retained if they loaded primarily on one factor or if on multiple factors their loading was at least 0.2 higher on one factor than any other. Particular attention was given to items loading on factors that gave an interpretable solution.

Through several rounds of eliminating items and factor analysis (these rounds of factor analysis are described in Appendix F) ultimately the 39 practice pool in the SearchQ1 survey was reduced to 12 items (Table 5.5) that were found to collapse into five measurable and meaningful dimensions when empirically tested in the EFA (these factors are subsequently confirmed via CFA). That is not to say that the eliminated items are not useful for innovation search but only that they did not load on any factor in a meaningful way.

For ease of use the 12 practices presented initially in Table 4.1 are repeated below in Table 5.5.

Table 5.5 Final retained radical innovation search practices

	Survey Best Practice Question (retained items)	Practice Name
1.	Our organisation sets up teams to actively search out and implement new ideas that will take our business in new directions.	Create active teams
2.	When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.	Seek multiple applications
3.	We have people (part-time or full-time) officially charged with scouting for new ideas, finding new sources of potential radical ideas and looking for trends and developments that might have implications for organisation's future.	Employ scouts
4.	We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services.	Suggestion website
5.	We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions.	CrowdSourcing
6.	We actively try to find those lead users who are innovating to solve problems present at the leading edge of a trend and seek to 'co-evolve' new products and services together with them..	Work with lead users
7.	We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need.	Connect with end consumers
8.	We currently have systems or procedures in place that ensure insights from mainstream staff who have the opportunity to gather information from external sources are being collected systematically.	Mobile mainstream staff
9.	We actively encourage people to go to events/conferences/courses that are outside their current realms of experience.	Activity diversity
10.	In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback.	Idea management system
11.	In our organisation, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm.	Connect people internally
12.	Our organisation operates some form of brokering/bridge-building that involves bringing together people from different knowledge sets, backgrounds or functions in order to support Discontinuous Innovation.	Broker knowledge sets

The following section outlines the process of exploratory factor analysis that was performed on the retained items.

5.3.2 Exploratory Factor Analysis: Search

The 12 practices from the Search Q1 survey characterising radical innovation search were subjected to principal component analysis using SPSS V. 18. Prior to performing the analysis the suitability of the data for factor analysis was assessed. Inspection of the correlation matrix, Table 5.6 revealed the presence of many correlations between the individual practices with coefficients of .3 or over confirming factor analysis could be completed on the data.

The Kaiser Meyer-Olkin measure of sampling adequacy was 0.717, exceeding the recommended value of 0.6 (Kaiser 1970, 1974) and the Bartlett Test of Sphericity reached significance supporting the factorability of the correlation matrix (See Appendix G for all SearchQ1 SPSS output tables).

Table 5.6 Correlations between individual search practices

N=87	Create active teams	Seek multiple app	Employ scouts	Suggest website	Crowd Sourcing	Engage lead users	Connect with end con	Mobile main staff	Activity diversity	Idea man system	Connect people internally	Broker knowledge sets
Create active teams	1											
Seek multiple applications	.428**	1										
Employ scouts	.496**	.389**	1									
Suggestion website	.014	-.148	.004	1								
Crowd Sourcing	.227*	.096	.288*	.351**	1							
Work with lead users	.237*	.375**	.280*	-.088	-.011	1						
Connect with end consumers	.367**	.259*	.340**	.067	.050	.362**	1					
Mobile mainstream staff	.178	.081	.313**	.180	.299**	.298**	.056	1				
Activity diversity	.317**	.289*	.300**	-.116	.195	.189	.108	.445**	1			
Idea management system	.297**	.214	.313**	.264*	.350**	.079	.062	.347**	.367**	1		
Connect people internally	.392**	.314**	.476**	.131	.356**	.180	.106	.217*	.306**	.354**	1	
Broker knowledge sets	.349**	.205	.348**	.337**	.417**	.050	.135	.287*	.375**	.482**	.631**	1

A set of decision rules was established and used in interpreting the results of the factor analysis. In particular, an item was retained using the following criteria:

- If it loads primarily on one factor;
- When loading on multiple factors, the difference between the higher loading and all the other loadings (related to different factors) should be greater than or equal to 0.2;
- The item loading allows for an interpretable solution.

Principal component analysis revealed the presence of four factors with eigenvalues exceeding 1. While using eigenvalues > 1 is an acceptable method of identifying the number of factors to retain, it can lead to exclusion of a potentially important factor (Rahn 2011). Interpretability of the output was a key aim of the exploratory factor analysis. With this in mind a five factor solution was forced as this allowed for a more interpretable solution. Given that the research plan includes confirmatory factor analysis then this subjective decision can be justified. The 5 factors explained 30.6%, 15.6%, 9.5 %, 9.1% and 7% of the variance. Overall 72 % of the variance can be explained by the 5 factor solution (Table 5.7).

Table 5.7 Variance extracted by each of the underlying search factors

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings		
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %
1	3.668	30.566	30.566	3.668	30.566	30.566
2	1.872	15.598	46.165	1.872	15.598	46.165
3	1.140	9.497	55.662	1.140	9.497	55.662
4	1.097	9.140	64.802	1.097	9.140	64.802
5	.844	7.031	71.833	.844	7.031	71.833
6	.702	5.852	77.686			
7	.618	5.152	82.838			
8	.588	4.897	87.735			
9	.484	4.037	91.772			
10	.419	3.488	95.260			
11	.302	2.513	97.773			
12	.267	2.227	100.000			

The rotated solution revealed the presence of a simple structure with all components showing a number of strong loadings and all items loading substantially on only one factor (Table 5.8). 'Idea management system' did not load on any factor but is not eliminated as doing so changed the underlying factor structure. Further to this, similar

work being completed in parallel (Aloini et al. 2013) demonstrated that 'idea management system' did load onto one of the factors in a separate exploratory factor analysis using the same practices. Its inclusion can be reassessed during the confirmatory analysis stage.

Table 5.8 Pattern Coefficients Matrix and Communalities

Practice	Factor 1	Factor 2	Factor 3	Factor 4	Factor 5	Communalities
Create active teams	**.742**	.010	.092	.161	.062	.688
Seek multiple apps	**.640**	-.224	.138	-.127	.221	.591
Employ scouts	**.499**	.058	.118	.178	.261	.522
Suggestion website	-.242	**.884**	.134	-.054	.045	.818
CrowdSourcing	.197	**.575**	-.312	.093	.181	.606
Work with lead users.	-.107	-.160	**.855**	.184	.151	.819
Connect with end consumers	.433	.297	**.678**	-.113	-.163	.754
Mobile mainstream staff	-.221	.085	.153	**.893**	.037	.828
Activity diversity	.278	-.179	-.048	**.738**	.096	.750
Idea management system	.388	.330	-.166	.419	.114	.869
Connect people internally	.023	-.073	.045	-.026	**.938**	.750
Broker knowledge sets	-.004	.284	-.038	.135	**.727**	.625
Cronbach alpha	0.7					
Pearson correlation		.351**	.362***	.445***	.631***	
Spearman rho		.429***	.405***	.431***	.616**	

**p<.01. ***p<.001, Pearson/Spearman shown for two item measures

Factor 1

The three items that relate to Factor 1 are; creating active teams, seeking multiple applications and employing scouts. This factor can be labelled as *Market Awareness*.

Factor 2

The two items that relate to Factor 2 are; using a suggestion website and using CrowdSourcing techniques. Factor 2 can be labelled *Internet Enabled Search*

Factor 3

The two items that relate to Factor 3 are; connecting end users, engaging lead users. This factor is labelled as *Engaging with customers*.

Factor 4

The two items that relate to Factor 4 are; mobilising the mainstream and activity diversity. This factor can be labelled *Open Environment*.

Factor 5

The two items that relate to Factor 5 are; connecting people and brokering knowledge sets. This factor may be labelled as *Internal Networking*.

5.4 CONFIRMATION OF RADICAL SEARCH FACTORS

The previous section identified 5 search factors characterising radical innovation search practice. This section presents the results confirming the previously identified search factors.

The search section of the SearchSelectQ3 survey focused on the same 12 items identified in the SearchQ1 survey for the final exploratory factor analysis as per Section 4.4. The 12 items characterising radical innovation search were subjected to principal component analysis (PCA) using SPSS V18 using an identical procedure to that of the exploratory factor analysis stage. Inspection of the correlation matrix, Table 5.9 revealed the presence of many correlation coefficients of .3 or over, similar to that seen in Table 5.6, confirming factor analysis was appropriate for this data set.

Table 5.9 Search Practices Correlation Matrix

N=87	Create active teams	Seek multiple app	Employ scouts	Suggest website	Crowd Sourcing	Engage lead users	Connect with end con	Mobile main staff	Activity diversity	Idea man system	Connect people internally	Broker knowledge sets
Create active teams	1											
Seek multiple applications	.779**	1										
Employ scouts	.734**	.757**	1									
Suggestion website	.372**	.260*	.207	1								
Crowd Sourcing	.352**	.171	.277*	.695**	1							
Work with lead users	.350*	.417**	.329**	.040	.038	1						
Connect with end consumers	.273**	.398**	.261*	-.043	-.050	.607**	1					
Mobile mainstream staff	.325**	.213	.108	.282*	.299**	.313**	.189	1				
Activity diversity	.142	.120	.099	-.053	-.011	.204	.039	.407**	1			
Idea management system	.257**	.119	.048	.228*	.350**	.118	.095	.387**	.395**	1		
Connect people internally	.272**	.202	.18	.131	.060	.203	-.051	.229**	.182	.072	1	
Broker knowledge sets	.217	.225*	.177	.337**	.095	.226*	.126	.185	.082	.102	.584**	1

The Kaiser Meyer-Olkin measure of sampling adequacy was .671, exceeding the recommended value of 0.6 (Kaiser 1970, 1974) and the Bartlett Test of Sphericity reached significance supporting the factorability of the correlation matrix (See Appendix M for all SPSS output tables).

Principal component analysis revealed the presence of five factors with eigenvalues exceeding 1. The 5 factors explained 30.3%, 14.5%, 13.7 %, 10.6% and 8.4% of the variance. Overall 77.5 % of the variance can be explained by the 5 factor solution. All 5 factors had eigenvalues of greater than 1 which qualifies the decision made during the exploratory stage to include a factor that had an eigenvalue of marginally less than 1.

Table 5.10 Variance extracted by each of the underlying search factors

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.637	30.305	30.305	3.637	30.305	30.305	2.756
2	1.734	14.447	44.752	1.734	14.447	44.752	1.907
3	1.646	13.717	58.469	1.646	13.717	58.469	1.893
4	1.275	10.626	69.095	1.275	10.626	69.095	1.819
5	1.011	8.422	77.517	1.011	8.422	77.517	1.996
6	.656	5.463	82.980				
7	.580	4.834	87.814				
8	.457	3.810	91.625				
9	.367	3.062	94.687				
10	.283	2.356	97.043				
11	.183	1.526	98.569				
12	.172	1.431	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

The rotated solution revealed the presence of a simple structure with all components showing a number of strong loadings and all variables loading substantially on only one factor (Table 5.11).

Table 5.11 Pattern Coefficients Matrix and Communalities

	Market Awareness	Internet Enabled Search	Engaging with customers	Open Environ	Internal Network	Communalities
Create active teams	**0.825**	0.183	0.06	0.166	0.044	0.85
Seek multiple applications	**0.832**	-0.012	0.242	0.039	0.01	0.852
Employ scouts	**0.908**	0.065	0.043	-0.127	0.04	0.87
Suggestion website	0.103	**0.872**	-0.027	0.056	-0.089	0.806
CrowdSourcing	0.038	**0.89**	-0.041	-0.031	0.095	0.806
Work with lead users.	0.183	-0.075	**0.705**	0.079	0.176	0.675
Connect with end consumers	0.05	-0.024	**0.911**	-0.028	-0.091	0.835
Mobile mainstream staff.	-0.027	0.234	0.282	**0.506**	0.291	0.597
Activity diversity	0.144	-0.212	-0.199	**0.801**	0.18	0.744
Idea management system	-0.091	0.167	0.14	**0.795**	-0.174	0.713
Connect people internally	0.125	-0.063	-0.111	0.049	**0.878**	0.814
Broker knowledge sets	-0.073	0.078	0.152	-0.052	**0.841**	0.739
Cronbach alpha	0.902	.695***	.607***	0.68	.584***	
Pearson correlation		.746***	.600***		.551***	
Spearman rho						

****p<.001,* Pearson/Spearman shown for two item measures

As can be seen the same 5 factors emerge as were identified during the analysis of the SearchQ1 survey.

Factor 1 Market Awareness

The three items that relate to Factor 1 are; creating active teams, seeking multiple applications and employing scouts.

Factor 2 Internet Enabled Search

The two items that relate to Factor 2 are; using a suggestion website and employing crowd sourcing techniques.

Factor 3 Engaging with customers

The two items that relate to Factor 3 are; connecting with end users and engaging lead users.

Factor 4 Open Environment

The three items that relate to Factor 4 are; mobilising the mainstream and activity diversity and idea management system. In the exploratory factor analysis 'idea management system' did not load on any factor, however, in the confirmatory factor analysis it loaded onto factor 4 resulting in a refinement of the factor justifying its inclusion.

Factor 5 Internal Networking

The two items that relate to Factor 5 are; connecting people and brokering knowledge sets.

5.4.1 Validity and Reliability

Convergent Validity

Convergent validity is evaluated by examining the indicator loadings for statistical significance (Kenny and Kashy, 1992). To have convergent validity, the resulting factorial structure should be clear and well defined thus indicating that a significant relationship between each item and its respective factor: the factor loadings of each construct should be significantly high (Dunn et al. 1994).

Table 5.11 shows that the factorial structure for radical search capability is clear and well defined. The Cronbach's alpha of the subscales ranged from 0.68 to 0.9 achieving showing fine internal consistency and adequate reliability (Hair et al., 1998). Where applicable, Pearson correlation, for two item measures are also highly significant. Convergent validity can also be assessed from the measurement model, as assessed using Lisrel, by determining whether each indicator's estimated pattern coefficient on

its posited underlying construct is significant. Anderson and Gerbing (1988) argue that the significance can be tested by determining whether the estimated pattern coefficient is greater than twice its standard error, as shown in Table 5.12. In addition the critical ratios also exceeded the 1.96 benchmark (Green 2000) demonstrating the variables significance (Table 5.12).

Table 5.12 Search Factors: Evidence of convergent validity

		Estimate Coefficient	Standard Error	Critical Ratio	Practice significant to factor
Create active teams	→ *Market awareness*	1.12	0.12	9.33	***
Seek multiple applications	→ *Market awareness*	1.10	.11	10.0	***
Employ scouts	→ *Market awareness*	1.11	.12	9.25	***
Suggestion website	→ *Internet Enabled Search.*	1.07	0.16	6.69	***
CrowdSourcing	→ *Internet Enabled Search*	1.16	0.16	7.25	***
Connect people internally	→ *Internal Networking*	0.92	0.19	4.84	***
Brokering knowledge sets	→ *Internal Networking*	0.87	0.17	5.12	***
Work with lead users.	→ *Engaging with customers*	0.82	0.12	6.83	***
Connect with end consumers	→ *Engaging with customers*	0.71	0.12	5.92	***
Mobile mainstream staff.	→ *Open Environment.*	0.92	0.15	6.13	***
Activity diversity	→ *Open Environment.*	0.71	0.15	4.75	***
Idea management system	→ *Open Environment.*	0.76	0.16	4.75	***

****p<.001*

Discriminant Validity

For evidence of discriminant validity analysis of the factor loadings and the inter-factor correlations are conducted. Each item should present high loading on only one factor and significantly lower loadings on all the other factors (Table 5.11). The mean value of all the items loading in the same factor has been calculated in order to obtain a single value for each factor. These values have been used to calculate the correlation coefficients for all possible pairs of latent constructs (Table 5.13). By looking at the correlation coefficient among the factors, it can be seen that the constructs are correlated

and none above the recommended level of 0.65 (Tabachnick and Fidell, 1996, p. 86). As can be seen in Table 5.13, the various factors are significantly and moderately inter-correlated, suggesting that they measure distinct, but related, constructs.

Table 5.13 Search Factor Correlation Matrix

	Market awareness	Internet Enabled Search	Engaging with customers	Open environment	Internal networking
Market awareness	1				
Internet Enabled Search	.260*	1			
Engaging with customers	.319**	.144	1		
Open environment	.172	.261*	.143	1	
Internal networking	.398*	.136	.005	.272*	1

**p<0.01, *p<0.05

Construct unidimensional reliability

Finally, construct unidimensional reliability was established by assessing the overall model fit of the general model by Lisrel (Lisrel output can be viewed in full in Appendix N). The values of χ^2, RMSEA, NFI, N-NFI, CFI, IFI and χ^2/df are reported in Table 5.14 All the goodness-of-fit indexes are excellent or alternatively within the suggested thresholds so that construct unidimensionality can be inferred.

Table 5.14 Model goodness of fit indices for Search factor structure

Index	Value	Recommended values for very good fit	Sources
χ^2	57.67(p-value .081)	-	-
RMSEA	0.061	< .06	(Hu and Bentler 1999)
NFI	0.88	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
N-NFI or TLI	0.93	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
CFI	0.96	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
IFI	0.96	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
χ^2/df	1.31	>1 and <3	(Bollen 1989, McIver and Carmines 1981, Hair et al. 1998, Jöreskog 1969

RMSEA= Root mean square error of approximation, NFI= normed fit index, N-NFI= non-normed fit index, TLI= Tucker-Lewis index, CFI=Comparative fit index

5.4.2 Summary

This section has identified and confirmed the underlying search factors that characterise radical innovation search. Figure 5.1 shows the underlying search factors. These underlying factors will be integrated into the research model at the end of the chapter.

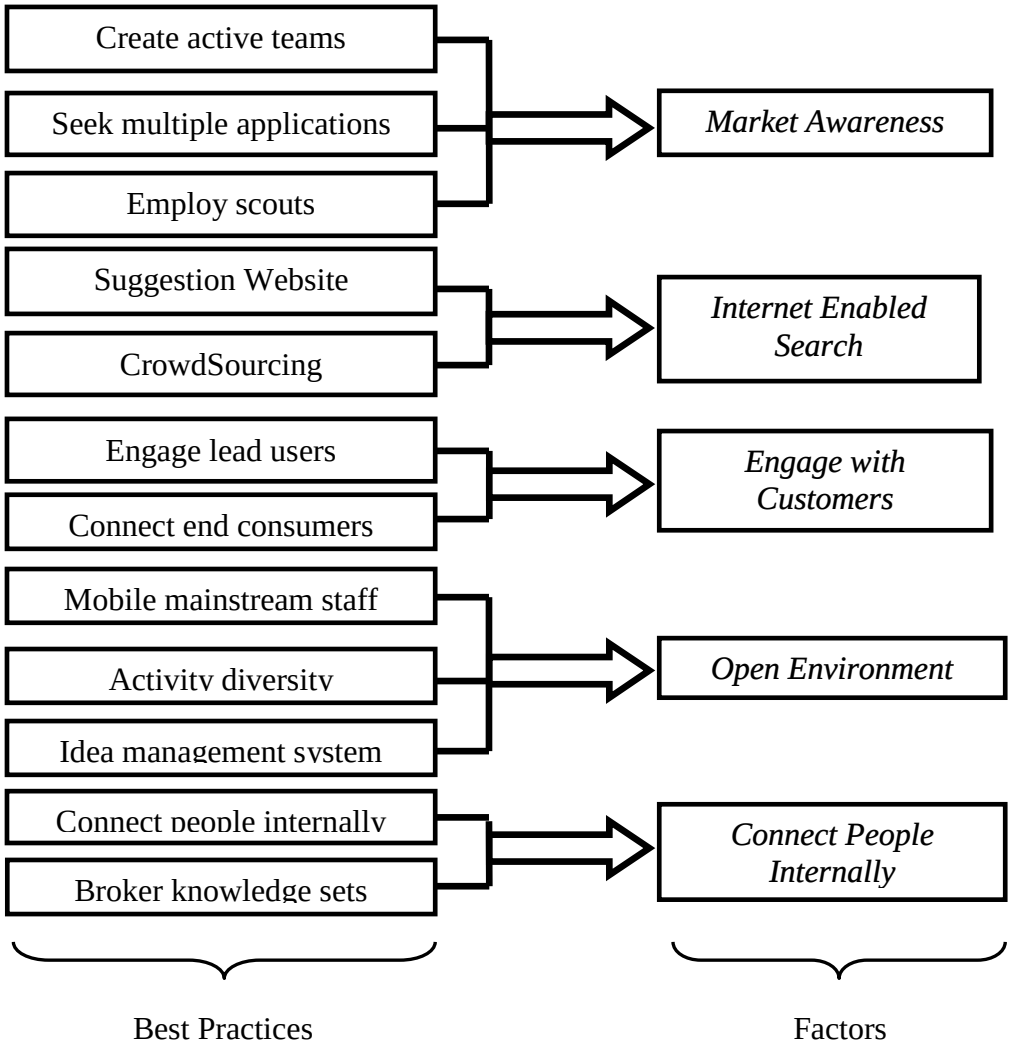


Figure 5.1 Research Model: Search Factors

5.5 IDENTIFICATION OF SELECTION FACTORS

5.5.1 Introduction

The following analysis presents the results of the exploratory factor analysis on the survey data. This allows the investigation of research question R5b:

> *R5b: What are the underlying factors that can be used to categorise radical **selection** practices?*

The questions used in the survey to describe the practices during the 'select' phase of the radical innovation process were extremely broad in nature. As mentioned in the previous chapter, it is not unusual to begin with three to four times the number of items ultimately in the final factors (DeVellis, 1991). Upon analysis items are either discarded or retained and interpreted. Items were retained if they loaded primarily on one factor or if on multiple factors their loading was at least 0.2 higher on one factor than any other. Particular attention was given to items loading on factors that gave an interpretable solution.

The 20 practices were used initially after which using exploratory factor analysis the items are either either discarded or retained and interpreted. Through several rounds eliminating items and factor analysis (these rounds of factor analysis are described in Appendix H) ultimately the 20 item practice pool from Select Q2 was reduced down to 14 items (Table 5.15) that were found to collapse into four measurable and meaningful dimensions when empirically tested in the EFA (these factors are subsequently confirmed via CFA). That is not to say that the eliminated items are not useful for innovation selection but only that they did not load on any factor.

For ease of use the 14 practices presented initially in Table 4.11 are presented again in Table 5.15.

Table 5.15 Retained Radical Innovation Selection Practices

Survey Best Practice Question (retained items)	Practice Name
1. We remain open to re-consider our future position in our industry value chain and make shifts if we have to.	Strategic flexibility
2. When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market.	Strategic openness
3. We use prototypes to build bridges in the selection process. By using prototypes we 'build bridges' in the minds of potential supporters (e.g. senior management, investors etc.) between the current state of affairs and what might be if this project is given opportunity to develop.	Prototyping to build bridges
4. We use prototyping to reduce uncertainty when making selection decisions i.e. we often 'buy a look' before deciding whether or not proceeding.	Prototyping to reduce risk
5. We use prototyping to 'take a small step' in a few different directions before committing to a large step in one direction.	Prototyping to explore
6. When evaluating radical opportunities we use alternative measurement and evaluation criteria to the ones used for non-radical opportunities.	Alternative measurement.
7. Our senior managers understand that it takes times for radical innovation projects to acquire the necessary learning experience before they can move forward.	Senior management support
8. Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and prove themselves.	Longer time timeline
9. In the company there are identifiable project champions in senior positions within the company who promote the development of radical and discontinuous projects?	Senior champions.
10. Our firm funds radical innovation project development differently than they fund incremental innovation projects.	Alternative funding
11. The process for accessing and leveraging resources (funding, personnel, capital equipment, and other organisational resources) for radical innovation projects in our firms is clear.	Clear ring fenced funding
12. There is an atmosphere in our organisation which encourages everyone to take part in innovation.	Innovation embraced
13. We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs	Risk taking encouraged
14. In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.	Failure accepted

The following section outlines the process of exploratory factor analysis that was performed on the retained items.

5.5.2 Exploratory Factor Analysis: Selection

The 14 practices identified from Select Q2 characterising radical innovation selection were subjected to the principal component analysis using SPSS V. 18. Prior to performing the analysis the suitability of the data for factor analysis was assessed.

Inspection of the correlation matrix, Table 5.16 revealed the presence of many correlations between the individual selection practices with coefficients of 0.3 or over confirming factor analysis could be completed on the data. The Kaiser Meyer-Olkin measure of sampling adequacy was 0.836, exceeding the recommended value of 0.6 (Kaiser 1970, 1974) and the Bartlett Test of Sphericity reached significance supporting the factorability of the correlation matrix (See Appendix I for all SPSS tables).

Table 5.16 Correlations between individual selection practices

	Strategic flexibility	Strategic openness	Proto build bridges	Proto reduce risk	Proto to explore	Altern measure	Senior man support	Longer time timeline	Senior champ	Altern funding	Clear ring fenced funding	Innov embraced	Risk taking encour	Failure accept
Strategic flexibility	1													
Strategic openness	.630**	1												
Prototyping to build bridges	.346**	.259*	1											
Proto to reduce risk	.226*	.193	.614**	1										
Prototyping to explore.	.115	-.023	.593**	.609**	1									
Alternative measure	.414**	.307**	.427**	.342**	.407**	1								
Senior management support	.229*	.302**	.066	.164	.186	.378**	1							
Longer time timeline	.341**	.299**	.275*	.333**	.361**	.700**	.576**	1						
Senior champions	.393**	.480**	.186	.265*	.108	.397**	.224*	.422**	1					
Alternative funding	.264*	.260*	.256*	.320**	.295**	.697**	.390**	.590**	.368**	1				
Clear ring funding	.317**	.504**	.295**	.189	.054	.516**	.388**	.527**	.462**	.506**	1			
Innovation embraced	.390**	.492**	.347**	.188	.086	.370**	.452**	.460**	.520**	.324**	.660**	1		
Risk taking encouraged	.174	.277*	.254*	.193	.123	.350**	.296**	.456**	.375**	.461**	.560**	.685**	1	
Failure accepted	.121	.222*	.167	.215*	.154	.304**	.399**	.406**	.395**	.409**	.543**	.591**	.720**	1

A set of decision rules was established and used in interpreting the results of the factor analysis. In particular, a practice was retained using the following criteria:

- If it loads primarily on one factor;
- When loading on multiple factors, the difference between the higher loading and all the other loadings (related to different factors) should be greater than or equal to 0.2;
- The practice loading allows for an interpretable solution.

Principal component analysis revealed the presence of three factors with eigenvalues exceeding 1. While using eigenvalues > 1 is the typically acceptable method of identifying the number of factors to retain, it can lead to exclusion of a potentially important factor (Rahn 2011). Interpretability of the output was a key aim of the EFA. With this in mind a 4 factor solution was forced as this allowed for a more interpretable solution. The 4th factor had an eigenvalue of just less than 1 (.927). Given that the research plan includes confirmatory factor analysis on a separate data set then this subjective decision can be strengthened through this confirmatory factor analysis.

The 4 factors explained 44%, 13.8%, 9.5 % and 6.7% of the variance with a total of 74%.

Table 5.17 Total variance extracted by each of the underlying selection practices

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.163	44.023	44.023	6.163	44.023	44.023	4.106
2	1.941	13.867	57.890	1.941	13.867	57.890	2.809
3	1.337	9.552	67.442	1.337	9.552	67.442	2.970
4	.927	6.619	74.061	.927	6.619	74.061	4.001
5	.651	4.648	78.709				
6	.622	4.439	83.149				
7	.504	3.600	86.748				
8	.468	3.345	90.093				
9	.311	2.219	92.313				
10	.292	2.085	94.398				
11	.262	1.874	96.272				
12	.196	1.398	97.670				
13	.173	1.239	98.909				
14	.153	1.091	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

The rotated solution revealed the presence of a simple structure with all components showing a number of strong loadings and all variables loading substantially on only one factor (Table 5.18).

Table 5.18 Pattern Coefficients Matrix and Communalities

	Factor 1	Factor 2	Factor 3	Factor 4	Communalities
Failure accepted	**.803**	.108	-.011	-.088	.752
Risk taking encouraged	**.794**	.035	.034	-.155	.771
Innovation embraced	**.698**	.058	.290	-.086	.812
Clear ring fenced funding	**.673**	.061	.099	-.239	.760
Prototyping to build bridges	-.029	**.875**	.062	-.073	.811
Prototyping to explore.	.046	**.862**	-.148	-.174	.818
Prototyping to reduce risk	.111	**.797**	.241	.107	.519
Strategic openness	.131	-.012	**.832**	.021	.813
Strategic flexibility	-.232	.155	**.817**	-.193	.578
Senior champions.	.288	.003	**.614**	-.048	.735
Alternative measurement.	-.002	.214	.116	**-.801**	.716
Alternative funding	.082	.077	.083	**-.777**	.763
Longer time timeline	.255	.077	.031	**-.739**	.782
Senior management support	.280	-.144	.092	**-.543**	.738
Cronbach alpha	0.84	0.83	0.72	**0.88**	

Factor 1

The four practices that relate to Factor 1 are; clear ring fenced funding, innovation embraced, risk taking encouraged and failure accepted. The factor is labelled as *fostering and supporting radical selection.*

Factor 2

The three practices that relate to Factor 2 are; prototyping in order to explore, reduce risk and build bridges. This factor is labelled as *prototyping as a selection tool.*

Factor 3

The three practices that relate to Factor 3 are strategic openness, strategic flexibility and senior champions. This factor can be labelled as *strategic and operational flexibility.*

Factor 4

The four practices that relate to Factor 4 are senior management support, alternate measurement, alternate funding and longer timelines. Note the negative loadings on each of the factors. Negative variables may be regarded as measuring the negative aspect of the factor e.g. if a number of positive practices were interpreted to be measuring fear then practices with negative loading would be seen to be measuring the opposite of fear; courage etc. (Harmon 1976). If the loading were all positive then this factor would be labelled as *differentiating between radical and incremental selection.* However, given the negative loadings the factor can be labelled as *Not differentiating between radical and incremental innovation*. The signs of the loadings could be reversed without effecting the adequacy of the solution (Harman 1976), however, this may complicate the interpretation of the solution when running regression analysis on the factors scores.

5.6 CONFIRMATORY OF RADICAL SELECTION FACTORS

The previous section identified 4 selection factors characterising radical innovation selection practice. This section presents the results confirming the previously identified selection factors.

The selection section of the SearchSelectQ3 focused on the same 14 practices used for the final selection exploratory factor analysis as per Section 5.4. The 14 practices characterising radical innovation selection were again subjected to principal components analysis (PCA) using SPSS V18 using an identical procedure to that of the exploratory factor analysis stage.

Inspection of the correlation matrix, Table 5.19 revealed the presence of many correlation coefficients of 0.3 or over, similar to that of Table 5.16, confirming factor analysis was appropriate for this data set.

Table 5.19 Selection Practices Correlation Matrix

N=88	Strategic openness	Strategic flexibility	Senior champions	Prototype build bridges	Prototype reduce risk	Prototype explore	Alternative measurement	Senior man support	Longer timeline	Alternative funding	Clear ring fenced funding	Innovation embraced	Risk taking	Failure accept
Strategic openness	1													
Strategic flexibility	.762**	1												
Senior champions	.665**	.641**	1											
Prototype build bridges	0.098	0.172	.311**	1										
Prototype reduce risk	0.142	0.13	.365**	.728**	1									
Prototype explore	0.158	0.175	.369**	.715**	.649**	1								
Alternative measure	.351**	.292**	.391**	.259*	.299**	0.192	1							
Senior management support	.343**	.293**	.337**	.251*	.227*	0.126	.671**	1						
Longer timeline	.360**	.264*	.347**	0.174	0.132	0.09	.569**	.725**	1					
Alternative funding	.398**	.327**	.374**	.276*	.297**	0.195	.668**	.715**	.707**	1				
Clear ring fenced funding	.221*	.249*	.234*	.293*	0.159	0.202	0.203	.229*	0.179	.387**	1			
Innovation embraced	.303**	.293**	.318**	.384**	.264*	.282**	.298**	.284*	0.142	.258*	.616**	1		
Risk taking encouraged	0.172	0.164	.247*	.392**	0.15	.230*	0.127	0.157	0.046	0.195	.580**	.801**	1	
Failure accepted	0.14	0.102	.243*	.252*	0.118	0.179	0.179	.247*	0.088	0.202	.541**	.760**	.838**	1

The Kaiser Meyer-Olkin measure of sampling adequacy was .745, exceeding the recommended value of 0.6 (Kaiser 1970, 1974) and the Bartlett Test of Sphericity reached significance supporting the factorability of the correlation matrix (See Appendix M for all SPSS output tables).

Principal component analysis revealed the presence of four factors with eigenvalues exceeding 1. The 4 factors explained 34%, 19.5%, 12.5 % and 11% of the variance with a total of 78 %. All 4 factors had eigenvalues of greater than 1 which qualifies the decision made during the exploratory stage to include a factor that had an eigenvalue of marginally less than 1.

Table 5.20 Variance extracted by each of the underlying selection factors

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.893	34.952	34.952	4.893	34.952	34.952	3.383
2	2.740	19.573	54.525	2.740	19.573	54.525	3.167
3	1.750	12.498	67.023	1.750	12.498	67.023	2.844
4	1.567	11.193	78.216	1.567	11.193	78.216	2.973
5	.725	5.176	83.392				
6	.482	3.440	86.832				
7	.368	2.631	89.463				
8	.332	2.371	91.834				
9	.314	2.242	94.076				
10	.253	1.807	95.883				
11	.197	1.405	97.288				
12	.147	1.048	98.336				
13	.134	.954	99.290				
14	.099	.710	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

The rotated solution revealed the presence of a simple structure with all components showing a number of strong loadings and all variables loading substantially on only one factor (Table 5.21).

Table 5.21 Pattern Coefficients Matrix and Communalities

	(not) Differentiating between radical and incremental Selection	Fostering and supporting radical selection	Strategic and operational flexibility	Prototyping as a selection tool	**Comm#**
Failure accepted	0.082	**0.928**	-0.028	-0.073	0.85
Risk taking encouraged	-0.124	**0.871**	0.025	0.1	0.804
Innovation embraced	0.023	**0.78**	0.15	0.163	0.752
Clear ring fenced funding	0.124	**0.611**	0.018	0.131	0.467
Prototyping to build bridges	-0.023	0.075	-0.064	**0.915**	0.863
Prototyping to explore.	0.024	0.041	0.068	**0.892**	0.838
Prototyping to reduce risk	0.103	0.128	0.017	**0.809**	0.757
Strategic openness	0.095	0.106	**0.917**	-0.128	0.907
Strategic flexibility	-0.013	-0.019	**0.94**	-0.042	0.871
Senior champions.	0.129	-0.01	**0.758**	0.286	0.761
Alternative measurement.	**0.819**	-0.086	0.101	0.087	0.732
Alternative funding	**0.788**	0.144	0.156	0.076	0.775
Longer time timeline	**0.855**	-0.034	0.065	-0.033	0.75
Senior management support	**0.894**	0.087	-0.005	0.007	0.823
Cronbach Alpha	.90	.90	0.86	.87	
#Communalities					

As can be seen the same 4 factors, identified in the exploratory factor analysis emerge.

Factor 1 Fostering and supporting radical selection

The four practices that relate to Factor 1 are; clear ring fenced funding, innovation embraced, risk taking encouraged and failure accepted

Factor 2 Prototyping as a selection tool

The three practices that relate to Factor 2 are; prototyping in order to explore, reduce risk and build bridges.

Factor 3 Strategic and operational flexibility

The three practices that relate to Factor 3 are strategic open, strategic flexibility and senior champions.

Factor 4 (not) Differentiating between Radical and Incremental Selection

The four practices that relate to Factor 4 are senior management support, alternate measurement, alternate funding and longer timelines.

5.6.1 Validity and Reliability

Convergent Validity

Convergent validity is evaluated by examining the indicator loadings for statistical significance (Kenny and Kashy, 1992). To have convergent validity, the resulting factorial structure should be clear and well defined thus indicating that a significant relationship between each practice and its respective factor: the factor loadings of each construct should be significantly high (Dunn et al. 1994).

Table 5.21 shows that the factorial structure for selection capability is clear and well defined. The Cronbach's alpha of the subscales ranged from 0.72 to 0.9 achieving acceptable values of at least 0.7, showing fine internal consistency and adequate reliability (Hair et al. 1998). Convergent validity can also be assessed from the measurement model by determining whether each indicator's estimated pattern coefficient on its posited underlying construct is significant. Anderson and Gerbing (1988) argue that the significance can be tested by determining whether the estimated pattern coefficient is greater than twice its standard error, as shown in Table 5.22 In addition the critical ratios also exceeded the 1.96 benchmark (Green 2000) demonstrating the variables significance (Table 5.22).

Table 5.22 Evidence of Convergent Validity of Selection Factors

			Estimate	Standard Error	Critical Ratio	P
Strategic openness	→	Strategic and operational flexibility	0.92	0.10	9.20	***
Strategic flexibility	→		0.96	0.11	8.72	***
Senior champions.	→		1.00	0.13	7.69	***
Prototyping to build bridges	→	Prototyping as a selection tool	1.00	0.10	10.0	***
Prototyping to reduce risk	→		0.90	0.11	8.81	***
Prototyping to reduce explore	→		0.86	0.10	8.6	***
Alternative measurement.	→	(not) Differentiating between Radical and Incremental Selection	0.92	0.12	7.6	***
Alternative funding	→		1.13	0.11	10.27	***
Longer time timeline.	→		1.01	0.12	8.41	***
Senior management support	→		1.04	0.11	9.45	***
Failure accepted	→	Fostering and supporting radical selection	1.06	0.11	9.63	***
Risk taking encouraged	→		1.02	0.09	11.03	***
Innovation embraced	→		1.05	0.11	9.51	***
Clear ring fenced funding	→		0.79	0.12	6.58	***

***p<.001

Discriminant Validity

For evidence of discriminant validity analysis of the factor loadings and the inter-factor correlations are conducted. Each practice should present high loading only on one specific factor and significantly lower loadings on all the other factors (Table 5.21). The mean values of the practices loading on each factor are calculated in order to obtain a single value for each factor. These values have been used to calculate the correlation coefficients for all possible pairs of latent constructs (Table 5.23). By looking at the correlation coefficient among the factors, it can be seen that the constructs are correlated and none above the recommended level of 0.65 (Tabachnick and Fidell, 1996, p. 86). As can be seen in Table 5.23, factors are all significantly and moderately inter-correlated, suggesting that they measure distinct, but related, constructs.

Table 5.23 Selection Factor correlation matrix

	Strategic and operational flexibility	Prototyping as a selection tool	(not) Differentiating between Radical and Incremental Selection	Fostering and supporting radical selection
Strategic and operational flexibility	1			
Prototyping as a selection tool	0.249*	1		
Differentiating between Radical and Incremental Selection	0.421**	0.293*	1	
Fostering and supporting radical selection	0.266*	0.360**	0.281*	1

****p<0.01, *p<0.05**

Construct unidimensional reliability

Finally, construct unidimensional reliability was established by assessing the overall model fit of the general model by Lisrel. The values of χ^2, RMSEA, NFI, N-NFI, CFI, IFI and χ^2 /df are reported in Table 5.24 All the goodness-of-fit indexes are excellent or alternatively within the suggested thresholds so that construct unidimensionality can be inferred.

Table 5.24 Model goodness of fit indices for Selection Factor structure

Index	Value	Recommended values for very good fit	Sources
χ^2	87.31(p-value .092)	-	-
RMSEA	0.053	< .06	(Hu and Bentler 1999)
NFI	0.91	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
N-NFI or TLI	0.97	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
CFI	0.97	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
IFI	0.97	> .9	(Schermelleh-Engel et al. 2003, MacCallum et al. 1996, Browne et al. 1993, Hu and Bentler 1999)
χ^2/df	1.23	>1 and <3	(Bollen 1989, McIver and Carmines 1981, Hair et al. 1998, Jöreskog 1969

5.6.2 Summary

This section has identified and confirmed the underlying selection factors that characterise radical innovation selection. Figure 5.2 shows the updated research model. These underlying factors will be integrated into the research model at the end of the chapter.

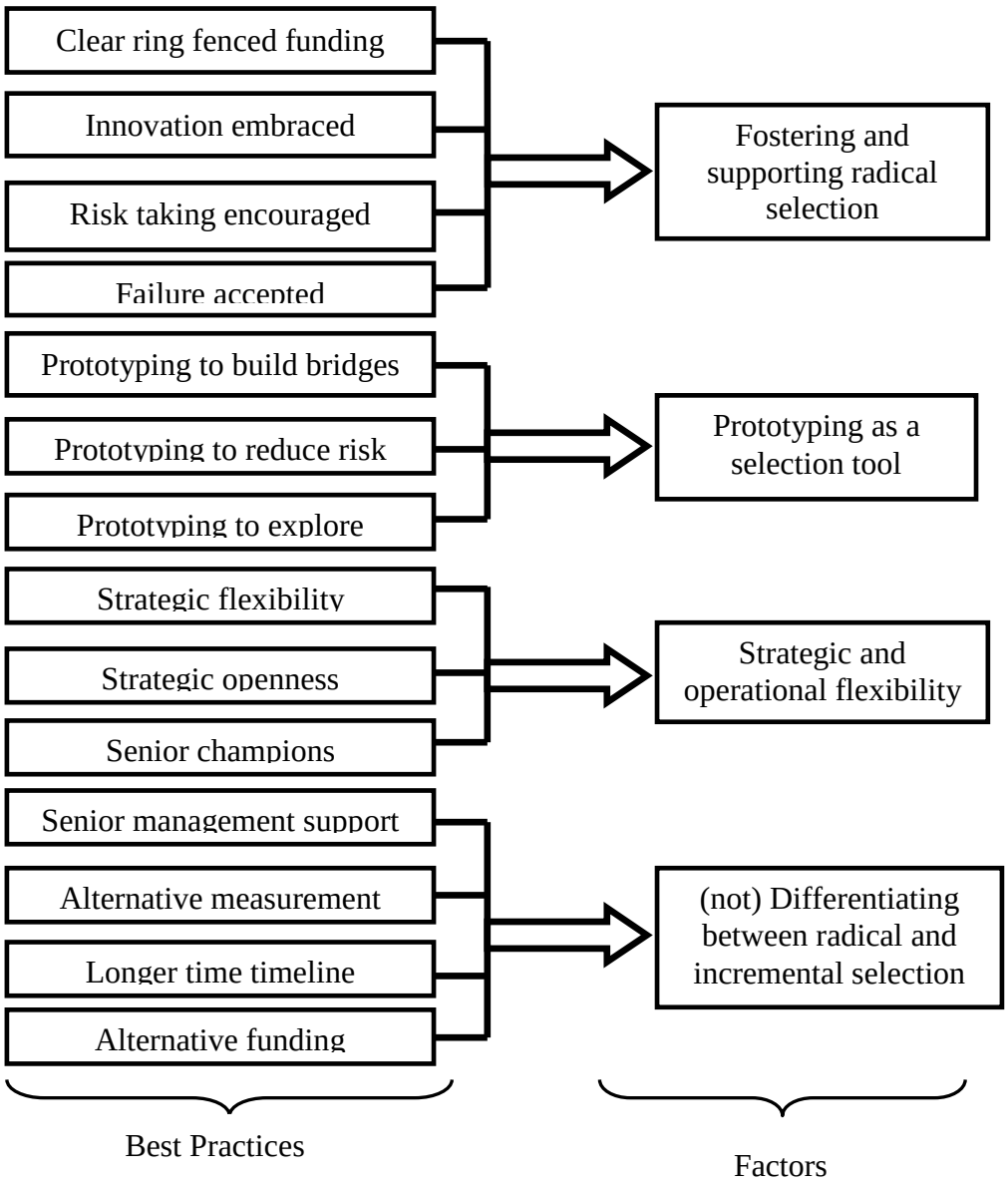


Figure 5.2 Updated Research Model: Selection Factors

5.7 REGRESSION MODELS: FACTORS VS. PERFORMANCE MEASURES

The previous sections identified and confirmed 5 search factors and 4 selection factors. This section presents regression analysis allowing the investigation of the following research questions;

> *R6a: Which of the identified **search** factors are linked with increased numbers of radical innovations?*
>
> *R7a: Which of the identified **search** factors are linked with more dominant market positions?*
>
> *R6b: Which of the identified **selection** factors are linked with more dominant market positions?*
>
> *R7b: Which of the identified **selection** factors are linked with increased numbers of radical innovations?*

In order to assess the predictive value that the identified search and selection factors have on the performance measures multiple regression analysis was completed in line with Pallant (2010).

- *Search model 1* assesses the predictive value of the five search factors on the Number of radical innovations a company had the previous 5 years (R6a).
- *Search model 2* assesses the predictive value of the search factors on the long term market position of each company (R7a).
- *Select model 1* assesses the predictive value of the four selection factors on the Number of radical innovations a company had the previous 5 years (R6b).
- *Select model 2* assesses the predictive value of the selection factors on the long term market position (R7b).

In each regression company size is included as a dummy variable. Given the exploratory nature of the research a minimum significant level of $p<0.1$ was used to establish significance of findings similar to Katila and Chen (2008) and Katila and Ahuja (2002).

Prior to running any of the regressions models the independent variables (the search and selection factors) were checked for correlation with the dependent variables (Number of radical new products and market position). None of the independent variables have a correlation with each other of greater than 0.7 (Pallant 2010). In all cases Tolerance is greater than 0.10 and the variance inflation factor (VIF) is less than 10 for all models (Pallant 2010). These conditions indicate that the multicollinearity assumption has not been violated (Appendix J and K). Both dependent variables were slightly skewed (Appendix J and K) indicating care should be taken when using the regression equation for predicting outcomes so not to overestimate the independent variables impact on the dependent variable. Given that the regression aim is not to predict an exact outcome but simply to show a link between the independent variables and the dependent variables the data is adequate.

5.7.1 Regression models

The following tables present the four regression models ran between the independent variables (5 search factors, 4 selection factors and company size) and the dependent variables of 'number of radical innovations' and 'market position'. All models are significant explaining between 28% and 40% of the variance of the dependent variables.

Table 5.25 Search Factor Regression Models

	Search Model 1 Dependent Variable Number of Radical Innovations	**Search Model 2** Dependent Variable Market Position
Company size	.416***	.363***
Market Awareness	.096	.274**
Internet Enable Search	-.124	.110
Engaging with Customers	.052	.-.150
Open Environment	.133	.112
Internal Networking	.146	-.287**
R^2	.296	.277
Model Significance	.002***	.003***
*p<0.1, **p<.05. ***p<.01		

Table 5.26 Select Factor Regression Models

	Select model 1 Dependent Variable Number of radical Innovations	**Select Model 2** Dependent Variable Market Position
Company size	.195*	.391***
Fostering and supporting radical selection	.306**	.305**
Prototyping as a selection tool	.205*	.064
(not) Differentiating between radical and incremental selection	-.278**	-.189
Strategic and operational flexibility	-.048	-.147
R^2	.397	.334
Model Significance	.001***	.001***
*p<0.1, **p<.05. ***p<.01		

5.7.2 Regression Search Model 1-Radical Innovation Success

The dependent variable for Search Model 1 is 'number of radical innovation over previous 5 years'. The independent variables are the 5 identified search factors and company size is a dummy variable. Table 5.25 presents the model ran between the 'number of radical innovations' and the 5 identified factors. The model was significant and had an R^2 of .296 (p<.01). None of the search factors made a unique contribution to the variance of 'number of radical innovations' over the previous 5 years. The negative coefficients reported for Internet Enabled Search (-.124) is surprising, although it is not significant to warrant further investigation. The dummy variable of company size was the only independent variable to make a unique contribution to the model (beta=.416, p<.01).

5.7.3 Regression Search Model 2-Market Position

The dependent variable for Search Model 2 is 'market position'. The independent variables are the 5 identified search factors and company size is a dummy variable. Table 5.25 presents the model ran between 'market position' and the 5 identified factors. The model was significant and had an R^2 of .277, (p<.01). Company size was the most significant predictor of market position (beta=.363, p<.01). Two of the search factors made a unique contribution to the variance of market position;

- The Market Awareness factor was a positive predictor (beta=274, p<.05).

- The Internal Networking factor was a negative predictor of market position (beta=-.260, p<.05).

The negative coefficients reported for engaging with customers (-.150) is surprising, although it is not significant to warrant further investigation.

5.7.4 Regression Select Model 1-Radical Innovation Success

The dependent variable for Select Model 1 is 'number of radical innovation over previous 5 years'. The independent variables are the 4 identified selection factors and company size is a dummy variable. Table 5.26 presents model ran between 'radical innovation success' and the 4 identified selection factors. The model was significant and had an R^2 of .397 (p<.001). Company size was a significant predictor of radical innovation success (beta=.195, p<.1). Three of the selection factors made a unique contribution to the variance of number of radical innovations.

- The Fostering and Supporting Radical Selection factor was a positive predictor (beta=.306, p<.01).
- Prototyping as a Selection Tool was a positive predictor (beta=.205, p<.1)
- The not Differentiating between Radical and Incremental Selection factor was a negative predictor (beta=-.278, p<.05). To clarify, this means that the opposite is also true i.e. when a company does differentiate between incremental and radical innovation then it has a positive effect on radical innovation success).

5.7.5 Regression Select Model 2-Market Position

The dependent variable for Select Model 2 is 'market position'. The independent variables are the 4 identified selection factors and company size is a dummy variable. Table 5.26 presents the model ran between 'market position' and the 4 identified selection factors. The model was significant and had an R^2 of .334 (p<.001). Company size was the most significant predictor of market position (beta=.391, p<.001). One of the selection factors also made a unique contribution to the variance of market position.

- The Fostering and Supporting Radical Selection factor was a positive predictor (beta=. 305, p<.05).

The negative coefficients reported for strategic and operational flexibility (-.147) is surprising, although it is not significant to warrant further investigation.

5.8 CHAPTER SUMMARY

This chapter identified and confirmed 5 search factors and 4 selection factors characterising radical innovation search and selection.

The 5 search factors are:

- Factor 1: Market Awareness;
- Factor 2: Internet Enabled Search;
- Factor 3: Engaging with Customers;
- Factor 4: Open Environment;
- Factor 5: Internal Networking.

The 4 selection factors are:

- Factor 1: Fostering and Supporting Radical Selection;
- Factor 2: Prototyping as a Selection Tool;
- Factor 3: Strategic and Operational Flexibility;
- Factor 4: Differentiating between Radical and Incremental Selection.

Table 5.27 summarises the regression results on the identified search and selection factors and the performance measures.

Table 5.27 Regression Analysis Summary

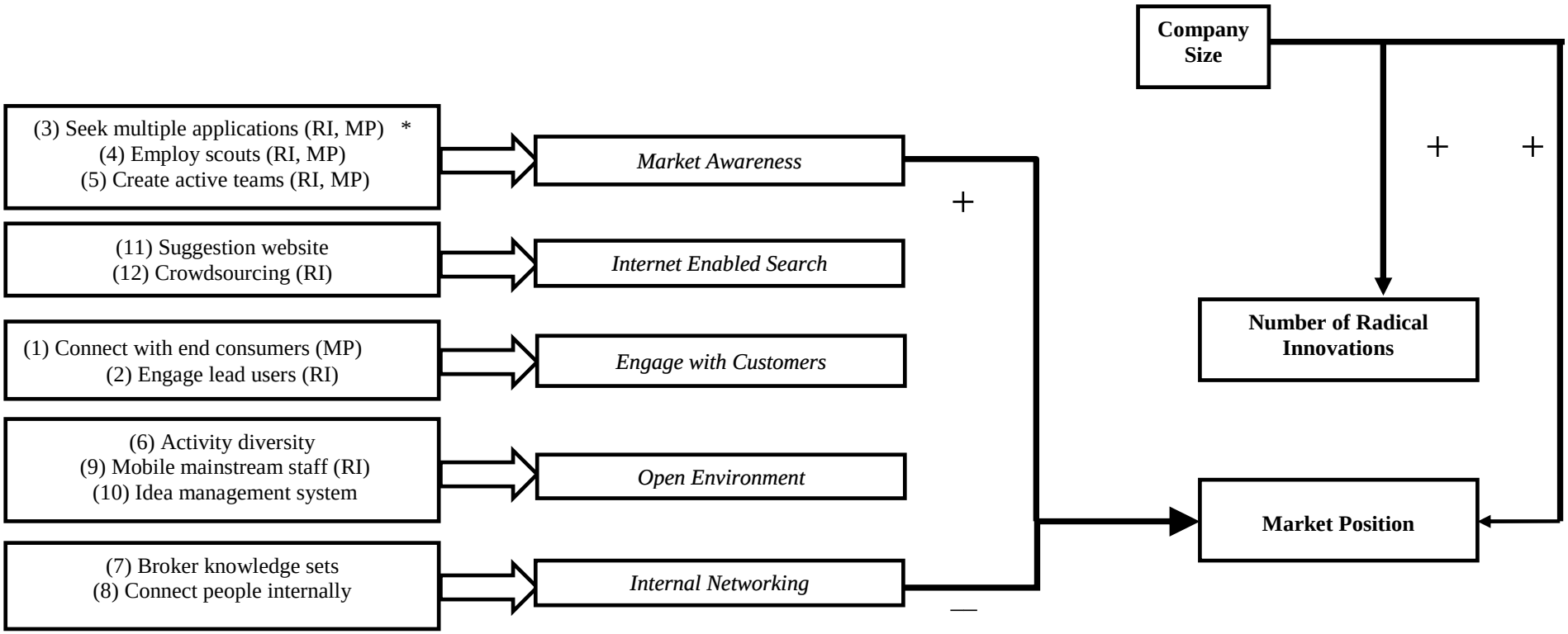
	Search Model 1 Dependent Variable Number of Radical Innovations	**Search Model 2** Dependent Variable Market Position	**Select Model 1** Dependent Variable Number of radical Innovations	**Select Model 2** Dependent Variable Market Position
Company size	.416***	.363***		
Market Awareness	.096	.274**		
Internet Enable Search	-.124	.110		
Engaging with Customers	.052	.-.150		
Open Environment	.133	.112		
Internal Networking	.146	-.287**		
Company size			.195*	.391***
Fostering and supporting radical selection			.306**	.305**
Prototyping as a selection tool			.205*	.064
(not) Differentiating between radical and incremental selection			-.278**	-.189
Strategic and operational flexibility			-.048	-.147
R^2	.296	.277	.397	.334
Model Significance	.002***	.003***	.001***	.001***
*p<0.1, **p<.05. ***p<.01				

- Regression analysis identified company size as a significant predictor of number of radical innovations developed over the previous 5 years and market position.
- None of the search factors were predictors of number of radical innovations developed over precious 5 years.
- The market awareness search factor was a positive predictor for market position.
- The internal networking search factor was a negative predictor for market position.
- The fostering and supporting radical selection factor was a positive predictor of number of radical innovations developed over previous 5 years.
- Prototyping as a selection tool was a positive predictor of number of radical innovations developed over previous 5 years.
- The not differentiating between radical and incremental selection factor was a negative predictor of number of radical innovations developed over previous 5 years (Meaning that the opposite is also true i.e. when a company does differentiate

between incremental and radical innovation then it has a positive effect on radical innovation released). For ease of interpretation the ‘Not Differentiating between Radical and Incremental Selection; factor is re-titled as the ‘Differentiating between Radical and Incremental Selection’ factor reversing its impact.

- The fostering and supporting radical selection factor was a positive predictor of market position.

Figures 5.3 and 5.4 integrate the identified search and selection factors and the subsequent regression analysis in to the research model. This model will be discussed in Chapter 6.



RI = Usage results in more radical innovations
MP= Usage results in more dominant market positions
* = Practices numbered in order of highest usage

Figure 5.3 Final Research Model: Search

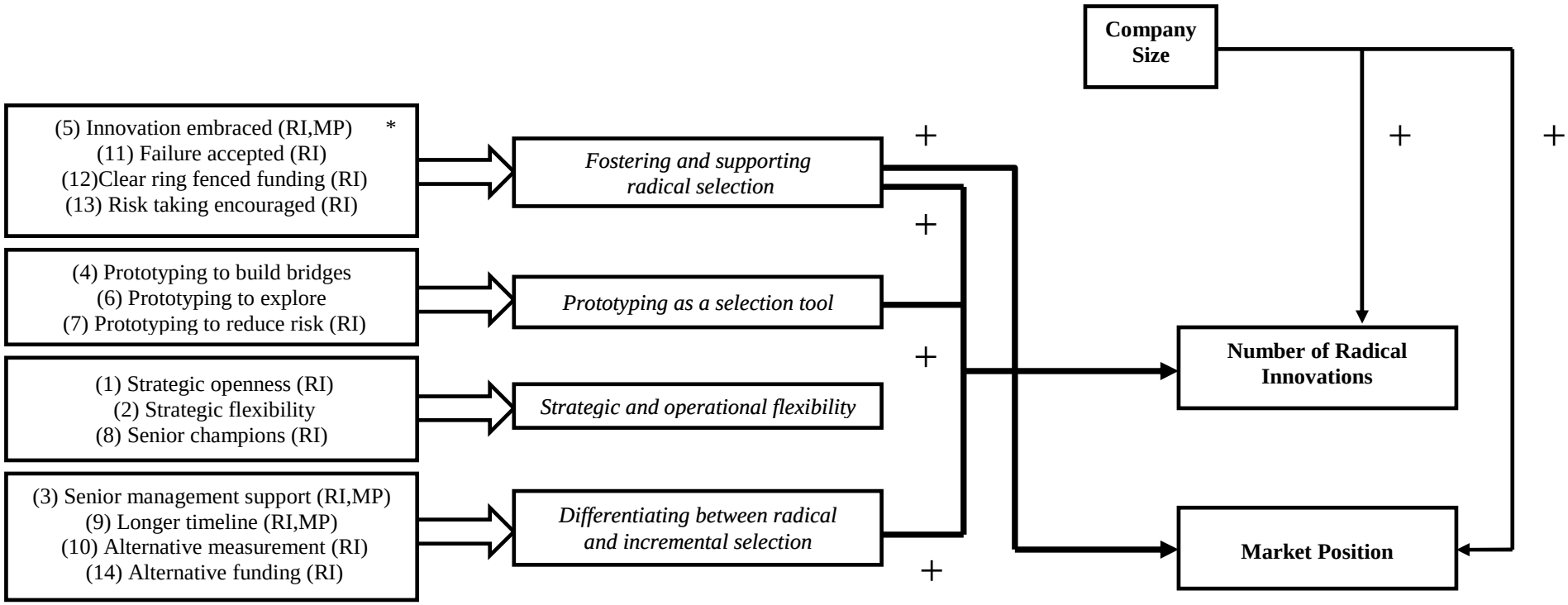


Figure 5.4 Final Research Model: Selection

Chapter Six Discussion

6.1 INTRODUCTION

To undertake radical innovation companies are required to explore their environment and develop innovations and products that either creates new markets for the company to operate in or greatly change the existing market place. Whilst the literature is fairly clear about the routines for exploitation – approaches to enable continuous, incremental extension and adaptation of a company's current products and technology; there is less known about the mechanisms to enable effective explorative search and selection for radical innovation.

The research methodology was discussed in Chapter 3 to allow radical search and selection to be explored in a sample of innovating companies. The results of this exploration were presented in Chapter 4 and 5. Chapter 4 presented the results and analysis of the SearchQ1 and SelectQ2 surveys relating to the individual search practices usage. Chapter 5 presented results from all three surveys relating to the identification and confirmations of underlying factors. This chapter discusses the results in relation to the research questions and existing literature in the area.

This chapter is structured as follows;

- Section 6.2 discusses the usage and importance of the individual practices for radical innovation search and selection (R1a and R1b).
- Section 6.3 discusses the usage and importance of the individual search and selection practices according to the two innovation performance measures; 'number of radical innovations over the previous 5 years' (R2a and R2b) and 'market position' (R3a and R3b).
- Section 6.4 discusses the usage and importance of the individual search and selection practices according to company size (R4a and R4b).

- Section 6.5 discusses the identification of underlying search factors characterising radical innovation search practice (R5a).
- Section 6.6 discusses the identification of underlying selection factors characterising radical innovation selection practice (R5b).
- Section 6.7 discusses the impact the identified search and selection practices have on the two innovation performance measures; 'number of radical innovations over the previous 5 years' (R6a and R6b) and 'market position' (R7a and R7b).
- Section 6.8 summarises the final search and selection research models.
- Section 6.9 summarises the chapter.

6.2 CURRENT PRACTICE USAGE AND IMPORTANCE

This section discusses the following research questions:

> *R1a: What practices do companies currently use when **searching** for new ideas during the front end of the radical innovation process?*
>
> *R1b: What practices do companies currently use when **selecting** new ideas during the front end of the radical innovation process?*

6.2.1 Practice Usage

Search

Search relates to the techniques used by a company to search for radical innovation opportunities, what idea sources are used and how ideation is managed etc. Examining the usage and importance for each of the 12 search practices (Table 4.5) reveals that the most used search practices by the companies in the sample were:

- Connecting with end consumers;
- Working with lead users;
- Seek multiple applications.

The high usage of these practices suggests that organisations in Ireland are utilising practices proven in the literature to aid radical innovation search. Lilien et al. (2002) demonstrated that lead user projects result in products that have higher novelty, addressed more original newer customer needs, and typically had significantly higher forecasted sales than other types of projects. Barczak et al. (2009) in their study identified a cluster of top performing companies who used certain techniques such as beta testing, customer site visits, voice of the customer and ethnography more than the other performing companies to connect with their end consumers. Gjerde et al. (2002) conclude that growth of a company can depend to a great extent on its ability to apply technology to develop new products and improve existing products, as well as to expand market applications for its existing products.

It may also be inferred that two of these practices 'working with lead users' and 'connecting with end customers' represent means to stay close to existing customers and satisfy their current and future needs. It appears that the primary focus for the companies in the sample was the company's 'local' and familiar markets. While they may claim to be open to radical innovation, their search for radical ideas is relatively nearby and focused on well understood markets. This would support previous literature e.g. Koudal (2004) found established companies are focused on short to medium term growth and so try to protect their current products and Rosenkopf and Lavie (2006) 'local search' where firms do extend but within bounded space, reinforcing rather than challenging underlying paradigms and dominant designs.

The least used search practices by the respondent companies consisted of;

- CrowdSourcing
- Using a suggestion website
- Using an idea management system

The use of Crowdsourcing techniques and using a suggestion website are two practices comprising of the 'Internet Enabled Search' factor that can be linked together to a degree in terms of the shift from 'closed' innovation to 'open' innovation (Chesbrough 2003). This

shift in terms of innovation is still in its infancy (Chesbrough and Crowther 2006) so perhaps it is not surprising the adoption of the associated innovation practices is relatively low. The internet is increasingly superseding personal contacts and trade-shows as the platform for finding collaboration partners (Braun et al. 2012). Dominguez (2011) discusses the use of the internet and websites as an innovation pathway. Companies are struggling to harness the full potential and make internet social platforms work in business. Companies need to recognise the potential the internet holds in connecting with a wide range of existing and potential consumers and problem solvers. Due to the increasing importance of internet platforms, firms need to extend their capacities accordingly (Braun et al. 2012). Information technology use throughout NPD, including the front end, has a positive long-term impact on the performance of new products (Barczak et al 2007).

The other practice that with low utilisation by companies in the sample was that of the 'idea management system'. Harnessing the power of a company's existing employees and using the employees efficiently and effectively is often over looked. In particular employees, those directly involved in innovation and development and those that are not involved may have identified opportunities that could be pursued. Using an idea management system where all employees can submit ideas for evaluation and receive feedback may be beneficial. Laforet (2009) found that employees suggestion systems are characteristics of prospector type companies, those companies that are at the forefront of radical innovation and strive to continuously bring products to the market first (Miles and Snow 1978, 2003).

Selection

Selection relates to the techniques used by a company to increase selection capability for radical innovation opportunities. Examining the usage of the 14 selection practices (Table 4.16) revealed that the most used selection practices by the companies in the sample were:

- Strategic openness
- Strategic flexibility
- Senior Management Support

Literature asserts these practices as importance for radical innovation selection. Innovation by its nature represents a turbulent and changeable environment. In line with this Sharfman

and Dean Jr. (1997) note that organisations who intend to survive and have ambitions to flourish and grow in the future require managers capable of overcoming barriers and 'practising flexibility in their strategic choices' and be particularly wary of 'rigidity in their decision processes'. Companies that fail to make flexible strategic choices may enter into organisational decline which is the failure to adapt or change to fit with the changing external environment (Weitzel and Jonsson 1989, Christensen 1997). Strategic flexibility helps firms with superior technology sustain their exploration (Zhou and Wu 2010) and achieve sustained innovation performance (Kekale et al. 2010). This high level of strategic openness and flexibility is positive for companies. Doz and Kosonen (2010) suggest that in strategically rigid companies, this is done only in response to competitive crises, usually triggered by an initially neglected or even derided 'inferior' innovation. Companies in the sample appear to be more proactive in their flexibility rather than reactive.

Strong senior management support could be viewed as a prerequisite to operating with strategic openness and flexibility (Doz and Kosonen 2010). Visible top-level management support is a factor that is vital for project selection. Cooper and Kleinschmidt (1995) recognised the importance of top-level support and according to their research success will result if senior management is strongly and visibly committed to the development of new products and devote the necessary resources. Assink (2006) found a lack of courage and support from senior management was an inhibitor to engaging radical innovation.

The least used selection practices by the sample consisted of

- Encouraging risk taking;
- Clear ring fenced funding;
- Using alternate means of funding.

Alternate funding may lend towards to a more open innovation environments which is a less used selection practice for radical innovation as companies slowly make the transition from closed innovation models to more open innovation models. Access to abundant, high quality resources increases an organisation's chances of coping with change (Christensen and Overdorf 2000). Christensen (1997) notes that it is difficult to keep resources focused

on innovation as when turbulent market conditions arise the radical innovation budget is an easy target.

Creating a culture of risk-taking within the company should result in more innovative ideas bank to select from. Organic flexible innovative cultures also help in ensuring that ideas flow readily through the organisation (Rosenfeld and Servo 1990). Creating an open, and inquiring environment and culture, that values experimentation, with leaders promoting innovation by creating a shared belief that team members are safe to take risks will facilitate radical innovation (Claver et al. 1998, Harborne and Johne 2003, Gudmundson et al. 2003).

6.2.2 Practice Importance

Search

The most important practices (Table 4.5) for radical innovation search as perceived by the sample were

- Connecting with end consumers
- Employing scouts
- Working with lead users

Given the prominence of these practices in previous literature as being positive indicators for successful innovation the fact the respondents rate them as being of high importance suggests that knowledge is relative high in relation to what is considered as best practice for radical innovation search. From this it can be seen that the practices that the sample perceived to be most important for radical innovation search were very similar to the most used practices by the sample adding further weight to the argument that many Irish companies are actively engaged in the search for radical ideas and are using techniques associated with the successful sourcing of novel ideas, however, they are staying within familiar and ‘local’ markets.

All of the practices were rated as being important for radical innovation search. Statistically the respondents rated the importance of each practice far greater than the usage of each

practice (all $p<0.001$). This suggests that while the companies acknowledge the practices importance for radical innovation many are not engaging them in their innovation efforts. This could be evidence that many companies are having problems utilising all the practices in their innovation search efforts. However, there is evidence that firms acknowledge this problem, since they attribute considerable importance to all the practices even when they don't use them suggesting barriers exist to engaging in them.

The two practices of least importance were 'using a suggestion website' and 'crowdsourcing'. It is important to note that even though these were allocated as being the least important for innovative search they are still rated as being of importance for successful search and identification of opportunities. This would affirm previous research that there is an increasing trend towards increased popularity and dissemination of open innovation practice (Huizingh 2011).

Selection

The most important selection practices (Table 4.16) were seen as

- Embracing innovation;
- Failure accepted;
- Risk taking encouraged.

These factors are prominent in the literature as being associated with radical innovation success. The fact the respondents rate them as being of high importance suggests that knowledge is relatively high in relation to what is considered as best practice for radical innovation selection. In contrast to the analysis of the search practice importance, none of the practices which are considered to be of most importance to radical innovation selection are also the most highly used practices demonstrating a gap between what practices companies are actually using and what practices they attribute the most importance towards.

All of the practices were rated as being highly important for radical innovation selection. Statistical testing (Wilcoxon signed-rank test) demonstrated a significant difference between usage and importance for each of the selection practices ($p<0.001$). This suggests

that while all the companies' acknowledge the practices importance for radical innovation selection many are not engaging them in their innovation efforts. This shows that there are barriers companies are experiencing when attempting to select radical innovation projects. Despite the perceived importance of different practices for radical innovation selection companies are not utilising them all.

Summary

Having identified the most used and most important practices sub questions R1a and R1b have been answered.

For radical innovation search the most used practices were:

- Connecting with end consumers;
- Seeking multiple applications;
- Working with lead users.

For radical idea selection the most used practices were:

- Strategic openness;
- Strategic flexibility;
- Senior management support.

6.3 SEARCH AND SELECTION PRACTICES AND SUCCESSFUL INNOVATION

This section discusses the answers to questions

> *R2a: Which **search** practices are linked with increased numbers of radical innovations?*
>
> *R3a: Which **search** practices are linked with more dominant market positions?*
>
> *R2b: Which **selection** practices are linked with increased numbers of radical innovations?*
> *R3b: Which **selection** practices are linked with more dominant market positions?*

6.3.1 Market Position vs. Size vs. Radical Innovation Involvement

For a company to be successful over extended periods of time they must not only focus on incremental innovation but also pay attention to radical innovation (Ancona et al. 2001, Benner and Tushman 2002, Eisenhardt and Martin 2000, Feinberg and Gupta 2004, March 1991, March 1996, March 2006). Within the sample of companies surveyed the requirement for this radical type innovation has clearly been identified and acted upon. More than half of the companies in the sample claimed to have developed at least one or more radical innovation in the previous 5 years.

Examining the correlations between company size, involvement in radical innovation and perceived market position (see tables 4.4 and 4.15) a relationship between the three variables can be observed. Larger companies are significantly more likely to be engaging in radical innovation than their small counterparts ($p<.05$ for SearchQ1, $p<0.01$ for SelectQ2), companies who see themselves as being in strong/dominant market position significantly are also more likely to be engaged in radical innovation than companies who are in favourable/viable/weak market positions ($p<.05$ in both surveys). Finally, larger companies are more likely to be in 'strong' or 'dominant market positions within their industries than smaller companies ($p<.05$ for SearchQ1, $p<0.01$ for SelectQ2).

Christensen (1997) demonstrated that larger, dominant companies were often less inclined to get involved in radical innovation as they had too much invested in the 'status quo' to potentially 'cannibalise' their own business through radical innovation. This contention is correct in many cases given that radical innovation typically disrupts and destroys existing markets and create new ones then large companies may sometimes be reluctant to risk an existing and established market share (Wieandt 1994, Schmidt and Druehl 2008, Christensen 1997). Of course research exists to counter this argument. Sorescu et al. (2003) found dominant firms introduce significantly more radical innovations than do non-dominant companies and the radical innovations they introduce are of a higher value than that introduced by the non-dominant firms.

However, given larger dominant companies would typically have a larger product line and operate in numerous markets then the established 'status quo' may not always be a significant deterrent to radical innovation as large companies would not typically be over reliant on a single product/market. Given that any other company, small or large, could be developing a product or technology to target a specific market share of a company then it is logical that the incumbent company attempts to pre-empt that development with development of their own. The high engagement in radical innovation by the large companies in the sample reflects this. The ability to remain a market leader even through radical change requires the constant acquisition of new knowledge (Drucker 1991, Grant 1996).

The SME companies in the sample when comparing a balanced sample of large vs. SME are innovating less. Small, entrepreneurial companies are often credited with being the source of radical innovations (Schumpeter 1934, Santarelli and Piergiovanni 1996. Kleinknecht et al.1993). Tether (1998) countered this view demonstrating that while small companies were often more innovative in terms of number of innovations per head the direct value of the innovations tended to increase with the size of the innovating firms. While this maybe more valid for start up small companies, who are characteristically innovative and entrepreneurial in nature, with regards to established small companies most are focused on protecting currently market share rather than growing or cannibalising their share (i.e. 72% of the small companies in our sample had no radical innovation over previous 5 years). Previous literature reflects this also. Storey (1994) found that many small companies had no ambitions to grow and expand. The added risk in attempting to developing new products out-weighted the possible growth benefits therefore the companies were content with their existing products and customers. Equally previous researchers have also found that some SMEs favour innovation as a strategy e.g. Mosey et al. (2002) demonstrated that the small companies with aggressive growth ambitions who repeatedly introduced innovative new products that opened up new market niches were the best performing companies.

While the larger companies in our sample were significantly more lightly to be engaged in radical innovation given that there was equal numbers of large/SME companies in the sample then this is perhaps not an unexpected result given large companies greater access to resources. 28% of the small companies in the sample developed a radical innovation indicating that small companies represent a significant source of radical innovation.

Engagement in radical innovation is also inextricably linked to market position. Whether companies are dominant because they are engaging in more radical innovation or they engage in more radical innovation because they are dominant in their market place was not determined in the study. It is likely that either starting position is possible i.e. a company may have become dominant through various radical developments over time or alternatively may have become dominant through other means but given their current dominance they can now afford to take risks on radical innovation. What the results do demonstrate is that large, dominant companies are significantly more likely to be involved in radical innovation and companies who continuously engage in radical innovation consistently dominate markets.

6.3.2 Innovators vs. Non-innovators

Search

This section discusses the answer to question:

> *R2a: Which **search** practices are linked with increased numbers of radical innovations?*

The practices used most by the innovator companies and the non innovators companies are similar. Regardless of whether they are a successful innovator or not a lot of emphasis is placed on existing customers with high usage of; connecting with end consumers and engaging lead users, however, the level of usage is far lower in the non-successfully innovating companies (Table 4.6).

The innovator companies used all 12 of the search practices more than the non innovator companies and used 6 of the practice significantly more than the non innovator companies; seeking multiple applications ($p<0.01$), creating active teams, employing scouts, crowdsourcing, engaging lead users and mobilise mainstream staff ($p<0.05$). There were negligible differences in the importance ratings between the two groups. Iwamura and Jog (1991) found the most significant difference that separates innovator companies from non-innovator companies is their management of the idea generation process. They found innovators tend to approach idea generation differently to the non-innovators. The innovators typically employed a variety of idea sources, both internal and external; assigned a specific person or group to be in charge of developing new ideas; encouraged employees at all levels to generate new ideas; used a variety of innovative techniques to stimulate creativity etc.

This higher usage by the innovators indicates a plausible link between radical innovation success and varying search practices. The higher usage of the practices demonstrates that the innovators are open to innovation triggers from various different sources. These companies are not only attempting to create radical innovations themselves through the implementation of specific knowledge building practices such as using practices such as sending out scouts but are also seek knowledge from external sources through the use of internet platforms via crowdsourcing and through mobilising their mainstream, e.g. crowdsourcing process generated user ideas that score significantly higher in terms of novelty and customer benefit (Poetz and Schreier 2012).

In short they are open to innovation triggers from any source for radical innovation as they recognise that there are practices a company can do during the 'search' stage of innovation that increases radical innovation performance. The importance of the early stages of the product development process cannot be underestimated as the ideas identified represents the root of success for firms involved with radical new product innovation (Reid and De Brentani 2004). There were no differences in the perceived importance of the search practices between the two groups indicating that the lower usage of the practices can be attributed to barriers that may be in place to engaging in certain search practices.

Selection

This section discusses the answers to questions

> *R2b: Which **selection** practices are linked with increased numbers of radical innovations?*

The selection practices the innovator companies and non-innovator companies used most often were again largely similar with a strong focus on strategic flexibility and strategic openness (Table 4.17). Mirroring the results of the search practices the level of usage was far lower in the non-innovator companies.

The innovator companies used all 14 of the selection practices more than the non innovator companies. The innovators use 11 of the 14 practices significantly more than the non-innovator companies; failure accepted, risk taking encouraged, embraced innovation, ring fenced funding, alternate measurement, prototyping to reduce risk, alternative funding, longer timelines, senior champions, senior management support ($p<0.01$), and strategic openness ($p<0.05$). There were some minor differences in importance ratings with the innovators rating clear ring fenced funding, risk taking encouraged and prototyping to reduce risk ($p<0.05$) as being more important than the non-innovators for radical innovation.

This higher usage by the innovators again indicates a strong link between radical innovation success and the selection practices. The search phase should provide a constant stream of potential ideas but the important decisions are made at the selection stage and in the early stages of development. That decision may be to select projects that push a company out of their normal boundaries or it may be to further invest in projects that appear to be resource hungry without progress and allow them time to develop fully. Regardless, having a system that can deal with radical ideas is clearly important for radical innovation success.

The high usage of the selection practices during the early stages of the development process indicates that innovator companies recognise the challenges they face when attempting to

reduce project risk and overcome cultural barriers that may result in the rejection of radical ideas. This early intervention gives radical projects opportunity to grow and flourish and reach their potential.

6.3.3 Market Leaders vs. Market Followers

Search

This section discusses the answers to questions

*R3a: Which **search** practices are linked with more dominant market positions?*

The practices used most by market leaders and market followers are similar and unsurprisingly follow previous results demonstrating a lot of emphasis on existing customers with high usage of; connecting with end consumers and engaging lead users, however, the level of usage is lower in the market followers (Table 4.9).

The market leaders used 9 of the search practices more than the market followers and 4 of the practices significantly more than the market followers; seeking multiple applications, create active teams, employ scouts and connecting with end consumers ($p<0.05$). These practices are proactive practices to engage in. The higher usage of these practices by the companies who dominate markets demonstrates their willingness to be the 'creators of change' (Miles and Snow 1978, 2003) within their existing markets and also their willingness to expand into and create new markets. Previous research has asserted that it is necessary to balance the narrow 'consumer-led' approach with proactive measures for identifying 'demand shift' identifying long term, latent customer needs (Ketchen et al. 2007).

Selection

This section discusses the answers to questions

*R3b: Which **selection** practices are linked with more dominant market positions?*

The practices used most by market leaders and market followers are similar and again follow previous results demonstrating a lot of emphasis on strategic flexibility and senior management support (Table 4.20). This is perhaps surprising given that the market leaders have a lot invested in current markets and research shows they may be reluctant to challenge the 'status quo' (Chandy and Tellis 1998, Cravens et al. 2002). Rohrbeck et al. (2009) see the need for dominant companies to find ways to increase their ability to grow into new business and foster innovation in fields where they do not have any prior expertise and demonstrate how incumbent companies can engage in open innovation practice to enhance their current dominance without risk their survival.

The market leaders used 13 of the 14 selection practices more than the market followers and 3 of the practices significantly more than the market followers; innovation embraced, longer timeline and senior management support ($p<0.05$) significantly more than the market followers. The higher usage of these practices, in particular, by the companies who dominate markets demonstrates their long term view of markets success and a willingness to invest in the future returns (Martinsuo and Poskela 2011).

6.3.4 Summary

Having identified which practices were correlated with the success measures sub questions *R2a, R3a, R2b and R3b* have been answered.

For radical innovation search 6 of the practices were directly related to increased numbers of radical innovations;

- Seeking multiple applications;
- Creating active teams;
- Employing scouts;
- CowdSourcing;
- Engaging lead users;
- Mobilise mainstream staff.

For radical innovation selection 11 of the 14 practices were directly to increased numbers of radical innovations.

- Failure accepted;
- Risk taking encouraged;
- Embraced innovation;
- Ring fenced funding;
- Alternate measurement;
- Alternative funding;
- Longer timelines;
- Senior management support;
- Prototyping to reduce risk;
- Strategic openness;
- Senior champions.

For radical innovation search 4 of the practices were directly related to more dominant market positions:

- Seeking multiple applications;
- Creating active teams;
- Employing scouts;
- Connect with end consumers.

For radical innovation selection 3 of the 14 practices were directly related to more dominant market positions:

- Innovation embraced;
- Longer timelines;
- Senior management support.

6.4 SME VS. LARGE COMPANIES

This section discusses the following research questions;

*R4a: What is the impact of company size on the use of **search** practices for radical innovation?*

*R4b: What is the impact of company size on the use of **selection** practices for radical innovation?*

Search

The search practices SMEs used most often were engaging lead users, connecting with end consumers and seeking multiple market applications (Table 4.10). SMEs typically have close relationships with their customers and consequently have a natural dependency on them due to their smaller product range (Ghobadian and Gallear 1997, Tidd and Bessant 2009, Karlsson and Olsson 1998).

While recent research suggests that SMEs engage in many open innovation practices and have increasingly adopted such practices in recent years (Van de Vrande et al 2009) the results of this study indicate that search practice is typically more local and closed. The high usage by SME's of 'lead users' and 'connecting with end consumers' allows them to maintain and enhance their relationships with their existing customers. The high usage of 'seeking multiple applications' gives SMEs the opportunity to make efficient use of their existing product lines and target new markets. The high usage of these three practices (engaging lead users, connecting with end consumers and seeking multiple market applications) suggests that SMEs primary focus is very much 'local' in nature; stay close to existing customers and try and apply existing technology in new ways. This is not surprising given the ambidexterity challenge and resource constraints SMEs experience. Previous research asserts that SMEs typically follow defender style strategies and avoid diversification (Brouthers et al. 1998, Aragón-Sánchez and Sánchez-Marín 2005, Laforet and Tann 2006) . Use of these practices enables SMEs to maintain their close working relation with their customers allowing them to maintain and protect their market share. The risk in following this strategy is that a company becomes over dependent on existing technology and customers and as a consequence are vulnerable to market changes

(Raymond and St-Pierre 2004). Laforet and Tann (2006) demonstrated how several British SMEs have thrived through the release of innovative new products. There is a need for SMEs to increasingly innovate to survive and compete in global and niche markets (Humphreys et al. 2005).

Larger companies most used practices were connecting with end consumers, engaging lead users and creating active teams (Table 4.10). Large companies may be utilising 'lead users' and 'connecting with end consumers' to overcome one of their natural disadvantages due to size; being distant from their customers (Ghobadian and Gallear 1997, Karlsson and Olsson 1998). Typically larger companies do not share the same close working relationship that SME's do with their customers. However, large companies not only attempt to maintain closeness with existing customers they also look beyond existing customers through their high usage of 'creating active teams' and 'innovations scouts' to pick up wider innovation trends and triggers. This dual approach means large companies are more receptive to radical innovation. They are being proactive in their efforts to search for radical innovation not only by engaging with their existing customer base but expanding their search space through the use of active teams.

There is a lot of consistency between Large companies and SMEs relating to the most used practices, however, the real difference is the level of usage within each group e.g 'connecting with end consumers was one of the most used practices in each group, however, the usage is higher in large companies than in SMEs. Large companies use 'creating active teams', 'connecting with end consumers' ($p<0.01$), 'suggestion website', 'employing scouts' and 'crowdsourcing', ($p<0.05$) significantly more than small companies.

The practices large companies' use significantly more than SMEs again highlights the dual approach large companies have to their innovation search. By not only engaging their existing customers by 'connecting with end consumers' and seeking multiple applications they also proactively search in new markets by 'employing scouts' and 'creating active teams'. Further to that they also seek to tap into with external expertise for their ideation endeavours through 'crowdsourcing' techniques.

Large companies rated several of the search practices as being more significantly more important for radical innovation, including 'engaging with lead users' and 'end consumers' to stay close with existing customers' and 'creating active teams' and 'employing scouts' to proactively search for radical ideas. In rating these practices significantly more important for radical search than SMEs do highlights the importance large companies place on an open and diverse search approach. Aside from the increased importance given to certain search practices the increased usage by larger companies' can also be explained by their greater access to resources than SMEs (Ghobadian and Gallear 1997, Karlsson and Olsson). Large companies can often invest in new technologies and equipment, providing world-class skills, training to their workforce enabling them to win new markets this is not always the case smaller companies (Laforet and Tann, 2006). The identification, assimilation, and utilisation of external knowledge inputs will often be challenging and resource intensive (Salge et al 2013). However, a lack of resources does not have to represent a significant barrier to innovation, in particular when searching for radical innovation. As highlighted by Christensen's (1997) review of the disk drive industry, market leaders with large amounts of resources at their disposal do not always succeed when faced with radical market shifts. Often, the more important issue is the management of resources; resources need to be allocated to support exploration of new search spaces. Searching for ideas does not need to be an expensive endeavour. Practices such as 'sending out scouts', 'activity diversity', 'mobilising the mainstream' etc can be implemented in a cost-effective manner meaning resources do not have to be a barrier to an open and diverse search approach (equally they can be implemented in a resource intensive fashion).

Selection

The practices SMEs used most often were strategic openness, strategic flexibility, and building bridges through prototyping (Table 4.21). Given that SMEs are generally more flexible and in a position to react quickly to dynamic market forces than larger companies (Ghobadian and Gallear 1997, Karlsson and Olsson, Tidd and Bessant 2005) then it is no surprise that SMEs make high use of these selection practices. SME's who implement more flexible practices are most likely to be among the most innovative of companies (Aragón-Sánchez and Sánchez-Marín 2005).

Larger companies most used practices were strategic openness, strategic flexibility, and prototyping to explore. The high usage by large companies is surprising given that large companies are typically more 'rigid' than SMEs (Ghobadian and Gallear 1997, Karlsson and Olsson, Tidd and Bessant 2005). The high usage of strategic flexibility and openness reflects the importance large companies attribute to flexibility in the decision making process and act accordingly to overcome the obstacle they face. Flexibility must be exercised to give an idea opportunity to develop its potential.

Large companies used 'longer timelines' 'strategic flexibility' and 'alternative funding' ($p<0.05$) more than smaller companies. These practices in particular demonstrate the long-term view larger companies have relating to innovation selection and support, in particular the use of longer time lines and the provision of alternative funding. SMEs must not view innovation as a quick fix; rather, it should be recognised as a longitudinal development programme (Humphreys et al. 2005). The usage of alternative funding and longer timelines by large companies can be attributed to their greater abundance of resources; both monetary and other. Large companies with large R&D budgets and can afford to ring fence funding and appropriate solely for radical innovation. Bessant et al. (2010) notes that successfully innovating companies have developed sophisticated alternative and parallel funding arrangements, which provide access to funding on a range of different terms (joint ventures, equity finance or development funding etc). These types of funding arrangement may be easier for large companies to implement and access than for SMEs given SMEs limited access to external contacts (Ghobadian and Gallear 1997, Karlsson and Olsson). Furthermore given large companies larger product range they can afford to measure progress over longer timeless with theoretically less pressure than an SME for progress. With regards to importance Large or SMEs did not attribute any greater importance to any of the selection practices indicating practitioners have similar thoughts regarding best practice regardless of company size. This indicated that there are significant barriers facing SMEs wanting to engage in the prescribed selection practices that they must overcome.

Summary

There is a lot of consistency regarding usage between SME and large companies with regards to both search and selection; however, usage in large companies is typically higher. When searching for radical innovations large companies use the following practices significantly more;

- Creating active teams;
- Connecting with end consumers;
- Suggestion website;
- Employing scouts;
- CrowdSourcing.

When selecting radical innovations large companies used the following selection practices significantly more;

- Longer timelines
- Strategic flexibility
- Alternative funding.

6.5 UNDERLYING SEARCH FACTORS

This section discusses the following research question;

> *R5a: What are the underlying factors that can be used to categorise radical **search** practices?*

6.5.1 Introduction

Exploratory factor analysis reduced the initial search practice pool from 39 practices to 12 practices. These 12 practices had 5 underlying factors characterising radical search practice (Section 5.3). These 5 factors were subsequently confirmed through confirmatory factor analysis on a second set of companies (Section 5.4) and have also been confirmed in a separate sample of companies in Italy further validating the underlying search factors (Ledwith et al. 2012, Aloini et al. 2013).

The 5 underlying search factors are listed below and each factor is discussed in more detail in the following sections;

Factor one:	Market Awareness
Factor two:	Internet Enabled Search
Factor three:	Engaging with Customers
Factor four:	Open Environment
Factor five:	Internal Networking

6.5.2 Factor 1 Market Awareness

The three individual practices that Factor 1 characterises are as follows:

Create active teams	Our organisation sets up teams to actively search out and implement new ideas that will take our business in new directions.
Seek multiple applications	When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.
Employ scouts	We have people (part-time or full-time) officially charged with scouting for new ideas, finding new sources of potential radical ideas and looking for trends and developments that might have implications for organisation's future.

Linking these three individual practices together it is clear that Factor 1 concerns the exploration of new markets by specialised functions and dedicated groups of people whose role is to actively search for new ideas and knowledge to trigger the innovation process. Each of these items relates heavily to practices that organisations can use when trying to discover and expand into new markets. This factor can be labelled as *Market Awareness*.

Within this factor the practices include sending out ‘scouts’ whose role is to actively search for new ideas to trigger the innovation process. Poolton and Barclay (1998) and Pitta and Franzak (1997) found the presence of a ‘gatekeeper’ (similar role as a ‘scout’) within a company is essential for successful product innovation. The gatekeepers function is to search and scan the organisations’ boundaries for ideas and bring information back to the organisation. These scouts increase the company’s market awareness regarding potentially radical opportunities.

The second practice to load on this factor was that of seeking multiple applications for technology. Applying new and existing technology to new situations has a number of important advantages for a company. Engaging in this type of practices results in less cannibalising of existing markets which is a key concern for many companies (Barton et al. 1989, Chandy and Tellis 1998, Cravens et al. 2002) and results in less pressure regarding the need for consumers to adopt your technology (McDermott and O'Connor 2002). The future growth of a company can depend to a great extent on its ability to expand market applications for its existing products (Gjerde et al. 2002). Searching for multiple applications for new technologies can create unforeseen connections between unrelated fields.

The third practice loading was ‘creating active teams’. This practice combines both previous practices. Management should actively try to stimulate radical innovation by ensuring that the organisation is focusing on innovation. Creating active innovation teams is one such method of stimulating creativity. These active teams may have the mandate of overseeing the development of radical innovation projects (O'Connor and DeMartino 2006) by scouting for ideas and seeking other application for existing products. Whilst radical innovation may sometimes seem to occur on an ad-hoc basis it is important that companies are proactive in their approaches and allocate resources accordingly.

6.5.3 Factor 2 Internet Enabled Search

The two individual practices that Factor 2 characterises are as follows:

Suggestion website.	We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services.
CrowdSourcing	We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions.

Linking these two individual practices together it is clear that Factor 2 is related to putting systems in place for capturing and collecting ideas and solutions from outside the

organisation using the internet as the collection platform. Factor 2 can be labelled as the *Internet Enabled Search* factor.

Crowdsourcing, a term populised by Howe (2006) describes a web-based business model that harnesses the creative solutions of a distributed network of individuals through what amounts to open calls for proposals/suggestions/solutions. Innovation contests, a competition of innovators who use their skills, experience, and creativity to provide a solution for a particular contest challenge defined by an organiser (Bullinger et al. 2009) would be closely related to the Crowdsourcing technique. These methods of connecting with external expertise allow a company to access cost effective problem solving. Crowdsourcing process generated user ideas that score significantly higher in terms of novelty and customer benefit (Poetz and Martin Schreier 2012).

Online innovation initiatives such as this require mechanisms to facilitate and encourage knowledge exchange through interaction among members (Boudreau and Lakhani 2012). Companies are increasingly recognising power the internet represents as a platform for co-creating value with customers (Sawhney et al. 2005). Given that the internet is an open and cost effective method of connecting with consumers (Afuah 2003) using systems such as suggestion websites allows consumers to become active players in the innovation process (Sawhney et al. 2005, Kozinets 1999). Bessant and Stamm (2007) cite numerous case examples regarding internet usage for radical innovation ideation. Small and large companies alike have turned to crowdsourced innovation as they seek cheap and fast solutions for parts of their work (Felstiner 2010, Moran 2010). Furthermore ‘organisations can derive value by learning about their ‘problem’ even if a solution is not found’ (Feller et al. 2012).

6.5.4 Factor 3 Engaging with Customers

The two individual practices that Factor 3 characterises are as follows:

Work with lead users.	Our organisation is able to identify and collaborate with its lead users.
Connect with end consumers.	We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need.

The two practices that relate to Factor 3 are; connecting end users and engaging lead users. Linking these two variables is straightforward as they both relate to using customer ideas as sources for innovations. This factor is labelled as *Engaging with customers*.

The practices included in this factor are centred on using customers' ideas and insights as the starting point for new products and new markets and services and connecting with the very end consumer to ensure their needs are being met. Engaging with lead users systematically results in a powerful source of radical ideas. These users experience needs far and above that of the 'average consumer' and these needs have the potential to become more main stream in the future. Lead users often apply and adapt existing products in new ways. Systematically identifying lead users perceptions and preferences and incorporating these to identify emerging needs for new products, processes and services exploits the value of lead users (Franke and Shah 2003, Herstatt and Von Hippel 1992, Lilien et al. 2002, Jeppesen and Molin 2003). Lilien et al. (2002) found lead user projects had significantly higher novelty, addressed more original newer customer needs, and also had significantly higher forecasted sales than other projects.

Engaging with the end consumer is also extremely important. Radical innovation is often technology driven as opposed to demand driven. Research shows the need for ongoing adaptation toward customers' requests (Mukherji and Francis 2008) and that proactive customer orientation is the most consistent driver of customer value (Blocker et al. 2011). Customers are especially important for feedback to the firm on ideas for new innovation or improvements to existing innovations (Kumar et al 2010).

6.5.5 Factor 4 Open Environment

The three individual practices that Factor 4 characterises are as follows:

Mobile mainstream staff.	We currently have systems or procedures in place that ensure insights from mainstream staff who have the opportunity to gather information from external sources are being collected systematically.
Activity diversity.	We actively encourage people to go to events/conferences/courses that are outside their current realms of experience.
Idea management system.	In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback.

These three practices depict an open environment where the organisation is put in connection with external resources in order to co-develop technologies and products, increase knowledge and widen their general network of connections. This factor can be termed *Open Environment*.

Practices such as attending conferences and events not only allow the firm to keep up-to-date with the developments in particular field of expertise but also provide a useful opportunity to exchange ideas, establish relationships with external stakeholders, encouraging the various functions to systematically collect ideas and opinions from outside sources such as universities, research centres, etc. Companies should encourage boundary spanning employees to attend industry conferences and, occasionally, conferences that are tangential to their disciplines (Brentani and Reid 2011). Mobilising the mainstream allows ideation from other stakeholders to be harnessed. Having an internal idea management system then can be used to capture the potential ideas that arise.

As discussed in previous chapters much innovation happens at the boundary between one knowledge set and another; not at the frontier of knowledge. The scope for transferring ideas from one sector/business to another is huge, and a powerful source of innovation. This type of networking is important for radical innovation to thrive in a company

(O'Connor and McDermott 2004). Increasing the diversity of firms' innovation partners and respective innovation stimuli, in turn, improves the capability of firms to introduce more advanced innovations. Explorative NPD projects have more to gain from search openness at the ideation stage than their exploitative projects (Salge et al 2013).

Further to using activity diversity to amplify the search capacity of a company is to make better or different use of the existing resources i.e. to mobilise the mainstream players in new or additional roles (Bessant and Stamm 2007). Companies need to have the systems in place to harness creativity, capture ideas and apply those to relevant problems and opportunities and ultimate convert them to successful, innovations. Companies with a history of producing new to market innovations regularly feature employee suggestion schemes (Laforet 2009).

6.5.6 Factor 5 Internal Networking

The two individual practices that Factor 4 characterises are as follows:

Connect people internally.	In our organisation, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm.
Broker knowledge sets.	Our organisation operates some form of brokering/bridge-building that involves bringing together people from different knowledge sets, backgrounds or functions in order to support Discontinuous Innovation.

These two practices relate to the creation of an internal network. Hence, this factor may be labelled as *Internal Networking*. In fact the items are examples of practices through which individuals with different backgrounds and skills are linked together in order to leverage on different skills and experience sets, to gain a knowledge and experience exchange and to learn new perspectives. In addition these practices favour the gathering and dissemination of knowledge in the organisation, making knowledge accessible to everyone.

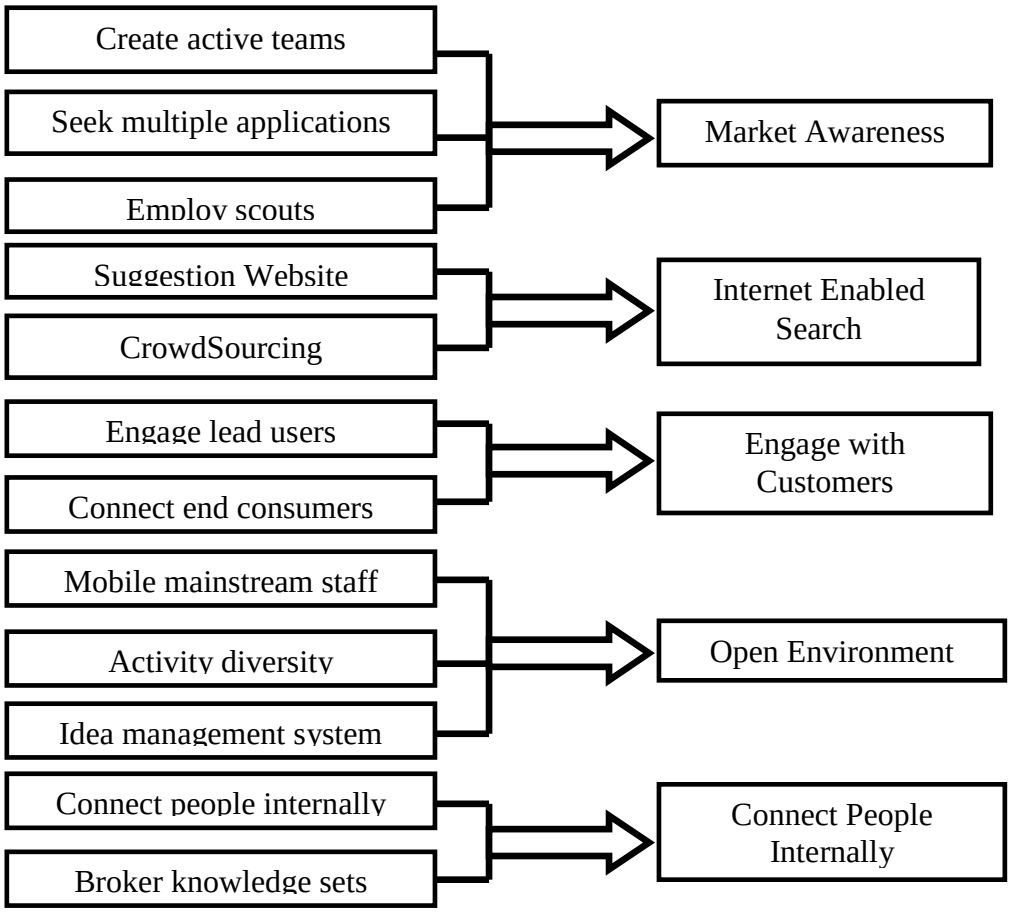
Lateral relationships and a widening of task boundaries within organisations create an environment favorable to innovation (Brown and Eisenhardt 1997). Product innovation

often involves synthesising and reusing existing knowledge and information. Intra-firm linkages between different knowledge sets are a positive predictor for incremental and radical innovation (Koberg et al. 2003, Cormican and O'Sullivan 2004, Rothwell 1992). McDermott and O'Connor (2002) suggest successful development teams rely on the existence of large informal networks of individuals both inside and outside the company, which could be utilised as required. These informal networks also helped long-term survival of projects when budgets restrictions were in place (McDermott 1999). Brokering between internal knowledge sets also fuels innovation by building synergies between research and commercial development (Ahmed 1997).

Design and development teams are deliberately staffed with individuals from peripheral disciplines who are unfamiliar with the core products or technology under development. These types of measures are taken to ensure that projects are approached from different and innovative perspectives, and that conventional wisdom and ‘status quo’ is constantly challenged and tested. A company failing to forge quality links with others outside the company and internal staff relying on immediate colleges rather than reach out to counterparts in other departments or divisions may result in a shortage of ideas. These companies need to build external networks as well as internal cross-unit networks to generate ideas from new connections (Hansen and Birksaw 2007).

Figure 6.1 visually describes the underlying structure of the radical search construct.

Figure 6.1 Visual representation and interpretation of search factor analysis



6.6 UNDERLYING SELECTION FACTORS

This section discusses the following research question;

> *R5b: What are the underlying factors that can be used to categorise radical **selection** practices?*

6.6.1 Introduction

Exploratory factor analysis reduced the initial selection practice pool from 20 practices to 14 practices. These 14 practices collapsed into 4 underlying selection factors characterising selection practices (Section 5.5). These 5 factors were subsequently confirmed through confirmatory factor analysis on a second set of companies (Section 5.6).

The 4 underlying selection factors are listed below and each factor is discussed in more detail in the following sections;

Factor one: Fostering and supporting radical selection;

Factor two: Prototyping as a selection tool;

Factor three: Strategic and operational flexibility;

Factor four: Differentiating between radical and incremental selection.

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6.6.2 Factor 1 Fostering and Supporting Radical Selection

The four individual practices that Factor 1 characterises are as follows:

Clear ring fenced funding	The process for accessing and leveraging resources (funding, personnel, capital equipment, and other organisational resources) for radical innovation projects in our firms is clear.
Innovation embraced	There is an atmosphere in our organisation which encourages everyone to take part in innovation.
Risk taking encouraged	We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs
Failure accepted	In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.

Linking these four practices together it can demonstrated that factor 1 relates to the existence of a culture encouraging risk taking and entrepreneurship and resource provision to support this culture. The factor is labelled as ***fostering and supporting radical selection.***

A radical-innovation life cycle may span many years so a project can expect to see its developers and funding sources change several times over that time period. Consequently, project leaders must approach a variety of potential funding sources and even reorient their projects to suit whoever in charge of resource allocation (Leifer et al. 2001). At the time of financial turbulence and stringency, it may be even more difficult to fund higher risk

breakthrough opportunities and ideas, unless a specific budget has been ring-fenced (He et al. 2008).

To be successful at innovation requires work and commitment. An appropriate organisational culture will facilitate creativity (Tesluk et al. 1997). The organisation members should be able to operate in a relatively unstructured, open and fluid environment (Amabile et al. 2002). Innovation much be embraced by the entire organisation by treating innovation as a corporate wide task (Rothwell 1992). Treating innovation as a corporate wide task results in a constant focus on ensuring that innovation is given high priority in day-to-day operations throughout organisations, rather than left as an ad-hoc activity (Ahmed 1997). An entrepreneurial organisational culture provides the foundation for success in the front end in process development (Kurkkio et al. 2011).

An informal, open, and inquiring environment that values experimentation, with leaders promoting innovation by creating a shared belief that team members are safe to take interpersonal risks will facilitate radical innovation (Claver et al. 1998, Harborne and Johne 2003, Gudmundson et al. 2003). Management should loosen control and become less risk averse in order to develop an environment that favors the appearance of radical innovation (Ekvall 1996). Cooper et al. (2004a) research found the best performing companies were supportive of innovation and had no punishment for failure. Learning from mistakes is a part of the development process and aids the development of both individual and group skills and experiences (Chatman and Cha 2003, Andriopoulos and Gotsi 2002). A company having explorative team culture tolerant of failure is a key factor for radical innovation success (Aagaard and Gertsen 2011). Furthermore, it is essential to anchor the idea of life-long learning company culture. For fostering this philosophy, a system of motivation needs to be established. Employees need to be willing and motivated to question existing knowledge and experience, this way freeing their minds to look out for innovative approaches (Herrmann et al. 2006).

6.6.3 Factor 2 Prototyping as a Selection Tool

The three individual practices that Factor 2 characterises are as follows:

Prototyping to build bridges	We use prototypes to build bridges in the selection process. By using prototypes we 'build bridges' in the minds of potential supporters (e.g. senior management, investors etc.) between the current state of affairs and what might be if this project is given opportunity to develop.
Prototyping to reduce risk	We use prototyping to reduce uncertainty when making selection decisions i.e. we often 'buy a look' before deciding whether or not proceeding.
Prototyping to explore.	We use prototyping to 'take a small step' in a few different directions before committing to a large step in one direction.

The three practices that relate to Factor 2 are; prototyping in order to explore, reduce risk and build bridges. This factor clearly relates to the use of ***prototyping as a selection tool*** within the radical innovation process. Prototyping can be used in many different ways depending on the goal of the prototype. Senior management encouraging early prototyping and being close to the process and exposed to the prototypes at an early stage is a significant index of the company's overall inclination to innovate (Hughes and Cosier 2001). When developers see something new, in order to take that forward and make the potential opportunity a reality, a major challenge they face is that of mobilising resources to proceed with the development. In this situation prototyping enables developers to build bridges in the minds of senior management the current state of affairs and what might be, creating stepping stones that allow people to better understand and shape the idea when it is still in its formative stages (Bessant et al. 2010).

Brown and Eisenhardt (1998) demonstrated that successful innovators were those who were able to improvise and experiment. This experimentation and freedom to experiment is a positive predictor of radical innovation (Koberg et al. 2003). Fundamentally, 'probe and learn' reduces the risks associated with radical innovation into smaller steps with more limited exposure, rather than forcing a single large commitment. This 'buying a look' helps assemble the beginnings of a case for further support and exploration (Cooper 2001,

Bessant et al. 2010). Valid, earlier customer input on the applications gives firms more confidence in their market prospects (Hende and Schoormans 2012).

It is difficult to imagine a radically different future. A powerful approach is to try something out – probe – and learn from the results, even if they represent a failure. This probing and learning provides information about what does and doesn't work and so in turn helps build the case for selection (or even rejection) or further support and exploration (Bessant et al. 2010). This way, emergent trends, potential designs, etc. can be explored and refined in a continuing learning process. Prototyping as an exploration tool often leads to unforeseen connections being made (Hughes and Cosier 2001). The learning gained from one development project to the next is invaluable for the sustained production of new-to-market products (Mosey 2005). Prototypes are very important for building a solid business proposition and optimising the product application into a final product (Hende and Schoormans 2012).

6.6.4 Factor 3 Strategic and Operational Flexibility

The three individual practices that Factor 3 characterises are as follows:

Strategic flexibility	We remain open to re-consider our future position in our industry value chain and make shifts if we have to.
Strategic openness	When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market.
Senior champions.	In the company there are identifiable project champions in senior positions within the company who promote the development of radical and discontinuous projects?

This factor can be interpreted as relating to ***strategic and operational flexibility*** by having a flexible selection strategy and support for this ideology from senior management 'sponsors'.

Radical innovation by its nature represents a turbulent and changeable environment. In line with this companies need to be flexible to adapt to change. Decision processes characterised by openness to novel alternatives are more like to produce the types of innovative decisions that facilitate organisational adaption (Sharfman and Dean Jr 1997). Strategic flexibility helps firms with superior technology sustain their exploration (Zhou and Wu 2010) and achieve sustained innovation performance (Kekale et al. 2010). Managers seeking innovation and new product success need to be responsive to the environmental contexts and to allocate resources to pursue the effective strategic orientations for the specific context (Yang et al. 2012).

Operating with strategic flexibility and openness can only be facilitated with support from senior management. Much of the literature around radical innovation identifies the roles of various players such as the ‘champion’ and the ‘sponsor’. These individuals are important in forcing radical innovations through existing selection systems that maybe not hospitable to radical innovation. In managing the people side of radical innovation, one of the leadership roles that facilitates innovation is that of a sponsor (McDermott and O'Connor 2002, Dougherty and Heller 1994).

Key to the selection phase is developing methods of engaging sponsors in a planned fashion rather than hoping for their emergence (Markham et al. 2010). Bessant et al. (2010) see the challenge as building sponsors into the decision-making process, rather than hoping that they will emerge. This may be done by making formal links with senior managers whose remit is to be a sponsor for radical innovation projects.

6.6.5 Factor 4 Differentiating between Radical and Incremental Selection

The four individual practices that Factor 4 characterises are as follows:

Alternative measurement.	When evaluating radical opportunities we use alternative measurement and evaluation criteria to the ones used for non-radical opportunities.
Senior management support	Our senior managers understand that it takes time for radical innovation projects to acquire the necessary learning experience before they can move forward.
Longer time timeline.	Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and prove themselves.
Alternative funding	Our firm funds radical innovation project development differently than they fund incremental innovation projects.

Each of these four practices may be linked to *differentiating between radical and incremental innovation.* Visible top-level management support is vital for success of any project (Brown and Eisenhardt 1995, Cooper and Kleinschmidt 1995a, Cooper et al. 2004a). Senior management should be aware that innovation cannot be planned easily but can be inhibited easily. Radical innovations require time to gather the required learning before moving forward. Rushing innovation and aiming for shorter development times can lead to higher or lower development costs, for example, and to lower-quality products (Kessler and Chakrabarti 1996).

Due to their proactive nature, R&D projects can be difficult to evaluate. The information required for evaluation is typically revealed gradually during the development of the project. Consequently when the opportunity is first identified there are no cash flow estimates available or similar information available that would either justify or invalidate the decision to proceed with the project (Carlsson et al. 2007). Assessment formality generates a hurdle in the early phases of product development (Martinsuo and Poskela 2011). Alternative review criteria may be utilised as ‘learning loops’ revealing what is required to be explored further rather than as ‘go/no-go’ decisions at stage gates (Bessant et al. 2010). These loops can also be linked to resource allocation and have the advantage of

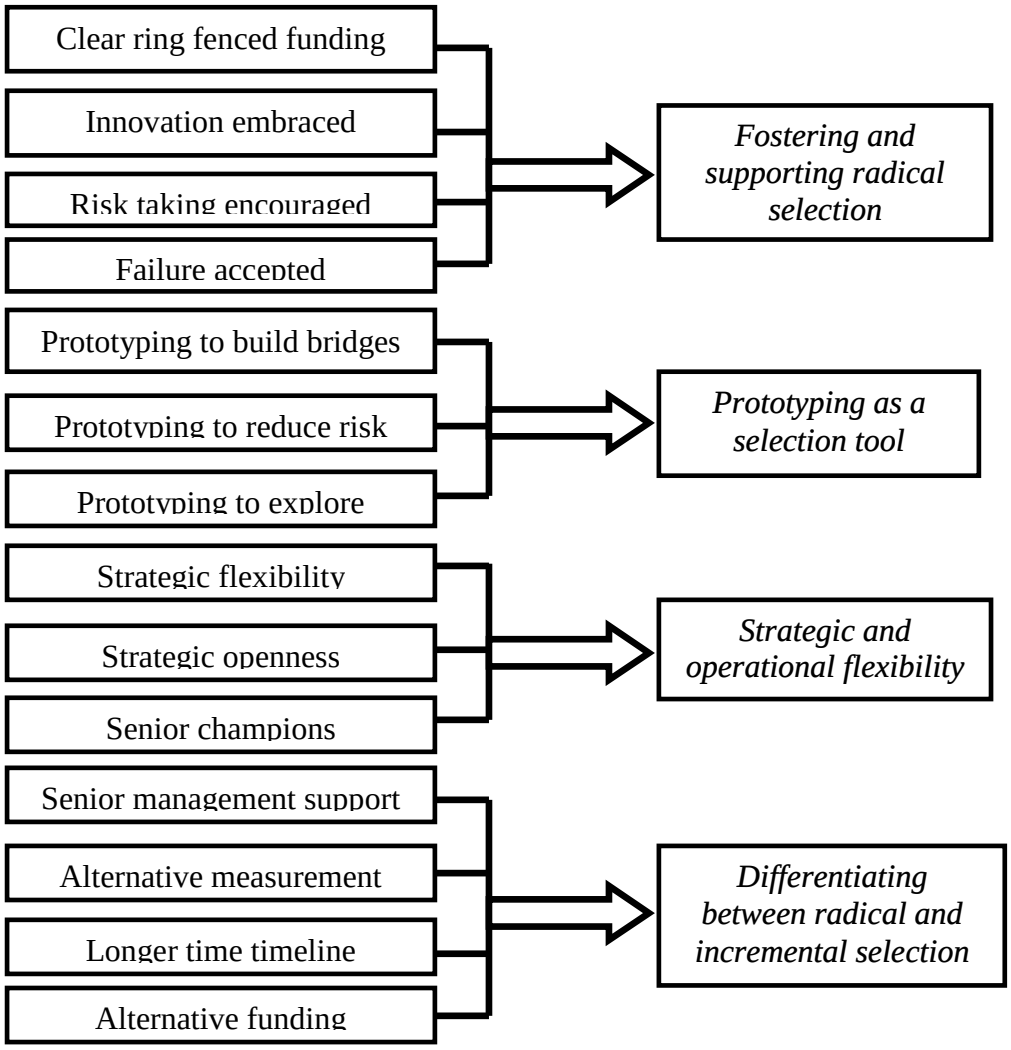
allowing further exploration to proceed despite not meeting the typical measurement criteria.

No two radical innovation projects are the same (Leifer et al. 2000). Radical innovation need time to mature before they can move forward. The Product Development & Management Association (PDMA) best practice study (Barczak et al. 2009) showed new to the world innovations are completed in on average 104 weeks and also on research by Leifer et al. (2000) whose research demonstrates that radical innovation can take up 10 years to fully realise the benefits. Radical innovation needs support and nurturing from senior management to allow them to mature and should be assessed on longer timescales than incremental innovations. The overall innovation strategy must allow for long term developments (Cooper et al. 2004b).

Resources within any company are limited. Radical innovation can be an expensive process so rather than drawing from the mainstream R&D budget, which is vital for the day to day innovation research, sometimes alternative funding structures are more appropriate. Rice et al. (2000) found that funding for radical innovation projects in the engineering industry originated from both internal and external. Funding options can include the conventional R&D budget, a special budget for radical innovation or external partnering with another company or knowledge institution. Access to abundant, high quality resources increases an organisation's chances of coping with change (Christensen and Overdorf 2000). Christensen (1997) states that innovation projects that obtain funding are likely to succeed. Rothwell (1992) noted the importance of making up-front commitment of resources to screening projects for their successful development.

Figure 6.2 visually describes the underlying structure of the radical selection construct.

Figure 6.2 Visual representation and interpretation of selection factor analysis



Summary

Having identified underlying 5 search and 4 selection factors sub question *R5a and R5b* have been answered. Radical search is characterised by 5 underlying factors:

- Market awareness;
- Internet enabled search;
- Engaging with customers;
- Open environment;
- Internal networking;

Radical innovation selection is characterised 4 underlying factors:

- Fostering and supporting radical selection;
- Prototyping as a selection tool;
- Strategic and operational flexibility;
- Differentiating between radical and incremental selection.

6.7 FACTORS IMPACT ON SUCCESS

This section discusses the results relating to research questions

*R6a: Which of the identified **search** factors are linked with increased numbers of radical innovations?*

*R7a: Which of the identified **search** factors are linked with more dominant market positions?*

*R6b: Which of the identified **selection** factors are linked with increased numbers of radical innovations?*

*R7b: Which of the identified **selection** factors are linked with more dominant market positions?*

6.7.1 Search

Regression Search Model 1 (Table 5.25) assessed the predictive value of the five identified search factors (market awareness, internet enabled search, engaging with customers, open environment, and internal networking) on the dependent variable 'number of radical innovations' a company developed over the previous 5 years. Company size was also assessed as an independent variable. The model was significant (R^2=.296, p<.01), however, none of the search factors were significant. This suggests that despite the five factor model being a good fit for the data (Section 5.4) and some of the individual practices being linked with success (Section 4.2.3) that the actual usage of the underlying factors has no impact on radical innovation involvement and success. This indicates that the search phase may not be of critical value to radical innovation success. In theory, a wider and more diverse search strategy is seen to be able to create more opportunities (Helfat 1994, March 1991, Katila 2002). This may be true but having more opportunities may not lead to more success. Ideas

are plentiful; companies generally have no shortage of potential ideas to take forward (Terwiesch and Ulrich 2009, Chesbrough 2003). Discovery and the creation of opportunities is an ongoing cycle that provides a rich milieu within which entrepreneurs find plentiful and varied opportunities (Zahra 2008). These opportunities may one day become successful innovations (Terwiesch and Ulrich 2009), however, given how plentiful potential ideas are perhaps excellence during the search phase of the radical innovation process is not of critical importance to final success.

Company size was the primary predictor of radical innovation success (beta=416, $p<.001$) as expected given the high correlations seen in the previous chapter between company size and number of radical innovations developed. As discussed previous research has indicated that larger often dominant companies are reluctant to get involved in radical innovation (Christensen 1997) as they have too much invested in currently selling products and technologies to risk cannibalising existing markets (Barton et al. 1989, Staw and Ross 1987, Chandy and Tellis 1998, Nijssen et al. 2005, Leonard-Barton 1992, Cravens et al. 2002, Koudal 2004). The fact that company size was a predictor of number of radical innovation developed demonstrates that the large companies in the sample are not afraid of radical innovation and are searching for and embracing the opportunities that they find.

Regression Search Model 2 (Table 5.25), assessed the predictive value of the five identified search factors (market awareness, internet enabled search, engaging with customers, open environment, and internal networking) on the dependent variable, the market position of the company. Company size was included as a dummy variable. The overall model was significant ($R^2=.277$), $p<.01$) Size was again a significant predictor of market position (beta=.363, $p<.01$). Given the resource advantage that large companies enjoy it would be expected that typically they would find themselves in more dominant market positions than smaller companies. Small companies often have no ambitions to grow (Storey 1994) and prefer instead to defend their market share (Brouthers et al. 1998, Aragón-Sánchez and Sánchez-Marín 2005) so would rarely in a position of dominance in a market.

Two of the search factors were significant making unique contributions to the variance of market position; the *'market awareness'* factor and the *'internal networking'* factor. Market awareness was a positive predictor of market position (beta=.274, p<.05). A company being aware of their environment and being proactive in their search endeavours is crucial to attainting a strong market position. The practices that comprise the market awareness factor are 'create active teams', 'seek multiple applications' and 'employ scouts'. These practices are very much proactive search practices. A company being open to opportunities 'presenting' themselves is obviously a route to success, however, a company also has the power to control (or at least attempt to influence) their performance by being proactive in their search effort. The most innovative organisation exercise proactivity and risk taking (Johannessen et al. 1999). Creating active teams and employing scouts allows a company to actively explore potential new markets with a view of expanding their current business. Activities such as described have the ability to increase strengthen market share by identifying opportunities for radical innovation. Radically new technologies can reinforce the market position of an already dominant firm by generating larger cash flows than the technology can for their less dominant counterparts (Sorescu et al. 2003).

Internal networking was found to be a negative contributor to market position (beta=-.260, p<.05). The practices the factor underlies are 'connect people internally' and 'broker knowledge sets'. These practices focus on internal communication to enable radical innovation. The use or perhaps over reliance on practices such as these may be negatively related to market position as becoming a dominant market player relies less on internal knowledge and communication and more on how a company connects with external knowledge. Research demonstrates that the ability to remain a market leader even through radical change requires the constant acquisition of new knowledge (Drucker 1991, Grant 1996); new knowledge that is difficult to attain if the prevailing company cultural is centred on internal problem solving rather than utilising external sources (Bessant et al. 2010). Balance with regards to search openness is crucial. That is too little as well as too much search openness at the ideation stage may be detrimental. Each NPD project is in need of a carefully tailored search strategy, effective leadership, and a supportive climate, if the full value of external knowledge sourcing is to be captured (Salge et al. 2013).

6.7.2 Selection

Regression Select Model 1 (Table 5.26), assessed the predictive value of the four selection factors (fostering and supporting radical selection, prototyping as a selection tool, strategic and operational flexibility and not differentiating between radical and incremental selection) on the 'number of radical innovations' a company had over the previous 5 years. Company size was included as a dummy variable. The overall model was highly significant (R^2=.397, p<.001). Company size, similar to the search results, was found to be a predictor of radical innovation success (beta=.195, p<.1). Three of the selection factors were also significant predictors of number of radical products over the previous 5 years. The '*fostering and supporting radical selection',* factor was a positive predictor (beta= .306, p<.o1). The *'prototyping as a selection tool'* factor was a positive predictor (beta=.205, p<.1) and the '*Not differentiating between radical and incremental innovation'* factor was a negative predictor (beta= -.278, p<.05).

The selection decisions made at the early stages of the development process guide the later development phases so have a direct influence on final success. The factors in particular are used to overcome the existing inertia of the existing selection systems which may reject all radical ideas. The foster and supporting radical selection factor is comprised of practices 'clear ring fenced funding', 'innovation embraced' 'risk taking encouraged' and 'failure accepted'. Senior management face tough decisions on how much to invest and which opportunities to pursue (Terwiesch and Ulrich 2009) so the practices associated with the fostering and supporting radical selection are practices to overcome existing barriers to selection within a company by providing funding for radical innovation and cultivating a environment to allow radical innovations to be selected and flourish.

Prototyping for selection also results in the reduction of risk (Verworn at al. 2008) so enables selection (Bessant et al. 2010) of successful radical products. Prototyping early in the development enhances top management support and reduces technical and market uncertainty (Verworn et al. 2008). Senior management encouraging prototyping during the fuzzy front end and being actively exposed to the prototypes at an early stage is a

significant index of the company's overall inclination to innovate (Hughes and Cosier 2001).

The model also demonstrates that if a company does not differentiate between radical and incremental innovation then it has a negative impact on its radical innovation success hence companies need to differentiate between radical and incremental projects when making vital selection decisions. Radical innovation is different to incremental innovation (Verworn et al. 2008) and recognising this and treating it differently will contribute to innovation success e.g radical ideas, during the fuzzy front end are too embryonic to permit evaluation of their future potential (Möller 2010). By treating radical ideas differently to incremental ideas and not exposing them to harsh selection criteria they have the opportunity to mature. The overall innovation strategy must allow for long term developments (Cooper et al. 2004b).

Regression Select Model 2 (Table 5.26), assessed the predictive value of the four selection factors (fostering and supporting radical selection, prototyping as a selection tool, strategic and operational flexibility and not differentiating between radical and incremental selection) on market position while controlling for company size. The overall model was highly significant (R^2=.334, p<.001). Company size again was found to be a predictor of market position (beta=.391, p<.001). The '***fostering and supporting radical selection*** factor was a significant predictor of market position (beta=.305, p<.05). The importance of this selection factors to market position is not an unexpected result especially given that many of the practices reflect the 'long-term' nature of radical innovation e.g. ring fencing funding and accepting failure as part of the innovation process. Typically radical innovation can take up to 10 years to develop, launch and paid tangible dividends (Leifer et al. 2000) then the importance of these practices is to be expected. Giving an early stage radical innovation time to mature into a workable idea will have a long term effect on market position through the release of more radical innovations resulting in growth levels that are significantly larger than the growth of the industry (Bessant et al. 2004).

Summary

Performing conducted regression analysis on the data allowed the following questions to be answered:

*R6a: Which of the identified **search** factors are linked with increased numbers of radical innovations?*

*R7a: Which of the identified **search** factors are linked with more dominant market positions?*

*R6b: Which of the identified **selection** factors are linked with increased numbers of radical innovations?*

*R7b: Which of the identified **selection** factors are linked with more dominant market positions?*

With regards to the 'Search' aspect of radical innovation:

- None of the search factors impact number of radical innovation developed.
- The 'Market Awareness' factor is a positive indicator for market position.
- The 'internal networking' factor is a negative indicator for market position

With regards to the 'Selection' aspect of radical innovation:

- The 'Fostering and supporting radical selection' and 'Prototyping as a selection tool' are positive indicators for number of radical innovations developed.
- The 'not differentiating between radical and incremental innovation' is a negative predictor for number of radical innovation developed (meaning that the opposite is also true and differentiation between radical and incremental innovation is a positive predictor of radical innovation).
- The 'Fostering and supporting radical selection' is a positive predictor for market position.

6.8 FINAL RESEARCH MODEL SUMMARY

A simple research model was presented at the end of Chapter 1 (Page 13). This model was extended through a literature review presented in Chapter 2 (Page 88) and was used to guide the research process and structure this thesis accordingly. Two models are assessed; one model covering the 'search' phase and one the 'select' phase of the fuzzy front end of radical innovation. The models consist of three levels outlining search and selection practice, underlying search and selection factors and innovation success. The models sought to establish the exact relationship between the individual search and selection practices and the factors underlying these practices. The relationship that exists between the individual practices and innovation success (number of radical products released and market position) was subsequently investigated before finally assessing the predictive value of the underlying factors on innovation success. Company size was also included as an important variable in the models.

6.8.1 Search

The final search model is presented in Figure 6.3. The model is structured across 3 levels outlining 12 search practices, characterised by 5 underlying search factors with an effect on two success measures. Company size is included as an important moderating variable. The search practices are numbered according to usage. Individual practices which were significantly linked with the two success measures are indicated through the 'RI' and 'MP' notation.

The 12 search practices describe a diverse range of practices that enable a company to expand their search space and find explore new possibilities and opportunities. The most used practices by the sample were 'connect with end consumer' and 'work with lead users', followed by 'seek multiple applications', 'employ scouts' and 'create active teams'. This suggests that the primary focus for companies is on existing markets and customers and developing new products to satisfy them with only secondary consideration given to the exploration of new markets.

As seen in the Figure 6.3, 6 of the 12 search practices were linked with the release of radical new products; ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, ‘crowdsourcing’, ‘work with lead users’ and ‘mobile mainstream staff’. Of the 12 search practices, 4 were linked with more dominant market positions; ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, and ‘connect with end consumers’. Three of the practices, in particular, appear to be crucial and are linked to both radical innovation success and market position (‘create active teams’, ‘seek multiple applications’, ‘employ scouts’). These three practices are among the most used practices, however, there are several obviously less important practices being utilised more often.

The search practices are characterised by 5 underlying search factors; ‘Market Awareness’, ‘Internet Enabled Search’, ‘Engaging with Customers’, ‘Open Environment’ and ‘Internal Networking’. None of the underlying search factors have an effect on ‘number of radical products’ released. One of the search factors has a positive effect on market position; the ‘market awareness’ factor. The three practices characterised by this search factor are the same three practices heavily linked with radical innovation success again highlighting their importance during the search phase of radical innovation. One of the underlying search factors was also a negative predictor of market position; ‘internal networking’ suggesting that the route to a strong market performance does not lie entirely within the company and too much internal networking and problem solving is an inhibitor to performance. Finally company size is important for radical innovation. It is a highly significant predictor of both market position and radical innovation involvement.

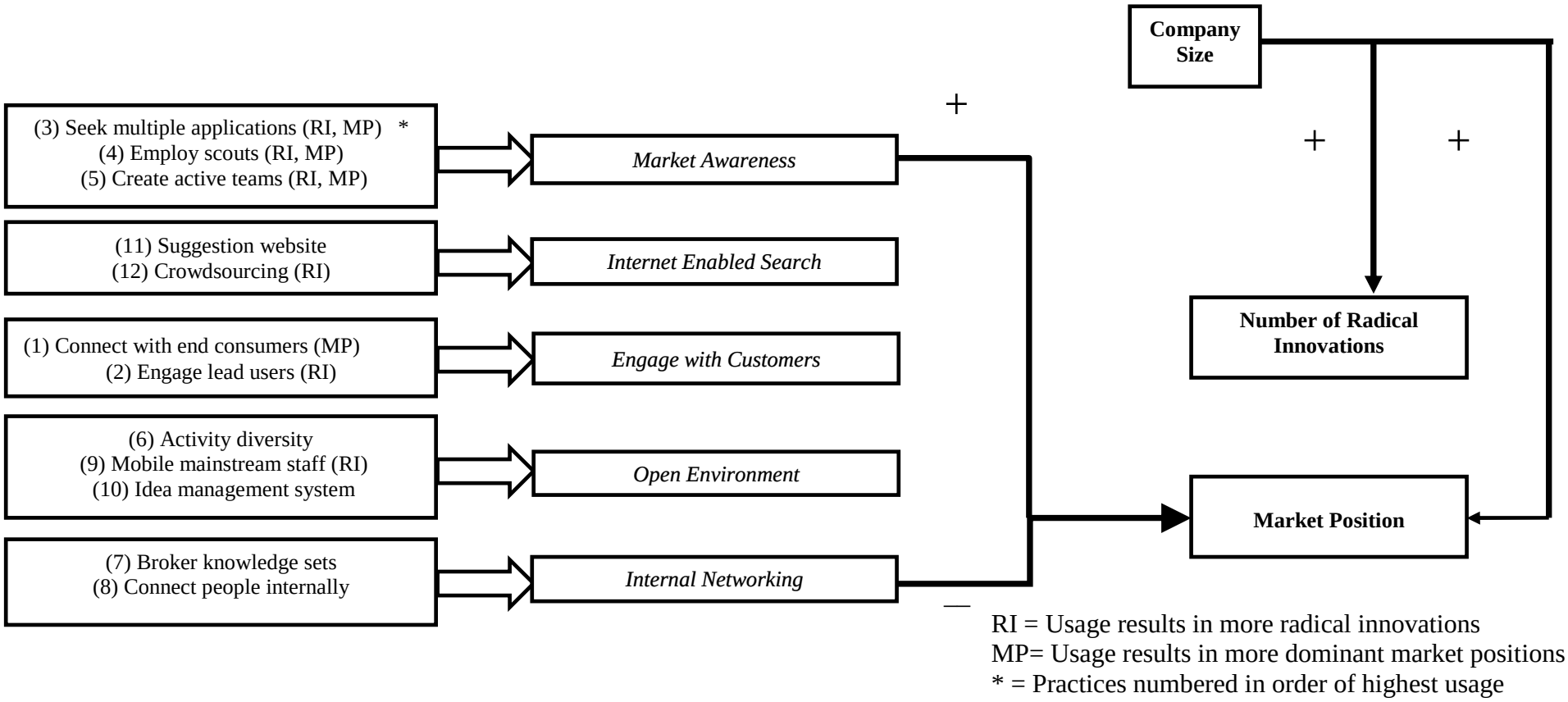


Figure 6.3 Final Research Model: Search

6.8.2 Selection

The final selection model is presented in Figure 6.4. The model is structured across 3 levels outlining 14 selection practices, characterised by 4 underlying selection factors with an effect on two success measures. Company size is included as an important moderating variable. The selection practices are numbered according to usage. Individual practices which were significantly linked with the two success measures are indicated through the 'RI' and 'MP' notation.

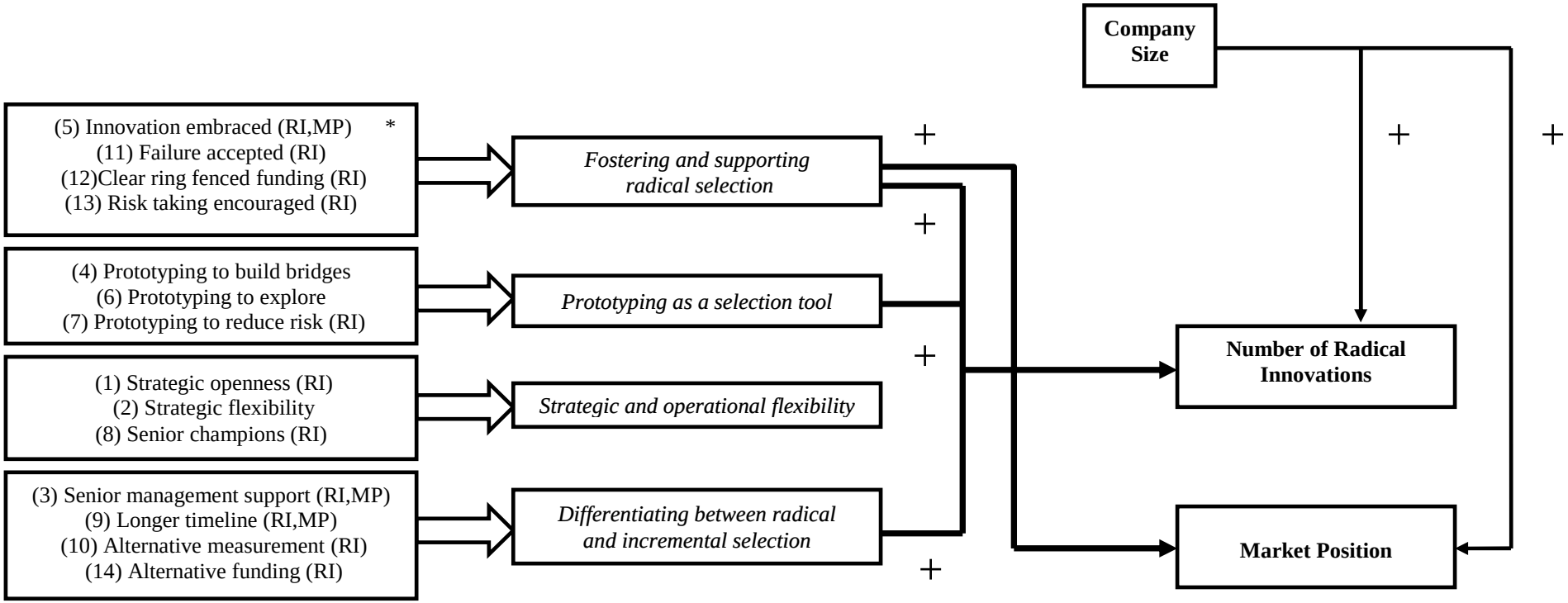
The 14 selection practices again represent a diverse range of practices that enable a company to overcome their existing selection inertia and select radical innovations for development. The most used practices by the sample were 'strategic openness' and 'strategic flexibility'. The usage of these practices suggests the companies in the sample are open and flexible in their selection practice with regards to radical innovation.

As seen in the model 11 of the 14 selection practices were linked with the release of radical new products; failure accepted', 'risk taking encouraged', 'innovation embraced', 'clear ring fenced funding', 'prototyping to reduce risk', 'strategic openness', 'senior champions', 'alternative measurement', 'alternate funding', 'longer timeline', and 'senior management support'. Of the 14 selection practices, 3 were linked with more dominant market positions; 'innovation embraced', 'longer timeline' and 'senior management support'.

The selection practices are characterised by 4 underlying selection factors; 'fostering and supporting radical selection', 'prototyping as a selection tool', 'strategic and operational flexibility' and 'differentiating between radical and incremental selection'. Three of the underlying selection factors have a positive effect on 'number of radical products' released; 'fostering and supporting radical selection', 'prototyping as a selection tool' and 'differentiating between radical and incremental selection'. One of the selection factors has a positive effect on market position; 'fostering and supporting radical selection'.

The model demonstrates that the two most used practices; ‘strategic openness’ and ‘strategic flexibility’ which are characterised by the ‘strategic and operational flexibility factor’ actually have no impact on the success measures. It is the other practices, especially the practices that are characterised by the ‘fostering and supporting radical selection’, which have the greatest impact on the success measures but these are largely unused by the sample.

Company size is again demonstrated as being important for radical innovation. It is a highly significant predictor of both market position and radical innovation involvement.



RI = Usage results in more radical innovations
MP= Usage results in more dominant market positions
* = Practices numbered in order of highest usage

Figure 6.4 Final Research Model: Select

6.9 POLICY IMPLICATIONS

This section outlines the policy implication the results of this research may have at a national level and at a company level.

6.9.1 National Policy

The introduction of this thesis asserted the importance of radical innovation and the fuzzy front end of radical innovation for overall company performance and to the performance of the national economy. Innovation performance in Ireland was assessed and general trends in innovation performance observed and summaried as below.

1. The performance of Ireland with regards to innovation compares relatively poorly with the EU27;
2. Patents applications are low in comparison with other EU nations;
3. Company turnover attributed to new to firm/market performance is below the EU27 average;
4. SMEs are collaborating less and introducing fewer new products and their general innovation involvement lags behind that of larger companies.

The trends identified in the introduction indicate that radical innovation performance within Ireland is an area of concern for policy makers and research was warranted to arrest potential erosion of competitiveness. The results of this research are contradictory to a certain degree with the identified trends. This study identified radical innovation performance as being relatively high with half of the Irish companies surveyed having introduced a radical innovation over the previous 5 years. This is higher or comparable to other studies (Lundvall 2002, Stringer 2000, Matsuno and Mentzer 2000, Aragón-Sánchez and Sánchez-Marín 2005). While patent application and company turnover remain relatively low in Ireland the rate of radical innovation is apparently high and performance is strong. Previous research identifies radical innovation as an area in which large established

companies struggle (Christensen and Overdorf 2000, Leifer et al 2000), however, this study supports more recent research which identified that large firms appear to be getting better at radical innovation, and therefore, their size does not have as negative an impact on the ability to move forward in the early stages of the radical innovation process as was the case historically (Reid and Brentani 2012).

Storey (1994) found that many small companies had no ambitions to grow and expand. The added risk in attempting to developing new products out-weighted the possible growth benefits therefore the companies were content with their existing products and customers. Instead SMEs typically follow 'defender' innovation strategies (Brouthers et al. 1998, Aragón-Sánchez and Sánchez-Marín 2005). However this research demonstrates that SMEs are very much interested in radical innovation and are pursuing radical innovations aggressively. While the results do indicate that an SME is typically less involved in radical innovation than a large company, supporting the trends identified earlier in the thesis, care must be taken when interpreting this finding. SMEs do represent a significant source of radical innovation. The larger companies in the sample were significantly more likely to be engaged in radical innovation. However, given that there was equal numbers of large/SME companies in the sample this is perhaps not an unexpected result as large companies have greater access to resources. SME's represent 99% of all companies in the EU (European Commission 2003). Almost 30% of the SME companies in the sample developed a radical innovation indicating that small companies represent a significant source of radical innovation given the relative numbers of large and SME companies in the country.

These results have a number of implications for Irish policy makers.

1) Firstly there appears to be a contradiction between apparent radical innovation rates and patent applications/turnover from new to the world products. Additional assistance and support should be given to companies to enable them to patent and commercialise their innovations and subsequently achieve higher sales and performance. This support may be through financial means, in particular for smaller resource limited companies, and also through information provision to

clarify the complex process for patent application. Patents and protection of IP are extremely important for long-term company outlook in particular when a company is seeking investment as the ability to secure financial capital is likely to be enhanced if a patent or the intention to patent exists (Reid and Brentani 2012).

2) SME companies, despite their obvious disadvantages for radical innovation, are a significant source of radical innovation in Ireland. Support for SMEs for continued radical innovation success is therefore vital. While initiatives such as the innovation voucher system (Enterprise Ireland) offer financial support to companies for innovation they neglect other significant barriers to innovation involvement, namely access to knowledge and expertise. The establishment of a national innovation network with the mandate of providing expertise to established companies to engage in innovation would overcome this barrier. By leveraging on existing resources, i.e. universities, institutes of technology, innovation incubation centres and other knowledge centres and making available the resources and expertise of these knowledge centres, established companies could be supported in a similar fashion to that of entrepreneurial start-up companies.

3) National bodies could also enable innovation partnerships between companies of varying size. While government bodies such as Enterprise Ireland do enable innovation partnerships between knowledge centres and innovating companies more can be done to enable open innovation between large and small companies. By bringing together companies of differing sizes the advantages that each company enjoys (resources in a large company, entrepreneurial climate in a small company) can be leveraged while the disadvantages that companies endure and project risk can both be reduced. Managing co-creation is a complex endeavor (Perks et al. 2012) and this would need careful management as resource-scarce, smaller entities may receive unfavorable terms in the joint innovation projects (Rosenbusch et al 2011).

6.9.2 Managerial Policy

The results also provide some broad implications for innovation managers of companies as discussed below.

1) The fuzzy front end is important for radical innovation success.

Previous research has asserted the important of the fuzzy front end for innovation success (Cooper and Kleinschmidt 1996, Cooper and Kleinschmidt 1995, Kim and Wilemon 2002, Markham 2013) and in particular for radical innovation success (Reid and De Brentani 2004). Several studies have provided evidence of a link between new product performance and time spent on fuzzy front end activities (Cooper and Kleinschmidt 1995, Urban and Hauser 1993). Recent research has also identified potential search and selection practices and factors (Aloini et al. 2013), however, their relationship with final success was not considered. This research has clarified the importance of the fuzzy front end and the effect that the varying practices at this early stage has on innovation success. It is a phase that management should prepare for accordingly. The companies that engage in the described search and selection practices and factors experience the most radical innovation success. This research demonstrated that 6 of the search practices and 11 of the selection practices were used more consistently by the most successful companies. Innovation managers must consider the utility of these practices during the early stages of the innovation process.

Furthermore managers must recognise the importance of radical innovation with regards to overall performance and long-term survival and growth. This research supports existent research in that it is the companies who engage in radical innovation that consistently dominate global market places (Veryzer 1998, Bollen 1998). The innovator companies in the samples were the companies in the strongest market positions. While radical innovation may not represent the only route to long-term growth and market domination it does represent a potential avenue for managers to consider.

2) The fuzzy front end may not be as “fuzzy” as research has suggested.

Existent research describes the fuzzy nature of the front end of the innovation process (Khurana and Rosenthal 1998, Reid and Brentani 2004). It is described as ‘fuzzy’ because it is perceived as being difficult to control and manage. Furthermore the study of the fuzzy front end is seen as difficult as by its nature it is dynamic and uncertain (Reid and Brentani 2004, Kim and Wilemon 2002). This research indicates that the front end of the innovation process is not as fuzzy as its name suggests. This research has identified specific practices and underlying factors that can be used to control the early stages of the process. Rather than assuming the fuzzy front end to be an ad-hoc stage where the normal route to success is large based upon chance and luck innovation managers can control and increase their chances of success by providing resources and engaging in the outlined search and selection practices and factors.

3) Management must carefully consider the relative importance of the different phases during the fuzzy front end.

Analysis has indicated that the identified search factors have a relatively small impact on final success in terms of number of radical innovations and market position. The identified search factors had no impact on ‘number of radical innovations’ released and only two of the search factors (one of the factors was a negative predictor) had impact on ‘market position’. Both selection models were highly significant with three of the selection factors having unique impact on ‘number of radical innovations’ over the last 5 years and one of the factors having an effect on ‘market position’. The selection factors appear to more important that the search factors indicating that the selection phase is of greater importance than the search phase.

While the search for new ideas to create a stream of potential new products is seen as an important step in the innovation process, it is one which is relatively low cost compared to the cost of actually selecting and implementing any one idea (Urban and Hauser 1993). Consequently the selection stage may be seen as a more crucial step towards innovation

success. Generating good ideas is only part of a long process; how you handle (or mishandle) them once they have been identified is an important matter (Hansen and Birkinshaw 2007). Selection and development of radical projects provides a platform for the long-term growth and survival of companies (Leifer et al. 2000) and guides the medium to long-term development of a company.

While 'selection' may appear to be a more important phase than 'search' it must be acknowledged that search and selection are complementary activities at that depend on one another. Results may indicate that selection best practices is more important than search best practice that is not to say that search should be ignored entirely and all resources focused on selection. One of the underlying assumptions that the selection practices outlined by this research are based on is that of selection being a long term event rather than a single action. Every project is under constant selection pressure, constant evaluation whether or not to proceed. In a similar fashion each project is under constant search pressure. Innovation search results in the identification of ideas which are subsequently selected for further investigation; further search develops the ideas further before it again faces further selection pressure. Both phases are interlinked and represent concurrent and complementary activities. After selecting an idea to work out in more detail, market uncertainty can be further reduced through search and exploration, which should lead to a more in-depth understanding of the market (Verworn 2009).

Indeed most fuzzy front end activities are interrelated and management must take a holistic perspective to build capabilities in this area (Kim and Wilemon 2002). As such the definition of the fuzzy front end 'the phase between the first identification of an opportunity and when it is judged ready to enter the structured development process (Kim and Wilemon 2003, Koen et al. 2001) indicates that search and selection is an iterative process where ideas are found identified and developed before deciding which ideas to pursue further. Verworn (2009) sees idea generation and selection as a combined phase. Managers need to recognise that the identification of valuable external knowledge is not the only challenge they are likely to face when engaging in radical innovation and adopting a more open search strategy. Substantial costs and challenges are also likely to arise at a later

stage when external inputs need to be assimilated and utilised (Salge et al 2013). This would support Verworn (2009) who clarifies the 'leverage effect' that search and selection activities have on performance by demonstrating that the front end has an indirect impact on project execution and hence new product development success. The activities and decisions that comprising the fuzzy front end represent the starting point for the entire NPD development process. Decisions made at this stage determine the direction of the development (Frishammar et al. 2011), consequently a clearer understanding of the activities and decisions potential impact could ultimately result in a competitive advantage.

6.10 CHAPTER SUMMARY

This chapter discussed the results presented in Chapters 4 and 5. The primary aim of the chapter was to discuss the results in relation to the presented research questions. Through the analysis and discussions it can be seen that radical search is characterised by 5 underlying factors;

1) Market awareness;
2) Internet enabled search;
3) Engaging with customers;
4) Open environment;
5) Internal networking.

Radical innovation selection is characterised 4 underlying factors

1) Fostering and supporting radical selection;
2) Prototyping as a selection tool;
3) Strategic and operational flexibility;
4) Differentiating between radical and incremental selection.

Regression analysis revealed which search and selection factors were linked with radical innovation success and long term market position. Radical selection in particular appears to be of crucial importance to radical innovation success.

Investigation into the most used practices and the practices considered being most important for radical innovation search and selection revealed that Irish companies are using many of the practices associated with successful search and selection of radical ideas. The high importance rating allocated to the practices also confirmed that respondent companies had high knowledge of best practices. There was, however, a large difference between usage and importance of the practices indicating barriers exist for companies wanting to engage in radical search and selection.

The practices and factors were also linked to success using the survey results. The higher usage of certain search and selection practices by the companies in the sample who had successfully developed radical new products and had stronger market positions creates a plausible link between the practice usage and radical innovation success.

Large companies utilised many of the search and selection practices more than the smaller companies. There was little difference in importance rating between large and small companies demonstrating that there are either barriers small companies have to overcome or alternatively small companies simply have less interest in engaging in radical innovation.

The following chapter presents the final thesis conclusions, limitations, implications and some potential future work to be completed.

Chapter Seven Conclusions

7.1 INTRODUCTION

The final chapter of this thesis is structured as follows:

- A reflective analysis of the preceding chapters' research findings;
- The contribution these findings have made to both academic and practitioner knowledge;
- Limitation of the research;
- Suggestions for future work.

7.2 REFLECTIVE ANALYSIS OF THESIS

In the current competitive landscape, many companies seek growth through technology-driven new-product breakthroughs. Rather than concentrating on their established technologies and markets, companies may adopt the strategy of searching for and selecting for radical innovation developments in new markets. To accomplish this, companies must develop a peripheral vision that allows them to see beyond their immediate focus and cast their search and selection net far and wide.

Companies in Ireland have recognised the need to innovate and are engaging in radical innovation. Almost half of the companies in the research sample claimed to have developed a radical innovation over the previous 5 years. While this figure is inflated in comparison to several studies (Lundvall 2002, Stringer 2000) and it is comparable to other studies (Matsuno and Mentzer 2000, Aragón-Sánchez and Sánchez-Marín 2005). This inflated involvement in radical innovation maybe as a result of the self reporting nature of the methodology and is dealt with in the limitations section of this chapter.

Regardless, it is a positive indicator for innovation involvement in Ireland and the economy given that it is typically characterised by high unemployment, budget cuts, and company closure. Many companies are fighting for survival in their current market with little time for innovation. This economic turbulence has not removed the consumers' desire for new and innovative products. Moments of economic turbulence provide the unique opportunity to start new businesses, launch new products, and strengthen customer loyalty by translating these moments of uncertainty into moments of opportunity through radical innovation (Razeghi 2009, Stangler 2009). Irish companies have recognised this opportunity and are engaging in radical innovation. To sustain competitive advantage over the long term, mature firms must develop radical innovations as a basis for building and dominating fundamentally new markets (O'Connor and Rice 2013).

Many companies in Ireland are widening their search and selection area and are utilising a wide range of search and selection practices to penetrate deeper into existing markets and expand horizontally into new unexplored markets. The higher rate of usage of search and selection practices by innovator companies in our study indicates that these practices are appropriate for companies wishing to search for ideas and select ideas for radical innovation and the prescribed practices may enable the exploration of new markets through exploratory search and selection behaviour. This thesis takes a step towards validating practices that can be used to search for and select ideas for radical innovation.

While SMEs continue to represent a significant source of radical innovation, large, dominant companies are leading the way in-terms of radical innovation. If the managers of SME companies wish to challenge the 'status quo' and develop radical new products in order to protect their company from extinction and grow their businesses then they need to consider the search and selection practices and factors outlined by this research.

A tension exists between exploitation and exploration for many companies. The high usage of certain search practices e.g. 'engaging lead users' and 'connecting with end users', even by the innovators companies, implies the primary concern for many companies is on existing markets and customers rather than exploring new markets. Within their established

markets companies might be pushing the boundaries but the underlying agenda is to stay close to existing customers and utilise their core competencies. If a company wishes to be more exploratory the other practices represent means to increase the flow of innovative new ideas.

Project selection is an key issue for radical innovation success. There are many opportunities for companies to innovate and the correct/incorrect decision with regard to radical innovation selection can have dramatic consequences for the company. It is for this reason that many companies err on the side of caution and reject radically new ideas. The selection practices outlined in this paper represent methods companies can use to increase their selection capacity for radical innovation.

A large gap exists between the usage of search and selection practices for radical innovation and the perceived importance of the practices for radical search and selection. Innovation practitioners are aware of the existence of radical search and selection best practice but are failing to utilise them. Given their awareness of the practices barriers clearly exists to engaging in radical search and selection.

The radical search and selection constructs developed in this thesis takes a step towards effectively measuring a firm's capability to search for and select ideas for radical innovation. Results show a gap between the practices of firms who have a record of successfully introducing radical innovations and those who do not. The innovator companies in the sample utilise a diverse variety of search practices opening up the companies to a wide range of opportunities. To close this gap, researchers need to diffuse the existing knowledge to practitioners and empower them to be successful in the search for and selection of radical innovations.

Further to this the usage of the identified factors for search and selection appear to have a direct impact on company performance in terms of radical innovation involvement and the market position of the company. In particular the selection factors appear to have a greater impact on performance suggesting that the search for new opportunities is not as crucial as

the selection of the right opportunity. That is not to say ‘search’ is not a key issue for an innovating company. Search and selection are inextricably linked activities that complement each other. In an iterative process the search and selection practices during the fuzzy front end should enable a company to converge upon the radical innovation development projects that have the greatest capability to be commercial successes.

The presented practices and taxonomy presents a practical way for an organisation to focuses on dimensions and practices that are required for a company to enhance their capability in the search and selection phases of radical innovation. This study suggests that there is still a lot to be learnt about how firms engage in radical innovation in the many different contexts and environmental conditions in which companies operate. As markets become more competitive and dynamic future success may be based less on the ability to exploit existing technologies and markets but on the ability to explore new business models and new technology trajectories. Companies that proactively search and select radical innovations and empower their employees with the necessary resources to expand their innovation space reduce their dependence on their existing markets and ensure long terms growth and survival.

7.2.1 Research Question Summary

The following table summarises the 7 research questions that were examined by this thesis.

Table 7.1 Research Sub Questions Summary

Research Question	Review
*R1a: What practices do companies currently use when **searching** for new ideas during the front end of the radical innovation process?*	For radical search the most commonly used practices were • Connecting with end consumers • Working with lead users • Seek multiple applications
*R1b: What practices do companies currently use when **selecting** new ideas during the front end of the radical innovation process?*	For radical selection the most commonly used practices were • Strategic openness • Strategic flexibility • Senior management support
*R2a: Which **search** practices are linked with increased numbers of radical innovations?*	**Search** The innovators use: seeking multiple applications ($p<0.01$), creating active teams, employing scouts, crowdsourcing, working with lead users and mobilise mainstream staff ($p<0.05$), significantly more than the non-innovators.
*R2b: Which **selection** practices are linked with increased numbers of radical innovations?*	**Selection** The innovators use: failure accepted, risk taking encouraged, embraced innovation, ring fenced funding, alternate measurement, prototyping to reduce risk, alternative funding, longer timelines, senior champions, senior management support ($p<0.01$), and strategic openness ($p<0.05$) significantly more than the non-innovators.
*R3a: Which **search** practices are linked with more dominant market positions?*	**Search** The market leaders use seeking multiple applications creating active teams, employing scouts and connect with end consumers ($p<0.05$), significantly more than the market followers.
*R3b: Which **selection** practices are linked with more dominant market positions?*	**Selection** The market leaders use embraced innovation, longer timelines and senior management support ($p<0.05$) significantly more than the market followers.
*R4a: What is the impact of company size on the use of **search** practices for radical innovation?*	**Search** The market leaders use seeking multiple applications, creating active teams and connect with end consumers ($p<0.05$), significantly more than the market followers.
*R4b: What is the impact of company size on the use of **selection** practices for radical innovation?*	**Selection** Market leaders use ring fenced funding, longer timelines, and senior management support ($p<0.05$) significantly more than the market followers.

Table 7.1 (Continued) Research Sub Questions Summary

Research Question	Review
*R5a: What are the underlying factors that can be used to categorise radical **search** practices?*	There are 5 underlying search factors that characterise radical innovation search practices 1. Market awareness 2. Engaging with customers 3. Internet enabled search 4. Open environment 5. Internal networking
*R5b: What are the underlying factors that can be used to categorise radical **selection** practices?*	There are 4 underlying selection factors that characterise radical innovation search practices 1. Fostering and supporting radical selection 2. Prototyping as a selection tool 3. Strategic and operation flexibility 4. Differentiating between radical and incremental innovation
*R6a: Which of the identified **search** factors are linked with increased numbers of radical innovations?*	**Search** None of the search factors are linked with increased numbers of radical innovation
*R6b: Which of the identified **selection** factors are linked with increased numbers of radical innovations?*	**Selection** The following selection factors are linked with increased numbers of radical innovations: 1. Fostering and supporting radical selection (+) 2. Prototyping as a selection tool (+) 3. Differentiating between radical and incremental selection (+)
*R7a: Which of the identified **search** factors are linked with more dominant market positions?*	**Search** The search factors linked with dominant market positions: 1. Market awareness (+) 2. Internal networking (-)
*R7b: Which of the identified **selection** factors are linked with more dominant market positions?*	**Selection** The selection factors linked with dominant market positions: 1. Fostering and supporting radical selection (+)

7.2.2 Research Model Summary

Figure 7.1 and 7.2 show the extended research question. Radical search consists of 12 search practices characterised by five search factors of which two factors 'Market Awareness' (+) and internal networking (-) have a direct impact on market position.

Radical selection consists of 14 practices characterised by four selection factors of which three of the factors have a direct impact on radical innovation success; Fostering and supporting radical selection (+), Prototyping as a selection tool (+) differentiating between radical and incremental selection (+). One of the selection factors has an impact on market position; Fostering and supporting radical selection (+). Company size is a positive predictor of radical innovation involvement and more dominant market positions.

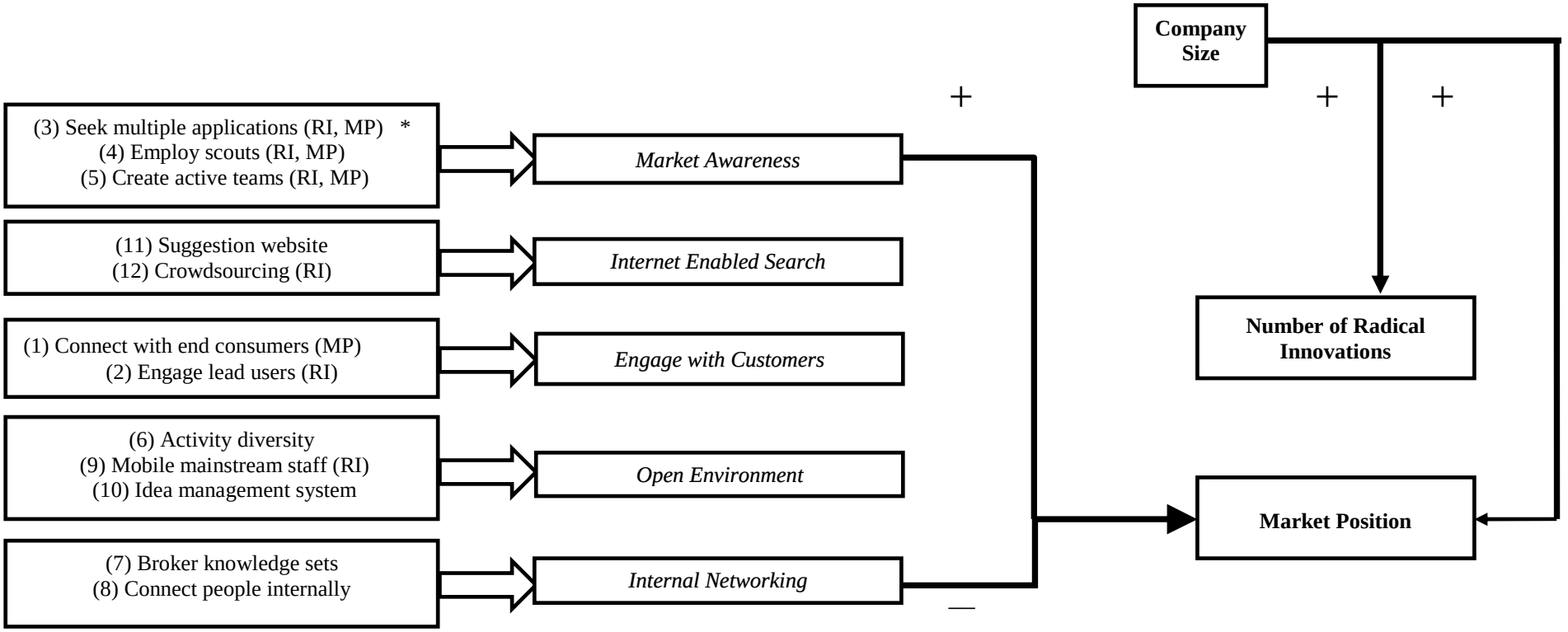


Figure 7.1 Final Research Model: Search

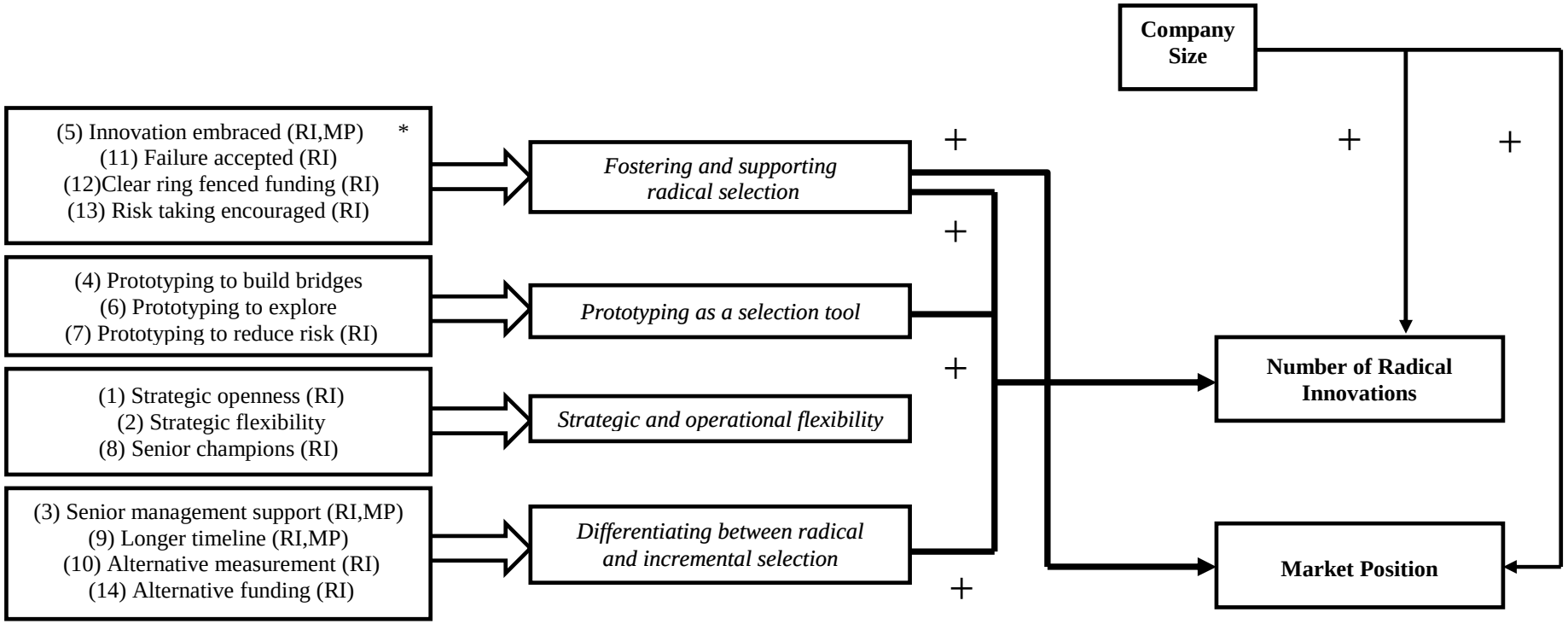


Figure 7.2 Final Research Model: Selection

7.3 CONTRIBUTION

The literature is vocal on the issue of incremental innovation and on the enabling factors and antecedents to success across the entire development process. However, it remains somewhat unclear on management actions to develop radical innovations in particular during the early stages of the development cycle. There is a tension between exploitation – incremental innovation, and exploration – radical innovation, in terms of the management of the innovation activity. There is less known about what practices and conditions support the early stages: searching and selecting innovation for radical innovation. This research examines the search and select aspects of the fuzzy front end of the innovation process. This research makes a contribution to enable companies to facilitate the search and selection of radical products for development.

7.3.1 Academic Contribution

- The 12 search practices and 14 selection practices developed to measure radical idea search practice and selection practice represent definable practices that may be of further use to other researchers carrying out empirical research and thus furthering the development of theory relating to radical innovation.

- This study has identified the practices companies used most often when searching for ideas for radical innovation; ‘seek multiple applications’, ‘work with lead users’ and ‘connect with end consumers’ and when selection for radical innovation; ‘strategic openness’, ‘strategic flexibility’ and ‘senior management support’. The identification of the most used practices offers opportunity for researchers to investigate the gap that exists between innovation best practice and actual innovation practice.

- Individual practices have been linked with radical innovation success further clarifying search and selection best practice. For radical search the following practices were linked with increase radical innovation involvement; ‘create active teams’, ‘seek multiple applications’, ‘employ scouts’, ‘crowdsourcing’, ‘work with lead users’ and ‘mobile mainstream staff’. For radical selection the following practices were linked with increase radical innovation involvement;

‘failure accepted’, ‘risk taking encouraged’, ‘innovation embraced’, ‘clear ring fenced funding’, ‘prototyping to reduce risk’, ‘strategic openness’, ‘senior champions’, ‘alternative measurement’, ‘alternate funding’, ‘longer timeline’, and ‘senior management support’

- Respondent companies rated the importance of the practices much higher than actual usage indicating that substantial barriers exist to companies engaging in search and selection practice. The identification of these barriers and strategies to overcome their effect represents a potential avenue for further research.

- The study has identified that regardless of company size similar practices are used to search and select for radical innovations. The key difference is that the level of usage is higher in large companies rather than SME companies.

- This research has identified 5 underlying factors relating to radical innovation search;

    1) Market awareness
    2) Engaging with customers
    3) Internet enabled search
    4) Open environment
    5) Internal networking.

- This research has identified 4 underlying factors relating to radical innovation selection;

    1) Fostering and supporting radical selection
    2) Prototyping as a selection tool
    3) Strategic and operational flexibility
    4) Differentiating between radical and incremental selection.

- The proposed five-factor search model and four-factor selection model presents a practical way for researchers to measure an organisation’s radical idea search and selection capability as the models focus on the dimensions and practices that

are required for a company to be considered as competent in the search and selection phase of radical innovation.

- The model identifies a gap between actual practice and performance in particular with regards selection practice. The two most used selection practices were 'strategic openness' and 'strategic flexibility' which are characterised by the 'strategic and operational flexibility factor'. This factor has no impact on the success measures. It is the other selection practices, especially the selection practices that are characterised by the 'fostering and supporting radical selection', which have the greatest impact on the success measures but these are largely unused by companies. For academics, there is a need to diffuse existing knowledge relating to innovation best practice and develop a better understanding of how best practices can be successfully implemented.

7.3.2 Implications for Managers

For *managers*, the research findings can be used to help understand aspects of searching and selection for radical innovation.

- The 12 identified search practices and 14 identified selection practices offer methods and tools practitioners can utilise to increase their search and selection capabilities. Moreover the search and selection practices that are linked with success radical involvement offer proven tools practitioners can utilise in their search and selection endeavors. The sample the research was completed on was a broad sample thus these search and selection practices are applicable outside the survey samples.

- The identification of underlying factors for search and selection forms the basis of a measure that could be used both descriptively and diagnostically. Initially it could be used to establish a baseline level of radical idea search and/or selection capability and then quantitatively, to chart an organisation's efforts to improve its radical innovation search and selection capacity. Further work is required to develop such a measure.

- The framework developed from the 12 search and 14 selection practices which organises search into 5 underlying factors and selection into 4 underlying factors offers a taxonomy that is useful for practitioners to ensure they are focusing their valuable resources to the key areas for innovation success. The links between the identified factors and the performance measures are of particular interest in guiding the future success of a company.

- The research has identified that there is a relative importance between the different phases of the fuzzy front end. While selection practice appears to be of greater importance to innovation performance in comparison to search practice, that does not mean that managers should focus all available resources to selection activities and ignore the search phase. It does indicate that the key for increasing innovation performance for managers may not lie in the identification of ideas but with the selection of the best idea from the 'bank' of opportunities that present themselves and managers should be aware of the relative importance between the different phases an allocate resources accordingly. It is important to note that search and selection practice represent complementary activities whose utility managers must consider not only in terms of direct impact on innovation success but also the indirect impact they potentially have on project execution and final new product development success.

7.4 LIMITATIONS

There are limitations associated with this research:

- The study has been conducted in one specific national context – Ireland. It is possible that the results could vary depending on the specific country. The SearchQ1 survey has been replicated in Italy (Ledwith et al. 2012, Aloini et al. 2013) with comparable results which suggest that the factor model of search practice is applicable in a wide number of national contexts.

- Limitations are inherent in the use of surveys as a means of data collection. Potential problems exist with identification of the respondent, their level of domain knowledge and their specific area of expertise. The majority of

respondents to the survey held senior management positions within their organisations and it is these individuals who are best placed to provide information relating to organisational performance (Kolberg et al. 2003). The results from this research may have differed if people at different levels of the organisation had completed the survey.

- Furthermore this single-informant approach might have led to a bias in terms of results, e.g. this sample contained a high amount of radically innovating companies. Maybe some respondents simply did not know that the product their company developed existed elsewhere or may have misinterpreted the definition of a radical innovation. Customers or industry experts might have reported a lower rate of radical developments.

- With the performed SPSS analysis of the exploratory SearchQ1 and Select Q2 survey there are certain limitation to the procedure used. When eliminating practices and deciding how many factors to retain a certain amount of subjectivity was used. One of the key criteria for retaining/eliminating practices was interpretability of the factors. A different researcher to the author may have interpreted and retained/eliminated practices in a slightly different manner. The completion of confirmatory factor analysis on a separate sample of companies minimises the potential bias that may have existed.

- Further to this some of the search factors only contain two practices which is relatively weak for a factor. Again the completion of confirmatory factor analysis on a separate sample of companies strengthens the identified factors considerably. The search factors have been refined through parallel research with further practices identified that load onto the search factors (Aloini et al. 2013).

- The study is based on a cross-sectional sample of high technology firms, the research findings are thus based on a number of organisations from various sectors. Limiting the study to a specific sector could potentially have produced

different results. The Italian study (Aloini et al. 2013, Ledwith et al. 2012) used a sample relatively different to the Irish the sample. The Italian sample was more focused towards heavy industry in comparison to the Irish sample which was high technology indicating that the results maybe apply across a wide variety of contexts. Further research is required for confirmation.

7.5 FUTURE WORK

- This study has identified 5 factors describing a firm's capability to search for ideas and 4 factors describing a firm's capability for selecting radical innovations. While this has provided some understanding of how firms search and select radical new product ideas and has identified possible links with innovation success; it does not identify the exact nature of the relationship between each factor and successful radical innovation. One plausible avenue is to establish the relationship between these dimensions and success in radical innovation across a range of different measures.

- The identified factors can also be extended and refined. Several of the search factors only contained two practices. While these have been extended and refined (Aloini et al. 2013) further work could be completed to extend all the factors to give a more complete view of search and selection practice and their underlying factors.

- This research only considered the fuzzy front end and the release of successful radical innovation, neglecting actual project execution. This opens opportunities for further research by integrating other factors characterising the entire project development.

- Respondent companies in the surveys sample rated the importance of the practices much higher than actual usage. Clearly substantial barriers exist to engaging in these search and selection practices exist which need to be clarified and strategies to overcome the barriers developed.

- The results indicate that the selection phase of the radical development process may be of greater importance to radical innovation success. This opens potential avenues for further research to identify the relative importance of the difference phases of the radical innovation development process.

7.6 CONCLUDING REMARKS

This final chapter has provided a summary of the thesis, from the development of the research question to the final interpretation of the results. It has summarised the contribution that this study has made to knowledge regarding the search and selection of radical innovation. The limitations of the study were discussed and finally several areas for future research were described.

To conclude every product, innovation or technology will eventually face the end of its lifecycle. Rather than approaching this endpoint with apprehension, companies should recognise that long-term survival is contingent on launching the next S-curve (Hinks et al. 2007, Sood and Tellis 2005) and pursue practices to identify that next curve. Thus, radical innovation and opportunity identification must become embedded capacities rather than standalone activities. Discovery and opportunity identification is a learnable and repeatable skill (Fiet et al. 2007). Empowering employees with a range of search skills and empowering them to select radical innovations projects for development results in the identification of more innovative opportunities with greater wealth creation potential (Ucbasaran et al. 2009). Research suggests that established companies should broaden their organisation's search of ideas to external sources and explore widely and can foster ambidexterity in innovation, to integrate and align radical innovation and incremental innovation (Chang et al 2012).

Shifting the focus from the current trajectory and taking a few steps in an alternative direction may reveal a less crowded and more rewarding marketplace. In this way, as markets become more competitive and dynamic, success in the future may come to be based less on the ability to exploit existing technologies and markets and more on the ability to explore new frames, which should reveal new business models and new technology trajectories.

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Appendices

APPENDIX A: SURVEY COVER LETTER

Dear <name>

My name is John Nicholas and I am involved in a piece of research connected to the Bizlabs initiative which is currently being run in the IMI in collaboration with Enterprise Ireland (EI) with its ultimate aim being to explore today's challenges and opportunities for organisations seeking to compete on innovation.

Below you will find a link to a secure internet survey that covers the topic of "Innovation Management" within your company for you to complete. The survey consists demographical questions for classification purposes and approximately 40 research questions all of which are answered using a simple Likert scale ranging from "very strongly disagree....to….very strongly agree" for each question.

Clicking on the link below will direct you to a website with the survey.

<<<< link>>>>>

Allow me remind you that any information received from you will not be shared with any third party.

If you have any questions do not hesitate to contact me.

Thank you for your participation.

Best Regards,

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APPENDIX B: UNPUBLISHED COMPANY "X" SURVEY

A. Learning about markets for radical innovation	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
A.1. **Multiple market experiments** When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
A.2. **Market diagnostic tools** To learn about unfamiliar markets, we rely on a set of unconventional market research tools to identify latent, yet unarticulated needs among different customer groups. .	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
A.3. **Applying existing technologies in new markets** We have a dedicated group of people (e.g. from marketing, sales, R&D) that explores new ways to apply our existing technology to new industries and new customers.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
A.4. **Co-developing products with lead users** We actively try to find those lead users who are actively innovating to solve problems present at the leading edge of a trend and seek to "co-evolve" new products and services together with them.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
A.5. **Look beyond the customer to the consumer** We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
A.6. **Learning from outside industry boundaries** We systematically seek out and learn from firms - within and in particular outside our industry - that are known to have well-functioning innovation practices in order to improve our own innovation system.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on market learning for radical innovation, now please rate Company X' overall performance on category A. Also, please evaluate the urgency of developing further competencies in "learning about new markets for radical innovation" for Company X, generally speaking.

A.P. How well do you think Company X performs in "learning about new markets for radical innovations"?	A. I. How critical is it to develop further competencies in "learning about new markets for radical innovation" for Company X in general?
Very poorly 1 ☐ poorly 2 ☐ Neutral 3 ☐ Well 4 ☐ Very Well 5 ☐	Not critical at all 1 ☐ Uncritical 2 ☐ Neutral 3 ☐ Critical 4 ☐ Very critical 5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (AP):

B. Managing radical idea generation

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

B.1. **Idea hunters** We have technical people with business development skills tasked with finding new sources of potential radical ideas within our firm. Note: Their task includes helping to prepare a business case to move ideas forward in the innovation process.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
B.2. **Using themed projects to stimulate radical idea generation of high strategic relevance** In our organisation, we try to stimulate radical innovation by periodically commissioning teams to generate ideas around major platforms or themes that are strategically relevant to us. Note: Teams could be challenged to think about a theme like: "how to involve more employees in radical innovation in Company X?"	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
B.3. **A central system to record and respond to ideas** In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
B.4. **Idea management team** We have a team of people with responsibility for our idea management system. Note: For instance to maintain the website, respond to ideas, set up idea generation workshops, and promote the system within the organisation to increase the flow of ideas.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
B.5. **All ideas are welcome** We encourage people to come forward with ideas, even if they have only a vague idea of the potential market applications for the idea.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

After having read and rated the above statements on "Managing radical idea generation", now please rate Company X' overall performance on category B. Also, please evaluate the urgency of developing further competencies in "Managing radical idea generation" for Company X, generally speaking.

B.P. How well do you think Company X performs in "Managing radical idea generation"?

Very poorly	poorly	Neutral	Well	Very Well
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

B. I. How critical is it to develop further competencies in "Managing radical idea generation" for Company X in general?

Not critical at all	Uncritical	Neutral	Critical	Very critical
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (BP):

C. The existence of an entrepreneurial environment	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
C.1. **Heroes** Successful innovators of breakthrough ideas are well-known and respected within the organisation serving as inspiration for others.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
C.2. **Entrepreneurial environment** There is an atmosphere in our organisation which encourages everyone to take part in innovation. Note: For instance to submit ideas, to participate in innovation teams, to receive training in innovation, etc.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
C.3 **Risk-taking environment** We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
C.4. **Accepting failure in radical innovation projects** In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
C.5. **Career advancement through radical innovation** In our firm, participation in radical innovation activities is seen as a broadening, career enhancing experience.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on "The existence of an entrepreneurial environment", now please rate Company X' overall performance on category C. Also, please evaluate the urgency of developing further competencies in "The existence of an entrepreneurial environment" for Company X, generally speaking.

C.P. How well do you think Company X performs in "The existence of an entrepreneurial environment"?	C. I. How critical is it to develop further competencies in "The existence of an entrepreneurial environment" for Company X in general?
Very poorly ☐ 1 · poorly ☐ 2 · Neutral ☐ 3 · Well ☐ 4 · Very Well ☐ 5	Not critical at all ☐ 1 · Uncritical ☐ 2 · Neutral ☐ 3 · Critical ☐ 4 · Very critical ☐ 5

Please feel free to comment below on this page in more details on why you have given Company X this performance score (CP):

D. Culture support system for radical innovation

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

D.1. **Ownership in radical projects** We have an innovation incentive program in place which offers employees an opportunity to become "owners" of radical innovation projects by investing part of their yearly bonus in internal ventures. Note: This system allows those employees who feel committed to a project to have a financial stake in it without investing own savings.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
D.2. **Avoid killing projects** To nurture the entrepreneurial spirit among our innovators and create a feeling of a fair assessment, we regularly review discontinued projects and sometimes give them a second chance by openly exposing them to the market, (e.g. through a licensing agreement).	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
D.3 **Skunk work** Our organisation allows some space and time for people to explore 'wild' ideas. Note: This could for instance be one day a week or 10-15% of the total time.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
D.4. **A HR plan for radical innovation** In our organisation, our Human Resources department has a plan for how to develop and retain employees involved with radical innovation. Note: This plan could include considerations of attractive career packages to lure employees to participate in radical innovation ventures, career development of management candidates by exposing them to the challenging requirements of growing a new and very different business area from scratch, and recognition of a need for offering a "fall back" plan for employees if ventures fail.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

After having read and rated the above statements on "Culture support system for radical innovation", now please rate Company X' overall performance on category D. Also, please evaluate the urgency of developing further competencies in "Culture support system for radical innovation" for Company X, generally speaking.

D.P. How well do you think Company X performs in "Culture support system for radical innovation"?

Very poorly	poorly	Neutral	Well	Very Well
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

D. I. How critical is it to develop further competencies in "Culture support system for radical innovation" for Company X in general?

Not critical at all	Uncritical	Neutral	Critical	Very critical
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (DP):

E. Helping employees solve their problems with radical innovation

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

E.1. **Seminars on radical innovation** To assist in developing our corporate wide capabilities in radical innovation, our employees and managers regularly get the opportunity to participate in seminars and courses on radical innovation. Note: These courses and seminars are either offered internally and/or externally and could range from e.g. basic courses in understanding the special characteristics of radical innovation to specific courses on tools or topics.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
E.2. **Coaching** In our organisation, senior or top level managers coach radical innovation teams. Note: For instance helping teams to clarify strategies, solve problems, and intervene on behalf of the radical teams when facing internal resistance from the main organisation (operating business units etc).	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
E.3. **Corporate innovation consultants** In our organisation, we have individuals who have received special training in radical innovation with the purpose of breeding "radical innovation black-belts" who act as consultants on radical innovation projects. Note: This could be similar to the six-sigma black-belt course	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
E.4. **A dedicated support unit** Within the organisation, we have an identified group of people charged with the responsibility of providing development support to radical innovation company-wide. Note: To e.g. nurture the projects with appropriate skills and staff. One typical task could be to assist in developing the opportunity into a business proposition (business case).	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

After having read and rated the above statements on "Helping employees solve their problems with radical innovation", now please rate Company X' overall performance on category E. Also, please evaluate the urgency of developing further competencies in "Helping employees solve their problems with radical innovation" for Company X, generally speaking.

E.P. How well do you think Company X performs in "Helping employees solve their problems with radical innovation"?					**E. I. How critical is it to develop further competencies in "Helping employees solve their problems with radical innovation" for Company X in general?**				
Very poorly	poorly	Neutral	Well	Very Well	Not critical at all	Uncritical	Neutral	Critical	Very critical
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (EP):

F. Project management for radical innovation

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

F.1. **Developing the business model** As we are developing radical innovation opportunities, we are constantly asking ourselves what the eventual business model will be.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
F.2. **Multidisciplinary and international diversity in radical innovation teams** When selecting our teams for radical innovation projects, we aim to include members that are multidisciplinary (different functions) and when possible of different nationalities to achieve the greatest diversity.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
F.3. **The skills of a radical project manager** We acknowledge that a project manager's required expertise for radical innovation must be more about anticipating and monitoring uncertainties than about planning, controlling and delegating.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
F.4. **Emergent strategy formulation as radical innovation projects develop** When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
F.5. **Securing organisational support** Our project managers are skilled at getting organisational buy-in for their projects.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
F.6. **Fast track of projects** In our organisation a clear business case and project plan is not always required from the outset to get approval to pursue a potentially radical opportunity further.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

After having read and rated the above statements on "Project management for radical innovation", now please rate Company X' overall performance on category F. Also, please evaluate the urgency of developing further competencies in "Project management for radical innovation" for Company X, generally speaking.

F.P. How well do you think Company X performs in "Project management for radical innovation"?

Very poorly	poorly	Neutral	Well	Very Well
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

F. I. How critical is it to develop further competencies in "Project management for radical innovation" for Company X in general?

Not critical at all	Uncritical	Neutral	Critical	Very critical
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (FP):

G. Network management system for radical innovation

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

G.1. **Network brokers** In our organisation, we have "network ambassadors" who can help radical innovation teams connect with other people company-wide when new knowledge or insight is needed	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
G.2. **A company wide network system that gives access to locating experts on radical innovation** In our organisation, teams engaged in radical innovation projects can locate experts on various disciplines in radical innovation when needed through accessing a database on our intranet.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
G.3. **Expanding the resource network through knowledge sharing** In our organisation, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm. Note: For instance by encouraging other employees to participate in meetings and workshops with the teams, by discussing the teams' progress and post questions on the intranet, etc.	We currently practice this in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐
	This practice is important for RI in X	Don't know ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

After having read and rated the above statements on "Network management system for radical innovation", now please rate Company X' overall performance on category G. Also, please evaluate the urgency of developing further competencies in "Network management system for radical innovation" for Company X, generally speaking.

G.P. How well do you think Company X performs in "Network management system for radical innovation"?

Very poorly	poorly	Neutral	Well	Very Well
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

G. I. How critical is it to develop further competencies in "Network management system for radical innovation" for Company X in general?

Not critical at all	Uncritical	Neutral	Critical	Very critical
1 ☐	2 ☐	3 ☐	4 ☐	5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (GP):

H. A flexible strategy for radical innovation	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
H.1. **The significance placed on radical innovation for the future of the organisation** Radical innovation is clearly communicated throughout our organisation as necessary for the long-term survival of our organisation.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
H.2. **Accepting that learning in radical innovation projects takes time.** Our senior managers understand that it takes times for radical innovation projects to acquire the necessary learning experience before they can move forward.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
H.3. **A continuous strategic commitment to the development of new business areas** We remain committed to developing new business areas as a source of future growth - even in times when our main business is prospering.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
H.4. **Strategic planning** In our strategy process we engage in creative thinking about the future and we consider ways to take our business into new markets or new ways of competing. Note: For instance by using various tools such as scenario planning to think about which products will be on the shelves in the supermarkets in 5-10 years.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
H.5. **Top management readiness for the unexpected** Our top managers are ready to accept promising ideas that challenge the firm to move beyond its current strategic focus even when these ideas are not in line with the current business strategy.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
H.6. **Our future role in our industry value chain** We remain open to re-consider our future position in our industry value chain and make shifts if we have to. Note: For instance if the opportunity arises to go from being a raw producer to further develop and sell final products to the end users.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on "A flexible strategy for radical innovation", now please rate Company X' overall performance on category H. Also, please evaluate the urgency of developing further competencies in "A flexible strategy for radical innovation" for Company X, generally speaking.

H.P. How well do you think Company X performs in "A flexible strategy for radical innovation"?	H. I. How critical is it to develop further competencies in "A flexible strategy for radical innovation" for Company X in general?
Very poorly 1 ☐ poorly 2 ☐ Neutral 3 ☐ Well 4 ☐ Very Well 5 ☐	Not critical at all 1 ☐ Uncritical 2 ☐ Neutral 3 ☐ Critical 4 ☐ Very critical 5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (HP):

I. Openness to external sources for radical innovation	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
I.1. **Online portal for problems and solutions** We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions. Note: The rationale behind this practice is that there are many researchers around the world that are willing to share their knowledge and work hard to solve a problem for even very small amounts of money (e.g. India and China).	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I.2. **Licensing** We openly share many of our patented technologies with a network of research partners in order to license-in and license-out new technology. Note: This question reflects a mindset that not every technology can or should be developed in-house and that some of our own technologies are sometimes better employed by others.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I.3. **Increasing reliance on external sources in R&D** Instead of doing all R&D ourselves we are moving towards open innovation by increasingly using external sources as input to our innovation process. Note: With external sources we mean knowledge and capital.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I.4. **Collaborative research with external research institutions** We have implemented an open and collaborative research environment with e.g. universities, research centres and specialised agencies. Note: In these collaborative agreements, corporate scientists work with external scientists on explorative research projects that are based when possible on non-exclusive IP rights.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
I.5. **Radical Short-term Flexible Alliances** Alongside our usual long-term strategic alliances, we develop short term technology-focused partnerships with other companies. Note: For instance to allow us to flexibly explore emerging new technologies.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on "Openness to external sources for radical innovation", now please rate Company X' overall performance on category I. Also, please evaluate the urgency of developing further competencies in "Openness to external sources for radical innovation" for Company X, generally speaking.

I.P. How well do you think Company X performs in "Openness to external sources for radical innovation"?	I. I. How critical is it to develop further competencies in "Openness to external sources for radical innovation" for Company X in general?
Very poorly 1 ☐ poorly 2 ☐ Neutral 3 ☐ Well 4 ☐ Very Well 5 ☐	Not critical at all 1 ☐ Uncritical 2 ☐ Neutral 3 ☐ Critical 4 ☐ Very critical 5 ☐

J. Transitioning radical innovation projects to operations

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

J.1. Assessing transition readiness

When a radical project is ready to stand on its own feet, we don't automatically assume that the project will be taken over by a operating business unit - but we carefully assess where it can get the best conditions for growth.

Note: This assessment includes:
1. Whether it should be placed in its own internal venture,
2. Should it be placed in an operating business unit? Do we have a unit that will accept it and be motivated to grow this project and not see it as a threat?
3. Or should we consider licensing it to an external party as it may not fit into our strategic focus?

	Don't know	1	2	3	4	5
We currently practice this in X	☐	☐	☐	☐	☐	☐
This practice is important for RI in X	☐	☐	☐	☐	☐	☐

J.2. Forming a transition team

When a radical project is transferred to a receiving operating business unit, we form a 'transition team' consisting of personnel from the project team as well as people from the receiving operating unit to help a radical innovation project cross the gap from development to operating status.

	Don't know	1	2	3	4	5
We currently practice this in X	☐	☐	☐	☐	☐	☐
This practice is important for RI in X	☐	☐	☐	☐	☐	☐

J.3. Managing leverage between new radical venture and existing firm

Our top managers oversee that new ventures develop independently but leverage optimally from the resources of the existing business.

Note: The rationale is that a top ranking manager with authority can ensure that the new internal venture will thrive as a distinct business and develop its own culture, processes and structure while also exploiting links to the established firm (to give it an advantage compared to an external start-up which would not have access to the same resources).

	Don't know	1	2	3	4	5
We currently practice this in X	☐	☐	☐	☐	☐	☐
This practice is important for RI in X	☐	☐	☐	☐	☐	☐

J.4. Developing the culture of a start-up

When a new internal venture is given its own home, it is provided with autonomy to allow it to develop a culture of a start-up.

Note: This autonomy implies that it has the opportunity to develop e.g. its own separate processes, people, and structures.

	Don't know	1	2	3	4	5
We currently practice this in X	☐	☐	☐	☐	☐	☐
This practice is important for RI in X	☐	☐	☐	☐	☐	☐

After having read and rated the above statements on "Transitioning radical innovation projects to operations", now please rate Company X' overall performance on category J. Also, please evaluate the urgency of developing further competencies in "Transitioning radical innovation projects to operations" for Company X, generally speaking.

J.P. How well do you think Company X performs in "Transitioning radical innovation projects to operations"?

Very poorly	poorly	Neutral	Well	Very Well
1	2	3	4	5
☐	☐	☐	☐	☐

J. I. How critical is it to develop further competencies in "Transitioning radical innovation projects to operations" for Company X in general?

Not critical at all	Uncritical	Neutral	Critical	Very critical
1	2	3	4	5
☐	☐	☐	☐	☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (JP):

K. Using alternative metrics for radical innovation	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
K.1. **Flexible stage gate** When identifying a promising radical innovation project, we develop it through a different and more flexible process than the traditional stage gate system. Note: A process that allows the project team to go in new directions when obstacles are encountered.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
K.2. **Measuring the success of radical innovation by using a portfolio approach** When we evaluate the success of radical innovation in our organisation, we look at our ability to manage a portfolio of radical innovation projects at various stages of development rather than on the success or failure of one single radical project.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
K.3. **Project evaluation by learning potential** Instead of a preoccupation with profitability potential, we assess the promise of radical projects by their potential to open up new territory and thereby provide opportunities for learning about technologies and markets.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
K.4. **Staged funding** Our funding process for projects is staged, based on their demonstrated progress. Note: As opposed to receiving one large sum of money from the outset; this method assumes that funding is given based on reaching development milestones.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
K.5. **Longer time horizon for radical innovation** Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and prove themselves.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on "Using alternative metrics for radical innovation", now please rate Company X' overall performance on category K. Also, please evaluate the urgency of developing further competencies in "Using alternative metrics for radical innovation" for Company X, generally speaking.

K.P. How well do you think Company X performs in "Using alternative metrics for radical innovation"?	K.I. How critical is it to develop further competencies in "Using alternative metrics for radical innovation" for Company X in general?
Very poorly 1 ☐ poorly 2 ☐ Neutral 3 ☐ Well 4 ☐ Very Well 5 ☐	Not critical at all 1 ☐ Uncritical 2 ☐ Neutral 3 ☐ Critical 4 ☐ Very critical 5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (KP):

L. A venture capital system for radical innovation	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
L.1. **Direct external investment in small start-ups** We have in our organisation an external venture capital program where we invest directly in promising start-up firms that operate at the edge of our own technologies. Note: For instance in order to learn about emerging technologies and market opportunities. In contrast to investing in funds, direct investments imply more risk but also more control over the development of new technologies.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
L.2. **Investment in external venture capital funds** We invest capital in external venture funds that specialise in managing a portfolio of firms that are related to our technological core competencies. Note: For instance in order to get a potential window into the technologies and business models of the future. Investing in funds provides a broader window on new technologies and less risk than direct investment in small firms but also less influence.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
L.3. **Taking options in investments** The team that manages the portfolio of internal and external investments exhibits an "options" mentality as it pertains to individual project selection. Note: The rationale is that a firm should take '"options" in several promising investments and as the future unveils some of these options will be abandoned as the premises are not longer valid. However, should the options come through, the firm will be ready to quickly move in and take advantage of the opportunities.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on "A venture capital system for radical innovation", now please rate Company X' overall performance on category L. Also, please evaluate the urgency of developing further competencies in "A venture capital system for radical innovation" for Company X, generally speaking.

L.P. How well do you think Company X performs in "A venture capital system for radical innovation"?					**L.I. How critical is it to develop further competencies in "A venture capital system for radical innovation" for Company X in general?**				
Very poorly	poorly	Neutral	Well	Very Well	Not critical at all	Uncritical	Neutral	Critical	Very critical
1	2	3	4	5	1	2	3	4	5
☐	☐	☐	☐	☐	☐	☐	☐	☐	☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (LP):

M. Acquiring funding for radical innovation	Answers (1-5) 1 – I strongly disagree with this statement 2 – I disagree with this statement 3 – I neither agree nor disagree with this statement 4 – I agree with this statement 5 – I strongly agree with this statement
M.1. **A central place to seek funding for radical innovation** We have a part of the organisation to which an employee with a breakthrough idea can seek funding to take the project one step further.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
M.2. **Using external sources to fund our projects through partnerships** We are increasingly using external sources to fund our R&D projects within innovation through partnerships and alliances with other firms..	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
M.3. **Dedicated R&D budget for radical innovation** We have a corporate level fund in place dedicated to finance radical innovation projects.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
M.4. **Clear processes for accessing resources** The process for accessing and leveraging corporate resources (funding, personnel, capital equipment, and other organisational resources) for radical innovation projects in our firms is clear.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐
M.5. **Managerial budgets for small scale experiments** In our organisation, all managers have been allocated a small financial budget, which they can use for small scale experiments on radical innovation projects. Note: The rationale is that an employee who wishes to realise an innovation project can freely seek multiple sources for funding (venture capital) by approaching any manager in the organisation. These small scale managerial budgets are not to be confused with, nor a substitute for the centralised corporate budget for radical innovation.	We currently practice this in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐ This practice is important for RI in X: Don't know ☐ 1 ☐ 2 ☐ 3 ☐ 4 ☐ 5 ☐

After having read and rated the above statements on "Acquiring funding for radical innovation", now please rate Company X' overall performance on category M. Also, please evaluate the urgency of developing further competencies in "Acquiring funding for radical innovation" for Company X, generally speaking.

M.P. How well do you think Company X performs in "Acquiring funding for radical innovation"?	M.I. How critical is it to develop further competencies in "Acquiring funding for radical innovation" for Company X in general?
Very poorly 1 ☐ poorly 2 ☐ Neutral 3 ☐ Well 4 ☐ Very Well 5 ☐	Not critical at all 1 ☐ Uncritical 2 ☐ Neutral 3 ☐ Critical 4 ☐ Very critical 5 ☐

Please feel free to comment below on this page in more details on why you have given Company X this performance score (MP):

Open-ended questions

1. What do you feel are the 3 biggest drivers that contribute positively to radical innovation in Company X? (please do illustrate with examples from your daily work/company in general)

2. What do you feel are the 3 biggest hindrances for radical innovation in Company X? (please do illustrate with examples from your daily work/company in general)

3. How do you see Company X can overcome these hindrances? (Any ideas are appreciated)

4. Can you think of initiatives of other companies which you regard as best practitioners of radical innovation that could be of interest for Company X? If so please list the name of the companies and briefly explain which initiatives they have implemented, and why you think these initiatives could be of benefit for Company X:

APPENDIX C: SEARCH Q1 SURVEY

Radical Innovation Search Survey

Part One-Demographics

Welcome to the Bizlabs Radical Innovation survey. This survey is designed to gather information relating to the techniques your company uses to search for and manage Radical Innovation idea generation.

There are a total of 48 questions in this survey.

All questions must be answered on a page before progression is allowed.

Please complete the following demographical questions.

ALL INFORMATION IN THIS FORM IS CONFIDENTIAL AND WILL NOT BE SHARED WITH ANY THIRD PARTY

1. Please enter your name (optional).

2. Please enter your company name (optional).

3. In which industry sector does your company primarily operate?

- Pharmaceutical
- Software and ICT
- Electrics and Electronics
- Medical Devices
- Other Technologies
- Other

Other (please specify)

4. What is your job title?

5. Approximately what is the size of your company in terms of number of employees?

6. Which of the following best describes the current market position of your company?

- Dominant
- Strong
- Favourable
- Viable
- Weak
- Nonviable
- Don't know

Page 1

Radical Innovation Search Survey

7. In the last five years approximately how many new products/services has your company developed and released in the following areas?

Incremental* innovation products/services

Substantial* innovation products/services

Radical* innovation products/services

Definitions

*Incremental innovation is unlikely to provide a dramatic change in business performance.

*Substantial innovation provides greater opportunity to value-add as it engenders the creation of business opportunities that are likely to lead the industry and provide a competitive advantage to the company developing them.

*Radical innovation can turn an industry on its head, creating new bases of performance, new competitors and new business models.

Radical Innovation Search Survey

Part Two-Learning about markets for radical innovation (7 questions)

The following page asks questions relating to the practices your company uses when trying to learn about new markets for radical innovation.

For each practice you are asked two questions.
The first question relates to your company's current usage of the practice.
The second question asks your opinion about the importance of the practice. (Note: You should answer this question even if your company does not use the particular practics.)

Please tick the box which applies

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

Note RI=Radical Innovation

1. When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation (RI)?	○	○	○	○	○	○

2. To learn about unfamiliar markets, we rely on a set of unconventional market research tools to identify latent, yet unarticulated needs among different customer groups.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

3. We have a dedicated group of people (e.g. from marketing, sales, R&D) that explores new ways to apply our existing technology to new industries and new customers.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

4. We actively try to find those lead users who are innovating to solve problems present at the leading edge of a trend and seek to "co-evolve" new products and services together with them.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

5. We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

6. We systematically seek out and learn from firms - within and in particular outside our industry - that are known to have well-functioning innovation practices in order to improve our own innovation system.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

Radical Innovation Search Survey

Part Two continued-Learning about markets for radical innovation (6 questio...

The following page asks questions relating to the techniques your company uses when trying to learn about new markets for radical innovation.

The following questions were developed using the publication by the U.K. Advanced Institute of Management Research (AIM), regarding the "Twelve search strategies that could save your organization." A link to this publication is provided on the the survey invitation email should you require further reading.

Please tick the box which applies.

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

Note RI=Radical Innovation

1. We make use of some form of futures study in order to create and explore alternative futures especially those which do not necessarily follow our current trajectory.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

2. We develop and use scenarios to help understand and influence our organisation's future.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

3. Our organisation looks deeply at how people actually use our products, as opposed to how people say they use our products.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

4. We ensure that our engineers and technical people get a chance to observe the use of our products and services in real life situations.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

5. Our organisation often conducts pilot-scale testing before moving into a main stream market.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

6. We frequently use prototypes when presenting new ideas as a means of learning and refining an idea.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

Part Three-Managing radical idea generation (6 questions)

The following page asks questions relating to the techniques your company uses to manage radical idea generation.

Please tick the box which applies

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

Note RI=Radical Innovation

1. We have people (part-time or full-time)officially charged with scouting for new ideas, finding new sources of potential radical ideas and looking for trends and developments that might have implications for organisation's future.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

2. Senior management is interested and receptive to such insights and new ideas.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

3. In our organization, we try to stimulate radical innovation by periodically commissioning teams to generate ideas around major platforms or themes that are strategically relevant to us.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

4. In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for RI?						

Radical Innovation Search Survey

5. We have a team of people with responsibility for our idea management system.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

6. We encourage people to come forward with ideas, even if they have only a vague idea of the potential market applications for the idea.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

Part Three continued-Managing radical idea generation (6 questions)

The following page asks questions relating to the techniques your company uses when trying to learn about new markets for radical innovation.

The following questions were developed using the publication by the U.K. Advanced Institute of Management Research (AIM), regarding the "Twelve search strategies that could save your organization." A link to this publication is provided on the the survey invitation email should you require further reading.

Please tick the box which applies

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

Note RI=Radical Innovation

1. Our organisation operates some form of creative idea generation to support Discontinuous Innovation.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

2. We access external sources that can help us to scan for ideas for future products and markets.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

3. Our organisation operates venture capital funds that can be used for the development of internally or externally generated ideas.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

4. Our organisation sets up teams to actively search out and implement new ideas that will take our business in new directions.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

5. Our organisation supports corporate intrapreneurship* as part of our Discontinuous Innovation efforts.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

6. We have a dedicated, ring-fenced budget available to fund intrapreneurs*.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Intrapreneur: The large-firm equivalent of an entrepreneur. Someone who develops new enterprises within the confines of a large corporation.

Radical Innovation Search Survey

Part Four-Network management system for radical innovation (6 questions)

The following page asks questions relating to your companies uses of a network management system for radical innovation.

Please tick the box which applies

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

Note RI=Radical Innovation

1. In our organization, we have "network ambassadors" who can help radical innovation teams connect with other people company-wide when new knowledge or insight is needed.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

2. In our organization, teams engaged in radical innovation projects can locate experts in various disciplines of radical innovation when needed through accessing a database on our intranet.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

3. In our organization, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

4. Our organisation operates some form of brokering/bridge-building that involves bringing together people for different knowledge sets, backgrounds or functions in order to support Discontinuous Innovation.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

5. Our organisation deliberately encourages diversity in terms of mind-sets and thinking in order to support Discontinuous Innovation.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

Part Five-Openness to external sources for radical innovation (10 questions...

The following page asks questions relating to your companies openness to external sources for radical innovation.

Please tick the box which applies

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

Note RI=Radical Innovation

1. We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

2. We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

3. We use some from of web-based exploration in order to identify future trends in technologies and markets that may impact on our business.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

4. We openly share many of our patented technologies with a network of research partners in order to license-in and license-out new technology.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

5. Instead of doing all R&D ourselves we are moving towards open innovation* by increasingly using external sources as input to our innovation process.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

*Open innovation is the use of purposive inflows and outflows of knowledge to accelerate internal innovation, and expand the markets for external use of innovation, respectively. This paradigm assumes that firms can and should use external ideas as well as internal ideas, and internal and external paths to market, as they look to advance their technology

6. We have implemented an open and collaborative research environment with e.g. universities, research centres and specialized agencies.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

7. Alongside our usual long-term strategic alliances, we develop short term technology-focused partnerships with other companies.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

8. Our organisation mobilises its mainstream resources, including staff and other organisations with which we work, to support Discontinuous Innovation/Radical Innovation.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

9. We currently have systems or procedures in place that ensure insights from mainstream staff who have the opportunity to gather information from external sources are being collected systematically.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical Innovation Search Survey

10. We actively encourage people to go to events/conferences/courses that are outside their current realms of experience.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

APPENDIX D: SELECT Q2 SURVEY

Radical Innovation Selection Survey

Part One-Demographics

Welcome to the Radical Innovation selection survey. This survey is designed to gather information relating to the techniques your company uses to enable the selection and support of Radical New Product Development (NPD) projects.

This survey should take no longer than 10 minutes to complete.

There are a total of approx 30 questions.

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1. Please enter your name (optional).

2. Please enter your company name (optional).

3. In which industry sector does your company operate?

- Pharmaceutical
- Software and ICT
- Electrics and Electronics
- Medical Devices
- Other Technologies
- Other

Other (please specify)

4. What is your job title?

5. Approximately what is the size of your company in terms of number of employees?

6. Which of the following best describes the current market position of your company?

- Dominant
- Strong
- Favourable
- Viable
- Weak
- Nonviable
- Don't know

Page 1

Radical Innovation Selection Survey

7. In the last five years approximately how many new products/services has your company developed and released in the following areas?

Incremental* innovation products/services	
Substantial* innovation products/services	
Radical* innovation products/services	

Definitions

*Incremental innovation is unlikely to provide a dramatic change in business performance.

*Substantial innovation provides greater opportunity to value-add as it engenders the creation of business opportunities that are likely to lead the industry and provide a competitive advantage to the company developing them.

*Radical innovation can turn an industry on its head, creating new bases of performance, new competitors and new business models.

Radical Innovation Selection Survey

Part two-Supporting early decision making

The following page asks questions relating to the techniques your company uses when supporting early decision making.

For each practice you are asked to rate....
1)Your company's current usage of the practice.
2)Your opinion about the importance of the practice. (Note: You should answer this question even if your company does not use the particular practice.)

Please tick the box which applies.

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

1. Our company engages in creative thinking about the future and we consider ways to take our business into new markets or new ways of competing.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

2. We remain open to re-consider our future position in our industry value chain and make shifts if we have to.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

3. When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

Radical Innovation Selection Survey

4. We use prototypes to build bridges in the selection process. By using prototypes we 'build bridges' in the minds of potential supporters (e.g. senior management, investors etc.) between the current state of affairs and what might be if this project is given opportunity to develop.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

5. We use prototyping to reduce uncertainty when making selection decisions i.e. we often 'buy a look' before deciding whether or not proceeding.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

6. We use prototyping to "take a small step" in a few different directions before committing to a large step in one direction.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

Radical Innovation Selection Survey

Part three-Measuring Progress for Radical innovation

The following page asks questions relating to the techniques your company uses when measuring radical innovation progress.

For each practice you are asked to rate....
1)Your company's current usage of the practice.
2)Your opinion about the importance of the practice. (Note: You should answer this question even if your company does not use the particular practice.)

Please tick the box which applies.

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

1. When evaluating radical opportunities we use alternative measurement and evaluation criteria to the ones used for non-radical opportunities.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

2. Our senior managers understand that it takes times for radical innovation projects to acquire the necessary learning experience before they can move forward.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

3. Instead of a preoccupation with profitability potential, we often assess the promise of radical projects by their potential to open up new territory and thereby provide opportunities for learning about technologies and markets.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

4. Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and prove themselves.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

Radical Innovation Selection Survey

5. When making decisions about the success of radical innovation in our organisation, we look at our ability to manage a portfolio of radical innovation projects at various stages of development rather than on the success or failure of one single radical project.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

Radical Innovation Selection Survey

Part four-Culture support system for radical innovation

The following page asks questions relating to the techniques your company uses to support an innovative culture.

For each practice you are asked to rate....
1)Your company's current usage of the practice.
2)Your opinion about the importance of the practice. (Note: You should answer this question even if your company does not use the particular practice.)

Please tick the box which applies.

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

1. In the company there are identifiable project champions in senior positions within the company who promote the development of radical and discontinuous projects?

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for Radical innovation?						

2. When identifying a promising radical innovation project, we develop it through a different and more flexible process than the traditional stage-gate system.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for Radical innovation?						

3. Our firm funds radical innovation project development differently than they fund incremental innovation projects

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for Radical innovation?						

4. We are increasingly using external sources to fund our R&D projects within innovation through partnerships and alliances with other firms/universities/state bodies etc.

	1	2	3	4	5	Don't know
This practice is used in my company?						
This practice is important for Radical innovation?						

Radical Innovation Selection Survey

5. The process for accessing and leveraging resources (funding, personnel, capital equipment, and other organizational resources) for radical innovation projects in our firms is clear.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

6. If a radical product idea doesn't fit our current trajectory we use alternative implementation structures (e.g. satellite SMEs, third party consultants, venture arms, partnership with other firms etc) to allow the idea to develop away from the mainstream business.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

7. There is an atmosphere in our organisation which encourages everyone to take part in innovation

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

8. We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

9. In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

We would like to thank you for your participation in this piece of research.

APPENDIX E: SEARCHSELECT Q3 SURVEY

Radical New Product Development Search and Selection Survey

Part One-Demographics

This survey is designed to gather information relating to the techniques your company uses to support Radical New Product Development (NPD) projects.

This survey should take no longer than 10 minutes to complete.

There are a total of 34 questions, distributed across 3 separate pages in this survey.

Please complete the following demographic questions (7).

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1. Please enter your name (optional)

Please note your name is only required to ensure duplicate survey requests are not sent.

2. Please enter your company name (optional).

3. In which industry sector does your company operate?

- Pharmaceutical
- Software and ICT
- Electrics and Electronics
- Medical Devices
- Other Technologies
- Other

Other (please specify)

4. What is your job title? (optional)

5. Approximately what is the size of your company in terms of number of employees?

Page 1

Radical New Product Development Search and Selection Survey

6. Which of the following best describes the current market position of your company?

- Dominant
- Strong
- Favourable
- Viable
- Weak
- Nonviable
- Don't know

7. In the last five years approximately how many new products/services has your company developed and released in the following areas?

Incremental* innovation products/services	
Substantial* innovation products/services	
Radical* innovation products/services	

Definitions

*Incremental innovation is unlikely to provide a dramatic change in business performance.

*Substantial innovation provides greater opportunity to value-add as it engenders the creation of business opportunities that are likely to lead the industry and provide a competitive advantage to the company developing them.

*Radical innovation can turn an industry on its head, creating new bases of performance, new competitors and new business models.

Radical New Product Development Search and Selection Survey

Part 2-Radical Selection

The following page asks questions relating to the techniques your company uses to support the selection of radical innovations

For each practice you are asked to rate....
1)Your company's current usage of the practice.
2)Your opinion about the importance of the practice. (Note: You should answer this question even if your company does not use the particular practice.)

Please tick the box which applies.

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

1. We remain open to re-consider our future position in our industry value chain and make shifts if we have to.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

2. When we enter a new market with many uncertainties we allow our strategy to change, as we learn more about the market.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

3. In the company there are identifiable project champions in senior positions within the company who promote the development of radical and discontinuous projects?

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation?	○	○	○	○	○	○

Radical New Product Development Search and Selection Survey

4. We use prototypes to build bridges in the selection process. By using prototypes we 'build bridges' in the minds of potential supporters (e.g. senior management, investors etc.) between the current state of affairs and what might be if this project is given opportunity to develop.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

5. We use prototyping to reduce uncertainty when making selection decisions i.e. we often 'buy a look' before deciding whether or not proceeding.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

6. We use prototyping to "take a small step" in a few different directions before committing to a large step in one direction.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

7. When evaluating radical opportunities we use alternative measurement and evaluation criteria to the ones used for non-radical opportunities.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

8. Our senior managers understand that it takes times for radical innovation projects to acquire the necessary learning experience before they can move forward.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

9. Radical innovation projects are evaluated with a longer time horizon than other projects to allow time for them to mature and prove themselves.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

Radical New Product Development Search and Selection Survey

10. Our firm funds radical innovation project development differently than they fund incremental innovation projects

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

11. The process for accessing and leveraging resources (funding, personnel, capital equipment, and other organizational resources) for radical innovation projects in our firms is clear.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

12. There is an atmosphere in our organisation which encourages everyone to take part in innovation

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

13. We have an environment where risk-taking is encouraged, e.g. to initiate radical innovation projects and become entrepreneurs.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

14. In our organisation failure is accepted in regard to radical innovation projects and considered a natural part of the learning process.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical innovation?	○	○	○	○	○	○

Radical New Product Development Search and Selection Survey

Part three-Radical Search

The following page asks questions relating to the techniques your company uses to support the search for radical innovations.

For each practice you are asked to rate....
1)Your company's current usage of the practice.
2)Your opinion about the importance of the practice. (Note: You should answer this question even if your company does not use the particular practice.)

Please tick the box which applies.

Answers (1-5)
1 – I strongly disagree with this statement
2 – I disagree with this statement
3 – I neither agree nor disagree with this statement
4 – I agree with this statement
5 – I strongly agree with this statement

1. When we have a very new and different technology, we search for multiple applications and conduct several market experiments to discover promising markets.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for Radical Innovation (RI)?	○	○	○	○	○	○

2. We have people (part-time or full-time)officially charged with scouting for new ideas, finding new sources of potential radical ideas and looking for trends and developments that might have implications for organisation's future.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

3. Our organisation sets up teams to actively search out and implement new ideas that will take our business in new directions.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

4. Our organization is able to identify and collaborate with its lead users.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical New Product Development Search and Selection Survey

5. We make an effort to connect to our customers' consumers (end users) and obtain regular feedback on their demands, as we recognise that they drive what our customers need.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

6. Our organisation operates some form of brokering/bridge-building that involves bringing together people for different knowledge sets, backgrounds or functions in order to support Discontinuous Innovation.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

7. In our organization, we encourage radical innovation teams to expand their resource network by tapping into the knowledge of any employee in our firm.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

8. We use an open innovation system in which technology-related challenges are posted online by our R&D staff so that a community of registered scientists anywhere in the world can propose their solutions.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

9. We have a website where outsiders can submit their suggestions and ideas for new markets, products and/or services.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

Radical New Product Development Search and Selection Survey

10. We currently have systems or procedures in place that ensure insights from mainstream staff who have the opportunity to gather information from external sources are being collected systematically.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

11. We actively encourage people to go to events/conferences/courses that are outside their current realms of experience.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

12. In our organisation, we have one company-wide centralised idea management system in place to which all employees can submit ideas for evaluation and receive quick feedback.

	1	2	3	4	5	Don't know
This practice is used in my company?	○	○	○	○	○	○
This practice is important for RI?	○	○	○	○	○	○

We would like to thank you for your participation in this piece of research.

APPENDIX F: SEARCHQ1 EXPLORATORY FACTOR ANALYSIS

SearchQ1 Exploratory Factor Analysis on entire data set

When developing a scale one typically develops a longer list of items that are expected to make it onto the final scale. Items that do not contribute to any factors or load across multiple factors or cannot be interpreted may be trimmed. Deciding how many factors to extract can be difficult (Zwick and Velicer 1986) and often subject criteria such as factor interpretability is a key consideration. A factor is considered interpretable to the extent that the items associated with it appear similar to one another and make theoretical and logical sense as indicators of a construct. The following analysis details how the initial practice pool (39 survey items) was reduced to the final 12 practices around which the search factors are based.

To reveal any latent variables within the survey data exploratory factor analysis was used in line with recommendations of Costello and Osborne (2005), utilizing SPSS (Version 18). Before performing the analysis, all practices are checked for normality and are found to be sufficiently normally distributed for further analyses. Additionally, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and the Bartlett Test of Sphericity (BTS) were conducted on the data. This preliminary analysis confirmed that the data distribution satisfied the psychometric criteria for the factor analysis to be performed. Principal component analysis (PCA) was therefore selected as the factor extraction method.

A set of decision rules was established and used in interpreting the results of the final factor analysis:

- if it loads primarily on one factor;
- when loading on multiple factors, the difference between the higher loading and all the other loadings (related to different factors) should be greater than or equal to 0.2.
- the practice loading allows for an interpretable solution

During the process of converging on the final solution the above criteria were also used as a guide to aid elimination of practices. Some of these criteria are highly subjective (most notable the interpretability criteria) and as a consequence a certain amount of trial and error was employed when deciding which practices were to be eliminated and the order of elimination of the practices for the final scales.

All items included in initial Factor Analysis (39 items)

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	12.589	32.279	32.279	12.589	32.279	32.279	5.617
2	3.451	8.849	41.127	3.451	8.849	41.127	3.672
3	2.947	7.556	48.683	2.947	7.556	48.683	2.816
4	2.190	5.615	54.298	2.190	5.615	54.298	4.783
5	1.967	5.043	59.341	1.967	5.043	59.341	4.297
6	1.641	4.207	63.548	1.641	4.207	63.548	3.991
7	1.584	4.062	67.610	1.584	4.062	67.610	5.726
8	1.337	3.427	71.037	1.337	3.427	71.037	5.381
9	1.271	3.260	74.297	1.271	3.260	74.297	5.009
10	1.126	2.888	77.185	1.126	2.888	77.185	3.007
11	.993	2.546	79.731				
12	.931	2.387	82.119				
13	.911	2.335	84.454				
14	.804	2.061	86.514				
15	.733	1.880	88.394				
16	.601	1.540	89.934				
17	.552	1.414	91.349				
18	.506	1.297	92.645				
19	.435	1.115	93.761				
20	.411	1.055	94.816				
21	.344	.881	95.697				
22	.298	.765	96.462				
23	.248	.636	97.098				
24	.208	.533	97.631				
25	.201	.515	98.146				
26	.154	.396	98.542				
27	.131	.336	98.878				
28	.100	.255	99.133				
29	.076	.196	99.329				
30	.076	.195	99.523				
31	.050	.128	99.651				
32	.042	.107	99.758				
33	.033	.085	99.843				
34	.028	.072	99.915				
35	.023	.060	99.975				
36	.007	.018	99.993				
37	.003	.007	99.999				
38	.000	.001	100.000				
39	-4.210E-17	-1.080E-16	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component									
	1	2	3	4	5	6	7	8	9	10
LMQ5use	.748					.296				
MRIGQ7USE	.612			-.272			.259			
MRIGQ3USE	.583						.275	.262		
MRIGQ10use	.471								-.377	
MRIGQ11use	.418	.279							-.272	
OESQ1use		.902								
NMSQ2USE		.533					.368			.312
LMQ8use		.468	-.426		.429			.269		
OESQ5USE			.686		.349					
OESQ6use			.373		-.328			.265		
OESQ4USE		.540	.580							
LMQ13use	.321		.566						-.425	
MRIGQ4use				-.656				.301		.251
OESQ10use				-.646	.272	.316				
MRIGQ6use		-.287		-.587			.269	.279		
OESQ7use				-.469		.452				
LMQ9use	.297	.260	-.409	-.468						
MRIGQ5USE		-.265		-.353	.261			.269		
LMQ7use					.800			.304		
OESQ9use					.759					
MRIGQ8USE					.609				-.261	
OESQ8USE		.258		-.315		.666				
LMQ6use	.370					.606				
LMQ11use				.318		.596	.252			
LMQ12use						.540				
NMSQ3use							.839			
NMSQ4use							.646			
NMSQ1use	.292						.312		-.304	.258
NMSQ5use		-.378				.280	.468	.269		
LMQ2use		.315					.365			.296
MRIGQ1use								.761		
LMQ3use								.713		
MRIGQ2USE								.573		-.315
LMQ10use									-.832	
MRIGQ9USE				.286					-.685	.348
LMQ1use				-.283		-.255		.266	-.580	
OESQ2use										.859
OESQ3use					.285					.494
MRIGQ12use	.305	.302					.255			.322

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 73 iterations.

10 factors were extracted with eigenvalues greater than 1. The structure shown is not "clean" with many poor loadings and cross loadings by items on multiple factors (loadings of less than .3 supressed). The following items were identified for elimination; MRIGQ5use. MRIGQ12use, OESQ4USE, LMQ2USE, LMQ8USE, LMQ9USE, OESQ6USE, NMSQ5USE, NMSQ1USE due to poor and cross loadings

Factor Analysis Run 2 (30 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	8.943	29.811	29.811	8.943	29.811	29.811	4.219
2	3.390	11.301	41.112	3.390	11.301	41.112	3.339
3	1.988	6.626	47.738	1.988	6.626	47.738	3.567
4	1.600	5.332	53.070	1.600	5.332	53.070	3.748
5	1.573	5.242	58.312	1.573	5.242	58.312	3.900
6	1.339	4.464	62.776	1.339	4.464	62.776	4.146
7	1.300	4.334	67.110	1.300	4.334	67.110	3.546
8	1.151	3.836	70.946	1.151	3.836	70.946	2.772
9	.989	3.296	74.242				
10	.884	2.948	77.190				
11	.822	2.739	79.929				
12	.774	2.580	82.509				
13	.705	2.352	84.861				
14	.690	2.300	87.161				
15	.657	2.189	89.350				
16	.570	1.901	91.251				
17	.449	1.496	92.747				
18	.382	1.273	94.020				
19	.359	1.195	95.216				
20	.288	.959	96.174				
21	.237	.789	96.963				
22	.207	.690	97.653				
23	.187	.622	98.275				
24	.150	.500	98.775				
25	.108	.360	99.136				
26	.100	.335	99.470				
27	.062	.205	99.675				
28	.042	.139	99.814				
29	.035	.115	99.930				
30	.021	.070	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component							
	1	2	3	4	5	6	7	8
MRIGQ4use	.802							.273
MRIGQ6use	.592		.402					
MRIGQ7USE	.479							
NMSQ2USE		.793						
OESQ1use		.773						
MRIGQ11use		.500		.436				
OESQ2use		.487				.278		.427
OESQ7use			.792					
OESQ8USE		.392	.708					
LMQ12use			.348		.347			
OESQ10use	.417		.442		.388			
LMQ1use				.837				
MRIGQ10use	.392			.524				
LMQ10use		.359		.484	.345	.256		
LMQ13use		-.430	.342	.447			.286	.359
LMQ7use					.777			
MRIGQ8USE					.697			
OESQ9use	.341			-.394	.467			.394
NMSQ3use						-.792		
MRIGQ2USE					.265	.367		
NMSQ4use			.266			-.552		.410
LMQ3use	.402					-.433		
MRIGQ1use	.269				.260	-.362		
LMQ6use							.836	
LMQ11use					.303	-.313	.334	
LMQ5use							.588	
OESQ3use					.400		-.474	.370
MRIGQ3USE	.333	.297				-.297	.376	
OESQ5USE								.898
MRIGQ9USE		.347		.397				.474

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 89 iterations.

8 factors were extracted with eigenvalues greater than 1. The structure shown is once again not “clean” with many poor loadings and cross loadings by items on multiple factors. The following items were identified for elimination MRIGQ6USE, MRIGQ11USE, LMQ12USE, LMQ13USE, MRIGQ9USE, LMQ11USE, OESQ3USE, MRIGQ3USE, MRIGQ2USE due to poor and cross loadings

Factor Analysis Run 3 (21 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.966	28.411	28.411	5.966	28.411	28.411	3.076
2	2.589	12.331	40.741	2.589	12.331	40.741	2.790
3	1.608	7.656	48.397	1.608	7.656	48.397	2.908
4	1.435	6.832	55.229	1.435	6.832	55.229	2.384
5	1.261	6.003	61.232	1.261	6.003	61.232	2.817
6	1.125	5.357	66.589	1.125	5.357	66.589	2.611
7	1.035	4.926	71.516	1.035	4.926	71.516	2.413
8	.897	4.270	75.785				
9	.727	3.460	79.246				
10	.687	3.270	82.516				
11	.564	2.685	85.200				
12	.519	2.473	87.673				
13	.494	2.354	90.028				
14	.449	2.138	92.166				
15	.390	1.858	94.024				
16	.331	1.576	95.599				
17	.266	1.265	96.864				
18	.230	1.094	97.958				
19	.177	.844	98.802				
20	.144	.686	99.488				
21	.107	.512	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component						
	1	2	3	4	5	6	7
NMSQ3use	.668				-.423		
LMQ3use	.666					.521	
MRIGQ7USE	.566					.264	
NMSQ4use	.534				-.468		
OESQ1use		.796					
NMSQ2USE		.790					
OESQ2use		.643		.256			.478
LMQ10use	-.364	.447	.417				-.366
LMQ7use			.826				
MRIGQ8USE			.671				
MRIGQ1use	.267		.381				
OESQ5USE				.787			
MRIGQ4use	.283			.750			
OESQ7use					-.815		
OESQ8USE					-.653	.260	
OESQ10use			.389		-.408		
LMQ5use		-.282				.799	
LMQ6use						.733	
LMQ1use							-.738
OESQ9use			.499	.425	-.269		.523
MRIGQ10use	.258					.336	-.494

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 48 iterations.

7 factors were extracted with eigenvalues greater than 1. The structure shown is once again not “clean” with many poor loadings and cross loadings by items on multiple factors. At this stage the amount of items being eliminated at a time is reduced as a solution is converged upon.

The following items; LMQ10USE, LMQ3USE were identified for elimination due to poor and cross loadings.

Factor Analysis Run 4 (19 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.570	29.315	29.315	5.570	29.315	29.315	3.472
2	2.494	13.125	42.440	2.494	13.125	42.440	2.697
3	1.506	7.924	50.364	1.506	7.924	50.364	2.271
4	1.236	6.504	56.868	1.236	6.504	56.868	2.642
5	1.188	6.251	63.119	1.188	6.251	63.119	2.320
6	1.099	5.785	68.904	1.099	5.785	68.904	2.940
7	.893	4.701	73.605				
8	.831	4.372	77.977				
9	.706	3.717	81.694				
10	.649	3.415	85.109				
11	.510	2.685	87.794				
12	.481	2.529	90.323				
13	.448	2.358	92.682				
14	.334	1.760	94.442				
15	.320	1.686	96.128				
16	.253	1.331	97.459				
17	.196	1.033	98.492				
18	.145	.762	99.254				
19	.142	.746	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component					
	1	2	3	4	5	6
OESQ7use	.725					
NMSQ3use	.694		-.318			
OESQ8USE	.674				.276	
NMSQ4use	.638	.277				
OESQ10use	.374					-.333
OESQ1use		.807				
NMSQ2USE		.787				
OESQ2use		.686	.321			
LMQ1use			-.656			
MRIGQ10use			-.627		.308	
OESQ9use	.259		.593	.461		-.373
MRIGQ7USE	.272		-.314			-.290
OESQ5USE				.772		
MRIGQ4use			-.260	.770		
LMQ6use					.801	
LMQ5use					.772	
LMQ7use						-.843
MRIGQ8USE						-.738
MRIGQ1use			-.269			-.477

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalisation.

a. Rotation converged in 72 iterations.

6 factors were extracted with eigenvalues greater than 1. The structure shown is once again not "clean" with many poor loadings and cross loadings by items on multiple factors.
The following item; MRIGQ7USE was identified for elimination due to poor and cross loadings.

Factor Analysis Run 5 (18 items)
After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	5.112	28.401	28.401	5.112	28.401	28.401	2.965
2	2.282	12.680	41.081	2.282	12.680	41.081	2.258
3	1.429	7.941	49.022	1.429	7.941	49.022	2.479
4	1.278	7.098	56.120	1.278	7.098	56.120	2.007
5	1.136	6.309	62.429	1.136	6.309	62.429	2.663
6	1.075	5.974	68.403	1.075	5.974	68.403	2.655
7	.857	4.760	73.163				
8	.798	4.431	77.594				
9	.772	4.287	81.881				
10	.662	3.680	85.561				
11	.567	3.148	88.709				
12	.461	2.563	91.272				
13	.430	2.389	93.662				
14	.323	1.795	95.457				
15	.284	1.580	97.036				
16	.218	1.212	98.248				
17	.173	.962	99.210				
18	.142	.790	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component					
	1	2	3	4	5	6
OESQ8USE	.635		.427			
NMSQ3use	.628				-.328	
NMSQ4use	.580	-.285				.256
OESQ2use		-.832				
OESQ1use	.347	-.644				
NMSQ2USE	.501	-.544			-.280	
OESQ9use			.840			
OESQ7use	.451		.596			
OESQ10use	.305		.484		-.271	
LMQ5use				.833		
LMQ6use				.793		
LMQ7use				.253	-.749	-.274
MRIGQ1use					-.639	
MRIGQ8USE		.261			-.606	.321
LMQ1use		.257		.253		.686
MRIGQ4use						.608
MRIGQ10use				.265	-.264	.535
OESQ5USE	-.351	-.416	.442			.472

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 35 iterations.

6 factors were extracted with eigenvalues greater than 1. The structure shown is once again not "clean" with many poor loadings and cross loadings by items on multiple factors.
The following items; OESQ5use and OESQ7use were identified for elimination due to poor and cross loadings.

Factor Analysis Run 6 (16 items)
After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.842	30.260	30.260	4.842	30.260	30.260	2.696
2	2.196	13.725	43.985	2.196	13.725	43.985	2.707
3	1.248	7.797	51.782	1.248	7.797	51.782	2.892
4	1.205	7.530	59.312	1.205	7.530	59.312	1.935
5	1.014	6.340	65.652	1.014	6.340	65.652	2.651
6	.920	5.749	71.401				
7	.831	5.192	76.593				
8	.748	4.677	81.270				
9	.603	3.770	85.040				
10	.499	3.122	88.162				
11	.487	3.045	91.207				
12	.381	2.383	93.590				
13	.316	1.973	95.563				
14	.297	1.859	97.422				
15	.262	1.638	99.060				
16	.150	.940	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
LMQ1use	.724				
MRIGQ10use	.569				-.286
NMSQ3use	.452	.320			
OESQ1use		.774			
NMSQ2USE		.756			
OESQ2use	-.358	.745			
NMSQ4use	.380	.467	.388		
OESQ9use	-.423		.802		-.263
OESQ10use			.651		
OESQ8USE	.267		.399		
MRIGQ4use	.297		.465		
LMQ6use				.809	
LMQ5use			.266	.797	
LMQ7use				.267	-.761
MRIGQ8USE					-.650
MRIGQ1use					-.607

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 49 iterations.

5 factors were extracted with eigenvalues greater than 1. The structure shown is once again not "clean" with many poor loadings and cross loadings by items on multiple factors.
The following item; OESQ8USE was identified for elimination due to poor and cross loadings.

Factor Analysis Run 7 (15 items)
After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.480	29.864	29.864	4.480	29.864	29.864	3.120
2	2.130	14.198	44.061	2.130	14.198	44.061	1.750
3	1.275	8.501	52.562	1.275	8.501	52.562	2.369
4	1.168	7.788	60.350	1.168	7.788	60.350	2.031
5	1.096	6.268	66.618	.940	6.268	66.618	2.740
6	.910	6.068	72.686				
7	.777	5.178	77.865				
8	.711	4.742	82.607				
9	.579	3.857	86.464				
10	.500	3.330	89.794				
11	.394	2.624	92.418				
12	.364	2.429	94.848				
13	.313	2.085	96.933				
14	.288	1.923	98.856				
15	.172	1.144	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
NMSQ3use	.819				
NMSQ2USE	.769	.297			
OESQ1use	.592	.448			
NMSQ4use	.560				
MRIGQ1use	.360				.300
OESQ2use		.914			
OESQ9use			-.872		
LMQ7use			-.586	.415	
OESQ10use			-.545		.310
LMQ6use				.856	
LMQ5use				.738	
MRIGQ4use		.330			.721
MRIGQ8USE	-.251		-.311		.661
MRIGQ10use	.286			.289	.546
LMQ1use	.268	-.296	.281	.272	.540

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 41 iterations.

5 factors were extracted with eigenvalues greater than 1. The structure shown is once again not "clean" with many poor loadings and cross loadings by items on multiple factors.
The following item; LMQ7USE was identified for elimination due to poor and cross loadings.

Factor Analysis Run 8 (14 items)
After elimination the remaining items were subjected to exploratory factor analysis. Note a 5 factor solution was forced here as it was more interpretable than the four factor solution.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.195	29.965	29.965	4.195	29.965	29.965	3.023
2	2.076	14.828	44.792	2.076	14.828	44.792	1.802
3	1.263	9.018	53.811	1.263	9.018	53.811	2.081
4	1.132	8.086	61.897	1.132	8.086	61.897	1.857
5	.935	6.677	68.574	.935	6.677	68.574	2.604
6	.794	5.671	74.245				
7	.725	5.181	79.425				
8	.696	4.969	84.394				
9	.533	3.807	88.201				
10	.487	3.477	91.678				
11	.383	2.735	94.413				
12	.313	2.236	96.650				
13	.289	2.067	98.717				
14	.180	1.283	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
NMSQ3use	.833				
NMSQ2USE	.730	-.352			
NMSQ4use	.588				
OESQ1use	.537	-.495			
OESQ2use		-.907			
OESQ9use			-.904		
OESQ10use			-.599		.264
LMQ5use			-.316	.817	-.278
LMQ6use		-.259		.815	
MRIGQ8USE	-.250				.751
MRIGQ10use	.291			.263	.583
MRIGQ4use		-.306	-.299		.574
LMQ1use	.319	.276		.258	.488
MRIGQ1use	.340				.403

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 33 iterations.

5 factors were extracted. The structure shown is once again not "clean" with many poor loadings and cross loadings by items on multiple factors.

The following items; MRIGQ8USE and NMSQ2USE were identified for elimination. These items were eliminated on a trial and error basis with the key factor being that of interpretability of the final solution

Factor Analysis Run 9 (12 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.668	30.566	30.566	3.668	30.566	30.566	2.391
2	1.872	15.598	46.165	1.872	15.598	46.165	1.694
3	1.140	9.497	55.662	1.140	9.497	55.662	1.537
4	1.097	9.140	64.802	1.097	9.140	64.802	2.203
5	.844	7.031	71.833	.844	7.031	71.833	2.375
6	.702	5.852	77.686				
7	.618	5.152	82.838				
8	.588	4.897	87.735				
9	.484	4.037	91.772				
10	.419	3.488	95.260				
11	.302	2.513	97.773				
12	.267	2.227	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
MRIGQ10use	.742				
LMQ1use	.640				
MRIGQ1use	.499				.261
OESQ2use		.884			
OESQ1use		.575	-.312		
LMQ5use			.855		
LMQ6use	.433	.297	.678		
OESQ9use				.893	
OESQ10use	.278			.738	
MRIGQ4use	.388	.330		.419	
NMSQ3use					.938
NMSQ4use		.284			.727

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 55 iterations.

5 factors were extracted giving a relatively clean structure and most importantly a interpretable solution. These 12 items and 5 factors are that which proceeded for further analysis and for confirmation. While selection of the items for elimination is somewhat subjective any bias for the final items included can be eliminated via confirmatory factor analysis.

APPENDIX G: SPSS TABLES FOR FINAL EXPLORATORY SEARCH FACTOR ANALYSIS

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.717
Bartlett's Test of Sphericity	Approx. Chi-Square	207.092
	df	66
	Sig.	.000

Communalities

	Initial	Extraction
MRIGQ10use	1.000	.688
LMQ1use	1.000	.591
MRIGQ1use	1.000	.522
OESQ1use	1.000	.606
OESQ2use	1.000	.818
LMQ5use	1.000	.819
LMQ6use	1.000	.754
OESQ9use	1.000	.828
OESQ10use	1.000	.750
NMSQ4use	1.000	.750
NMSQ3use	1.000	.869
MRIGQ4use	1.000	.625

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.668	30.566	30.566	3.668	30.566	30.566	2.391
2	1.872	15.598	46.165	1.872	15.598	46.165	1.694
3	1.140	9.497	55.662	1.140	9.497	55.662	1.537
4	1.097	9.140	64.802	1.097	9.140	64.802	2.203
5	.844	7.031	71.833	.844	7.031	71.833	2.375
6	.702	5.852	77.686				
7	.618	5.152	82.838				
8	.588	4.897	87.735				
9	.484	4.037	91.772				
10	.419	3.488	95.260				
11	.302	2.513	97.773				
12	.267	2.227	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component				
	1	2	3	4	5
MRIGQ1use	.689	-.156	.066	-.111	-.074
MRIGQ4use	.687	.270	-.042	.001	-.280
NMSQ4use	.686	.380	.070	-.092	.349
MRIGQ10use	.684	-.306	.079	-.186	-.293
OESQ10use	.680	-.080	-.481	.149	-.168
NMSQ3use	.665	.084	-.013	-.277	.586
LMQ1use	.481	-.469	.100	-.357	-.043
OESQ2use	.116	.618	.559	.333	-.006
LMQ5use	.277	-.589	.142	.508	.343
OESQ1use	.434	.579	.186	-.118	-.185
LMQ6use	.330	-.460	.588	.248	-.164
OESQ9use	.510	.170	-.411	.608	-.020

Extraction Method: Principal Component Analysis.
a. 5 components extracted.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
MRIGQ10use	.742	.010	.092	.161	.062
LMQ1use	.640	-.224	.138	-.127	.221
MRIGQ1use	.499	.058	.118	.178	.261
OESQ2use	-.242	.884	.134	-.054	.045
OESQ1use	.197	.575	-.312	.093	.181
LMQ5use	-.107	-.160	.855	.184	.151
LMQ6use	.433	.297	.678	-.113	-.163
OESQ9use	-.221	.085	.153	.893	.037
OESQ10use	.278	-.179	-.048	.738	.096
MRIGQ4use	.388	.330	-.166	.419	.114
NMSQ3use	.023	-.073	.045	-.026	.938
NMSQ4use	-.004	.284	-.038	.135	.727

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 55 iterations.

Structure Matrix

	Component				
	1	2	3	4	5
MRIGQ10use	.804	.050	.203	.323	.311
LMQ1use	.690	-.200	.249	.030	.332
MRIGQ1use	.624	.121	.191	.351	.455
OESQ2use	-.195	.866	.017	.017	.099
OESQ1use	.235	.647	-.332	.236	.343
LMQ5use	.088	-.197	.861	.206	.153
LMQ6use	.473	.210	.709	-.021	-.021
OESQ9use	-.016	.172	.137	.874	.221
OESQ10use	.434	-.067	.028	.795	.337
MRIGQ4use	.485	.421	-.129	.557	.378
NMSQ3use	.282	.062	.063	.215	.927
NMSQ4use	.225	.412	-.054	.354	.803

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.

APPENDIX H: SELECTQ2 EXPLORATORY FACTOR ANALYSIS

Select Q2 Exploratory Factor Analysis on entire data set

When developing a scale one typically develops a longer list of items that are expected to make it onto the final scale. Items that do not contribute to any factors or load across multiple factors or cannot be interpreted may be trimmed. Deciding how many factors to extract can be difficult (Zwick and Velicer 1986) and often subject criteria such as factor interpretability is a key consideration. A factor is considered interpretable to the extent that the items associated with it appear similar to one another and make theoretical and logical sense as indicators of a construct. The following analysis details how the initial item pool (20 survey items) were reduced to the final 14 items around which the search factors are based.

To reveal any latent variables within the survey data exploratory factor analysis was used in line with recommendations of Costello and Osborne (2005), utilizing SPSS (Version 18). Before performing the analysis, all items are checked for normality and are found to be sufficiently normally distributed for further analyses. Additionally, the Kaiser–Meyer–Olkin (KMO) measure of sampling adequacy and the Bartlett Test of Sphericity (BTS) were conducted on the data. This preliminary analysis confirmed that the data distribution satisfied the psychometric criteria for the factor analysis to be performed. Principal component analysis (PCA) was therefore selected as the factor extraction method.

A set of decision rules was established and used in interpreting the results of the final factor analysis:

- if it loads primarily on one factor;
- when loading on multiple factors, the difference between the higher loading and all the other loadings (related to different factors) should be greater than or equal to 0.2.
- the item loading allows for an interpretable solution

During the process of converging on the final solution the above criteria were also used as a guide to aid elimination of items. Some of these criteria are highly subjective (most notable the interpretability criteria) and as a consequence a certain amount of trial and error was employed when deciding which items were to be eliminated for the final scales.

All items included in initial Factor Analysis (20 items)

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.990	34.952	34.952	6.990	34.952	34.952	3.988
2	2.159	10.797	45.749	2.159	10.797	45.749	2.743
3	1.716	8.578	54.327	1.716	8.578	54.327	3.334
4	1.368	6.841	61.168	1.368	6.841	61.168	1.636
5	1.236	6.181	67.349	1.236	6.181	67.349	3.268
6	1.121	5.603	72.952	1.121	5.603	72.952	4.116
7	.797	3.986	76.938				
8	.698	3.492	80.430				
9	.664	3.322	83.753				
10	.538	2.692	86.445				
11	.514	2.571	89.016				
12	.383	1.916	90.931				
13	.382	1.908	92.840				
14	.324	1.620	94.460				
15	.270	1.349	95.809				
16	.246	1.230	97.040				
17	.239	1.193	98.233				
18	.145	.724	98.957				
19	.107	.533	99.490				
20	.102	.510	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component					
	1	2	3	4	5	6
Q20U	.707					
Q17U	.641					-.268
Q16U	.639			.575		
Q19U	.596		-.379			
Q21U	.574			-.366	.440	
Q4U		.860				
Q6U		.847				
Q5U		.765				
Q2U			-.802			
Q3U		.251	-.740			
Q12U			-.683			
Q1U			-.527		.465	
Q18U				.808		-.278
Q14U					.484	
Q11U				3.21	.261	
Q9U	.423				.455	
Q7U				.263		-.766
Q10U						-.699
Q15U						-.666
Q8U				-.460		-.626

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 27 iterations.

6 factors were extracted with eigenvalues greater than 1. The structure shown is not "clean" with many poor loadings and cross loadings by items on multiple factors. The following items were identified for elimination; Q1U, Q11U due to poor and cross loadings

Factor Analysis Run 2 (18 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.146	34.144	34.144	6.146	34.144	34.144	2.767
2	2.068	11.487	45.631	2.068	11.487	45.631	2.712
3	1.679	9.326	54.957	1.679	9.326	54.957	3.260
4	1.281	7.114	62.071	1.281	7.114	62.071	2.879
5	1.147	6.372	68.443	1.147	6.372	68.443	3.088
6	1.095	6.083	74.526	1.095	6.083	74.526	2.684
7	.757	4.203	78.730				
8	.670	3.724	82.453				
9	.626	3.477	85.930				
10	.504	2.798	88.728				
11	.425	2.364	91.092				
12	.381	2.119	93.211				
13	.288	1.598	94.809				
14	.269	1.496	96.305				
15	.250	1.389	97.694				
16	.162	.898	98.592				
17	.146	.812	99.404				
18	.107	.596	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component					
	1	2	3	4	5	6
Q8U	.740					
Q21U	.559				-.302	.467
Q6U		.885				
Q4U		.849				
Q5U		.732				.287
Q7U			-.770			
Q15U			-.676			
Q18U	-.534		.662		-.263	
Q10U	.401		.589			
Q2U				.834		
Q3U				.768		
Q12U				.677		
Q16U	-.335				-.420	
Q20U	.394				-.588	
Q17U	.265				-.574	
Q19U	.290			.361	-.502	
Q14U						.459
Q9U	.304				-.265	.505

a. Rotation converged in 51 iterations.

6 factors were extracted with eigenvalues greater than 1. The structure shown is not "clean" with many poor loadings and cross loadings by items on multiple factors. The following items were identified for elimination; Q18U due to cross loadings.

Factor Analysis Run 3 (17 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.236	36.680	36.680	6.236	36.680	36.680	3.850
2	2.036	11.974	48.654	2.036	11.974	48.654	2.985
3	1.454	8.552	57.207	1.454	8.552	57.207	3.187
4	1.140	6.706	63.913	1.140	6.706	63.913	2.889
5	1.057	6.215	70.128	1.057	6.215	70.128	2.983
6	.950	5.590	75.718				
7	.754	4.435	80.152				
8	.624	3.671	83.824				
9	.563	3.312	87.135				
10	.470	2.765	89.900				
11	.418	2.462	92.362				
12	.316	1.859	94.221				
13	.264	1.551	95.772				
14	.247	1.453	97.225				
15	.178	1.048	98.273				
16	.156	.918	99.190				
17	.138	.810	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total

Pattern Matrix[a]

	Component				
	1	2	3	4	5
Q8U	.773				
Q10U	.640				
Q7U	.494	.417			
Q15U	.429				.429
Q21U	.379			.295	.368
Q6U		.887			
Q4U		.872			
Q5U		.729			
Q2U			.863		
Q3U			.767		
Q12U			.658		
Q16U	-.299	.289		.488	
Q20U	.464			.527	
Q17U	.395			.498	
Q19U	.334		.417	.456	
Q14U	.358				.524
Q9U				.329	.469

Extraction Method: Principal Component Analysis.

Rotation Method: Oblimin with Kaiser Normalisation.

a. Rotation converged in 28 iterations.

5 factors were extracted with eigenvalues greater than 1. The structure shown is not "clean" with many poor loadings and cross loadings by items on multiple factors. The following items were identified for elimination; Q9U due to poor and cross loadings.

Factor Analysis Run 4 (16 items)

After elimination of the above items the remaining items were subjected to exploratory factor analysis.

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Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.029	37.684	37.684	6.029	37.684	37.684	3.898
2	2.003	12.520	50.204	2.003	12.520	50.204	2.980
3	1.400	8.749	58.953	1.400	8.749	58.953	3.217
4	1.122	7.010	65.963	1.122	7.010	65.963	2.407
5	1.019	6.371	72.334	1.019	6.371	72.334	2.757
6	.897	5.605	77.939				
7	.650	4.062	82.002				
8	.608	3.799	85.801				
9	.503	3.146	88.947				
10	.449	2.805	91.752				
11	.315	1.968	93.720				
12	.269	1.683	95.403				
13	.245	1.533	96.936				
14	.184	1.153	98.089				
15	.154	.965	99.054				
16	.151	.946	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
Q8U	.773				
Q20U	.585			.443	
Q10U	.584				.271
Q21U	.521				.253
Q17U	.486			.440	
Q19U	.444		-.403	.386	
Q6U		.910			
Q4U		.873			
Q5U		.715			
Q7U	.383	.392			.340
Q2U			-.862		
Q3U			-.794		
Q12U			-.642		
Q16U		.323		.435	
Q14U	.458				.589
Q15U	.362				.519

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 36 iterations.

5 factors were extracted with eigenvalues greater than 1. The structure shown is not "clean" with many poor loadings and cross loadings by items on multiple factors. The following items were identified for elimination; Q14U, Q16U due to cross loadings.

Factor Analysis Run 5 (14 items)

After elimination the remaining items were subjected to exploratory factor analysis. A four factor solution was forced here as it allowed for a readily interpretable solution. The eigenvalue of the 4th factor is just below 1.0 and drops to .65 for the 5th factor so it can be justified in keeping the 4th factor to allow an interpretable solution.

Total Variance Explained

Component	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.163	44.023	44.023	6.163	44.023	44.023	4.106
2	1.941	13.867	57.890	1.941	13.867	57.890	2.809
3	1.337	9.552	67.442	1.337	9.552	67.442	2.970
4	.927	6.619	74.061	.927	6.619	74.061	4.001
5	.651	4.648	78.709				
6	.622	4.439	83.149				
7	.504	3.600	86.748				
8	.468	3.345	90.093				
9	.311	2.219	92.313				
10	.292	2.085	94.398				
11	.262	1.874	96.272				
12	.196	1.398	97.670				
13	.173	1.239	98.909				
14	.153	1.091	100.000				

Extraction Method: Principal Component Analysis.
a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Pattern Matrix[a]

	Component			
	1	2	3	4
Q21U	.803			
Q20U	.794			
Q19U	.698		.290	
Q17U	.673			
Q4U		.875		
Q6U		.862		
Q5U		.797		
Q2U			.832	
Q3U			.817	
Q12U	.288		.614	
Q7U				-.801
Q15U				-.777
Q10U	.255			-.739
Q8U	.280			-.543

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 19 iterations.

4 factors were extracted giving a relatively clean structure and most importantly an interpretable solution. These 14 items and 4 factors are that which proceeded for further analysis and for confirmation. While selection of the items for elimination is somewhat subjective any bias for the final items included can be eliminated via confirmatory factor analysis.

APPENDIX I: SPSS TABLES FOR FINAL EXPLORATORY SELECTION FACTOR ANALYSIS

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.836
Bartlett's Test of Sphericity	Approx. Chi-Square	532.139
	df	91
	Sig.	.000

Communalities

	Initial	Extraction
Q2U	1.000	.752
Q3U	1.000	.771
Q4U	1.000	.812
Q5U	1.000	.760
Q6U	1.000	.811
Q7U	1.000	.818
Q8U	1.000	.519
Q10U	1.000	.813
Q12U	1.000	.578
Q15U	1.000	.735
Q17U	1.000	.716
Q19U	1.000	.763
Q20U	1.000	.782
Q21U	1.000	.738

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	6.163	44.023	44.023	6.163	44.023	44.023	4.106
2	1.941	13.867	57.890	1.941	13.867	57.890	2.809
3	1.337	9.552	67.442	1.337	9.552	67.442	2.970
4	.927	6.619	74.061	.927	6.619	74.061	4.001
5	.651	4.648	78.709				
6	.622	4.439	83.149				
7	.504	3.600	86.748				
8	.468	3.345	90.093				
9	.311	2.219	92.313				
10	.292	2.085	94.398				
11	.262	1.874	96.272				
12	.196	1.398	97.670				
13	.173	1.239	98.909				
14	.153	1.091	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Extraction Method: Principal Component Analysis.

Component Matrix[a]

	Component			
	1	2	3	4
Q10U	.809	-.140	-.242	-.284
Q19U	.790	-.232	.090	.279
Q17U	.777	-.252	-.106	.194
Q7U	.774	.077	-.174	-.427
Q20U	.755	-.315	-.148	.301
Q15U	.736	-.073	-.184	-.393
Q21U	.718	-.249	-.180	.358
Q12U	.612	-.088	.437	.071
Q8U	.610	-.308	-.102	.202
Q4U	.476	.751	-.117	.085
Q6U	.481	.683	-.326	.076
Q5U	.514	.662	.071	.230
Q2U	.562	-.016	.661	.017
Q3U	.519	.245	.615	-.252

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Pattern Matrix[a]

	Component			
	1	2	3	4
Q21U	.803	.108	-.011	-.088
Q20U	.794	.035	.034	-.155
Q19U	.698	.058	.290	-.086
Q17U	.673	.061	.099	-.239
Q4U	-.029	.875	.062	-.073
Q6U	.046	.862	-.148	-.174
Q5U	.111	.797	.241	.107
Q2U	.131	-.012	.832	.021
Q3U	-.232	.155	.817	-.193
Q12U	.288	.003	.614	-.048
Q7U	-.002	.214	.116	-.801
Q15U	.082	.077	.083	-.777
Q10U	.255	.077	.031	-.739
Q8U	.280	-.144	.092	-.543

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 19 iterations.

Structure Matrix

	Component			
	1	2	3	4
Q20U	.869	.158	.281	-.490
Q21U	.847	.212	.234	-.430
Q19U	.814	.200	.500	-.448
Q17U	.802	.197	.339	-.546
Q4U	.113	.896	.218	.242
Q6U	.173	.875	.049	.321
Q5U	.219	.829	.377	.147
Q2U	.335	.137	.859	-.228
Q3U	.073	.302	.830	-.324
Q12U	.465	.146	.699	-.311
Q7U	.375	.385	.343	-.869
Q10U	.570	.251	.286	-.864
Q15U	.425	.247	.302	-.845
Q8U	.506	.005	.270	-.650

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.

APPENDIX J: SEARCH Q1 SPSS TABLES

Correlations

Correlations

		StaffNo	Mrketrecode	NoRadical
StaffNo	Pearson Correlation	1	.280**	.269*
	Sig. (2-tailed)		.009	.012
	N	87	87	87
Mrketrecode	Pearson Correlation	.280**	1	.213*
	Sig. (2-tailed)	.009		.047
	N	87	87	87
NoRadical	Pearson Correlation	.269*	.213*	1
	Sig. (2-tailed)	.012	.047	
	N	87	87	87

**. Correlation is significant at the 0.01 level (2-tailed).
*. Correlation is significant at the 0.05 level (2-tailed).

Total Sample Tables

	Z	Asymp. Sig. (2-tailed)
MRIGQ10imp - MRIGQ10use	-5.232	.000
LMQ1imp - LMQ1use	-5.741	.000
MRIGQ1imp - MRIGQ1use	-5.825	.000
OESQ2imp - OESQ2use	-6.462	.000
OESQ1imp - OESQ1use	-6.478	.000
LMQ4imp- LMQ4use	-4.924	.000
LMQ6imp - LMQ6use	-4.098	.000
OESQ9imp - OESQ9use	-6.462	.000
OESQ10imp - OESQ10use	-5.617	.000
MRIGQ4imp - MRIGQ4use	-6.247	.000
NMSQ3imp - NMSQ3use	-5.950	.000
NMSQ4imp - NMSQ4use	-5.330	.000

Innovators V Non-Innovators

Usage of practices comparison

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Test Statisticsa	MRIGQ10use	622.000	1525.000	-2.240	.025
	LMQ1use	537.000	1483.000	-3.059	.002
	MRIGQ1use	634.500	1495.500	-2.117	.034
	OESQ2use	724.000	1585.000	-.372	.710
	OESQ1use	553.000	1414.000	-2.226	.026
	LMQ4use	719.000	1665.000	-1.960	.050
	LMQ6use	810.000	1756.000	-1.221	.222
	OESQ9use	560.000	1463.000	-2.370	.018
	OESQ10use	725.500	1628.500	-1.090	.276
	MRIGQ4use	854.500	1800.500	-.624	.533
	NMSQ3use	638.500	1499.500	-1.939	.053
	NMSQ4use	629.500	1490.500	-1.698	.090

Importance of practices comparison

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Test Statisticsa	MRIGQ10imp	902.500	1805.500	-.005	.996
	LMQ1imp	787.000	1648.000	-1.111	.267
	MRIGQ1imp	834.000	1737.000	-.275	.783
	OESQ2imp	562.500	1265.500	-2.069	.039
	OESQ1imp	576.000	1242.000	-.441	.659
	LMQ4	818.500	1764.500	-.951	.341
	LMQ6imp	806.000	1709.000	-.772	.440
	OESQ9imp	774.000	1635.000	-.053	.958
	OESQ10imp	736.000	1556.000	-1.041	.298
	MRIGQ4imp	738.500	1558.500	-.430	.667
	NMSQ3imp	695.500	1436.500	-.693	.488
	NMSQ4imp	696.000	1557.000	-.474	.635

SME v Large

Usage of practices compared

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
MRIGQ10use	501.000	1404.000	-3.095	.002
LMQ1use	578.000	1568.000	-2.324	.020
MRIGQ1use	565.000	1468.000	-2.467	.014
OESQ2use	569.500	1389.500	-1.687	.092
OESQ1use	524.000	1427.000	-2.151	.031
LMQ4use	721.500	1711.500	-1.607	.108
LMQ6use	523.500	1513.500	-3.527	.000
OESQ9use	666.500	1527.500	-.953	.340
OESQ10use	757.000	1660.000	-.405	.685
MRIGQ4use	813.500	1674.500	-.627	.530
NMSQ3use	656.500	1517.500	-1.424	.155
NMSQ4use	600.000	1420.000	-1.660	.097

Importance of practices comparison

	Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
MRIGQ10imp	723.500	1713.500	-1.710	.087
LMQ1imp	824.000	1770.000	-.763	.446
MRIGQ1imp	738.500	1684.500	-1.239	.215
OESQ2imp	687.000	1317.000	-.694	.488
OESQ1imp	604.000	1100.000	-.006	.995
LMQ4imp	701.000	1736.000	-1.990	.047
LMQ6imp	654.500	1600.500	-2.306	.021
OESQ9imp	737.000	1403.000	-.391	.696
OESQ10imp	748.000	1528.000	-.907	.365
MRIGQ4imp	757.500	1660.500	-.203	.839
NMSQ3imp	708.000	1569.000	-.543	.587
NMSQ4imp	716.000	1382.000	-.249	.804

Regressions: Search v performance measures

Search Model 1
Dependent Variable: Number Radical Innovation
Independent Variables: 5 factors**:**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.544[a]	.296	.223	3.274	.296	4.068	6	58	.002

a. Predictors: (Constant), IntertnalNet, EngageCus, Internetenabled, OpenEnvi, Marketaware, SMEStatus
b. Dependent Variable: NoRadical

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	261.669	6	43.612	4.068	.002[a]
	Residual	621.777	58	10.720		
	Total	883.446	64			

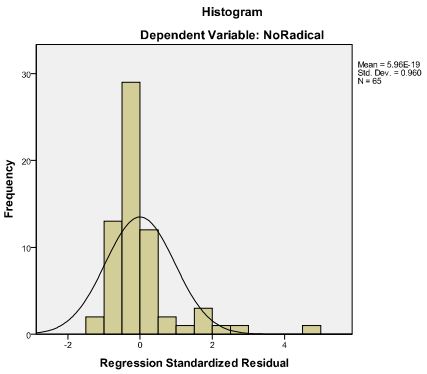
a. Predictors: (Constant), IntertnalNet, EngageCus, Internetenabled, OpenEnvi, Marketaware, SMEStatus
b. Dependent Variable: NoRadical

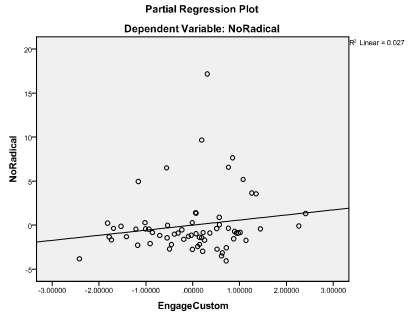
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	-2.680	1.340		-2.000	.050					
	SMEStatus	3.134	.912	.416	3.435	.001	.465	.411	.378	.826	1.211
	Marketaware	.358	.447	.096	.799	.427	.287	.104	.088	.837	1.195
	Internetenabled	-.460	.424	-.124	-1.086	.282	-.025	-.141	-.120	.933	1.072
	EngageCus	.195	.430	.052	.453	.652	.193	.059	.050	.905	1.105
	OpenEnvi	.493	.430	.133	1.145	.257	.182	.149	.126	.905	1.105
	IntertnalNet	.543	.442	.146	1.228	.224	.256	.159	.135	.858	1.166

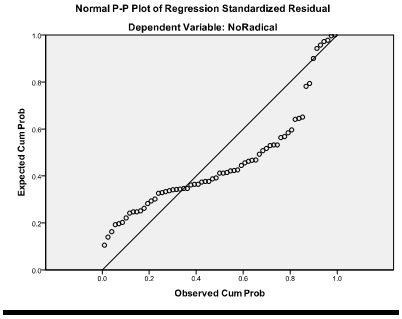
Residuals Statistics[a]

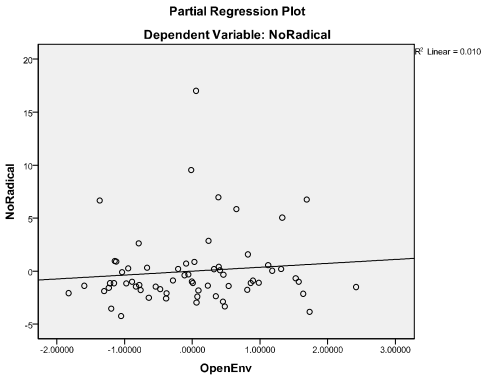
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-1.38	5.44	1.71	1.453	65
Std. Predicted Value	-2.121	2.566	.000	1.000	65
Standard Error of Predicted Value	.482	2.049	1.040	.302	65
Adjusted Predicted Value	-1.59	4.99	1.71	1.516	65
Residual	-4.468	16.990	.000	3.419	65
Std. Residual	-1.255	4.771	.000	.960	65
Stud. Residual	-1.326	4.887	.000	.996	65
Deleted Residual	-4.989	17.827	-.001	3.684	65
Stud. Deleted Residual	-1.334	6.280	.028	1.123	65
Mahal. Distance	.190	20.209	4.923	3.527	65
Cook's Distance	.000	.196	.013	.029	65
Centered Leverage Value	.003	.316	.077	.055	65

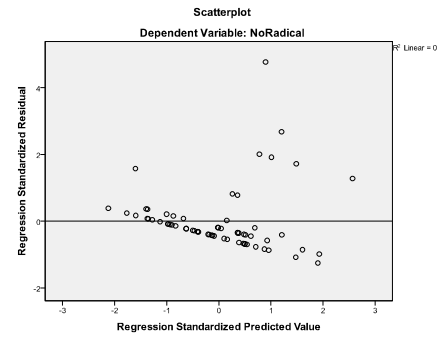
a. Dependent Variable: NoRadical

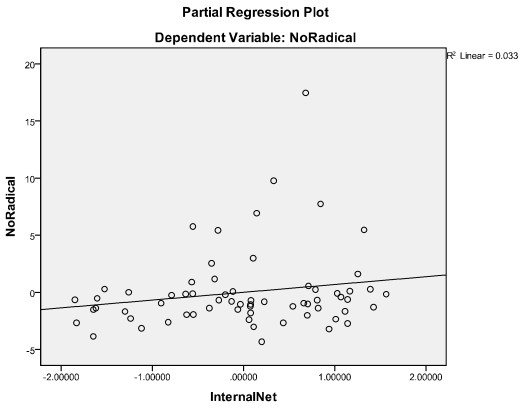

Histogram
Dependent Variable: NoRadical
Mean = 5.96E-19
Std. Dev. = 0.960
N = 65
Frequency
Regression Standardized Residual

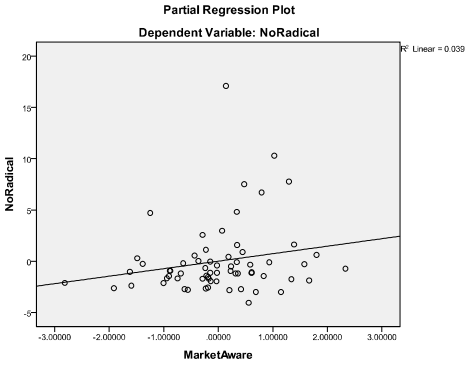

Partial Regression Plot
Dependent Variable: NoRadical
R² Linear = 0.027
NoRadical
EngageCustom

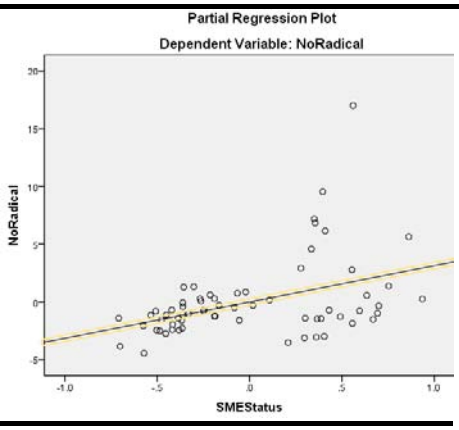

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: NoRadical
Expected Cum Prob
Observed Cum Prob

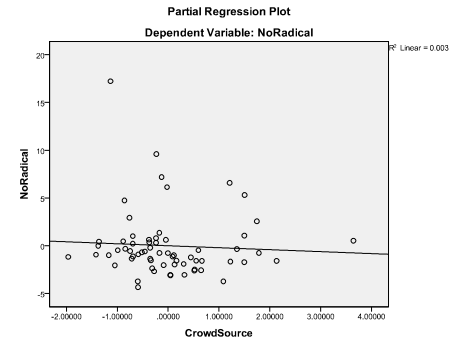

Partial Regression Plot
Dependent Variable: NoRadical
R² Linear = 0.010
NoRadical
OpenEnv


Scatterplot
Dependent Variable: NoRadical
R² Linear = 0
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: NoRadical
R² Linear = 0.033
NoRadical
InternalNet


Partial Regression Plot
Dependent Variable: NoRadical
R² Linear = 0.039
NoRadical
MarketAware


Partial Regression Plot
Dependent Variable: NoRadical
NoRadical
SMEStatus


Partial Regression Plot
Dependent Variable: NoRadical
R² Linear = 0.003
NoRadical
CrowdSource

Search Model 2

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.526[a]	.277	.202	.98457	.277	3.707	6	58	.003

a. Predictors: (Constant), OpenEnvi, SMEStatus, Internetenabled, EngageCus, IntertnalNet, Marketaware
b. Dependent Variable: Mrketrecode

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	21.561	6	3.593	3.707	.003[a]
	Residual	56.224	58	.969		
	Total	77.785	64			

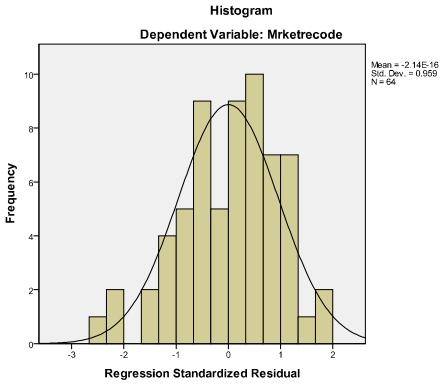
a. Predictors: (Constant), OpenEnvi, SMEStatus, Internetenabled, EngageCus, IntertnalNet, Marketaware
b. Dependent Variable: Mrketrecode

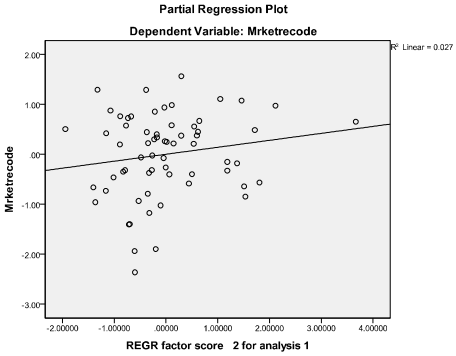
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	4.281	.403		10.620	.000					
	SMEStatus	.811	.274	.363	2.954	.005	.379	.362	.330	.826	1.211
	Marketaware	.302	.135	.274	2.241	.029	.310	.282	.250	.837	1.195
	IntertnalNet	-.287	.133	-.260	-2.160	.035	-.082	-.273	-.241	.858	1.166
	Internetenabled	.121	.127	.110	.951	.345	.160	.124	.106	.933	1.072
	EngageCus	-.165	.129	-.150	-1.275	.208	-.023	-.165	-.142	.905	1.105
	OpenEnvi	.123	.129	.112	.951	.345	.110	.124	.106	.905	1.105

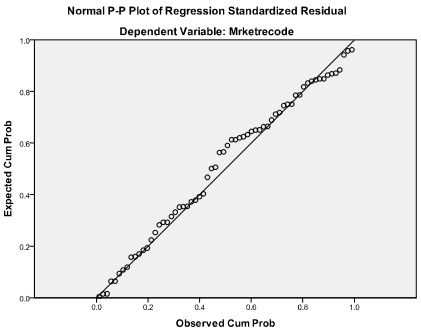
Residuals Statistics[a]

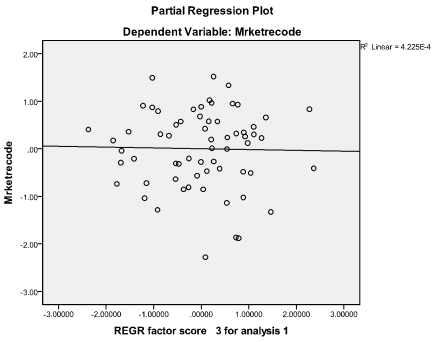
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.3723	6.6364	5.4844	.49544	64
Std. Predicted Value	-2.245	2.325	.000	1.000	64
Standard Error of Predicted Value	.117	.497	.252	.073	64
Adjusted Predicted Value	4.3065	6.5436	5.4853	.49882	64
Residual	-2.27977	1.52150	.00000	.82154	64
Std. Residual	-2.663	1.777	.000	.959	64
Stud. Residual	-2.714	1.846	-.001	1.005	64
Deleted Residual	-2.36838	1.69351	-.00095	.90146	64
Stud. Deleted Residual	-2.879	1.886	-.005	1.023	64
Mahal. Distance	.183	20.237	4.922	3.532	64
Cook's Distance	.000	.136	.016	.025	64
Centered Leverage Value	.003	.321	.078	.056	64

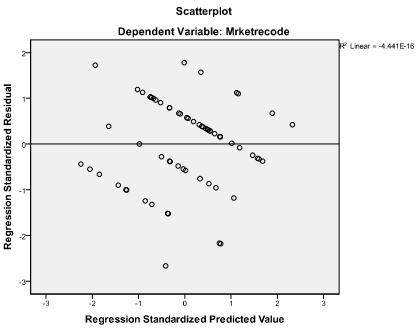
a. Dependent Variable: Mrketrecode

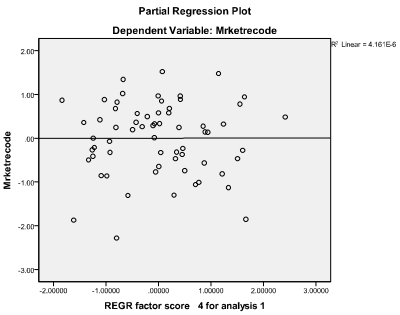

Histogram
Dependent Variable: Mrketrecode
Mean = -2.14E-16
Std. Dev. = 0.959
N = 64
Frequency
Regression Standardized Residual

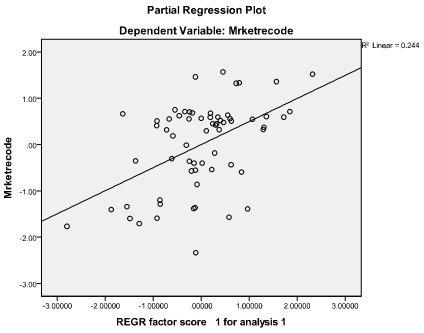

Partial Regression Plot
Dependent Variable: Mrketrecode
R² Linear = 0.027
Mrketrecode
REGR factor score 2 for analysis 1

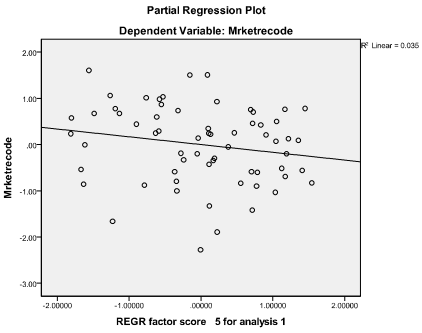

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: Mrketrecode
Expected Cum Prob
Observed Cum Prob

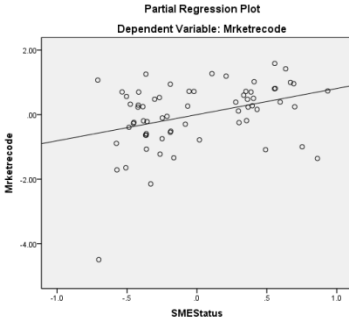

Partial Regression Plot
Dependent Variable: Mrketrecode
R² Linear = 4.225E-4
Mrketrecode
REGR factor score 3 for analysis 1


Scatterplot
Dependent Variable: Mrketrecode
R² Linear = 4.441E-16
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: Mrketrecode
R² Linear = 4.161E-6
Mrketrecode
REGR factor score 4 for analysis 1


Partial Regression Plot
Dependent Variable: Mrketrecode
R² Linear = 0.244
Mrketrecode
REGR factor score 1 for analysis 1


Partial Regression Plot
Dependent Variable: Mrketrecode
R² Linear = 0.035
Mrketrecode
REGR factor score 5 for analysis 1


Partial Regression Plot
Dependent Variable: Mrketrecode
Mrketrecode
SMEStatus

APPENDIX K: SELECT Q2 SPSS TABLES

Correlations

Correlations

		StaffNo	MrkPosRecode	innovator2plus
StaffNo	Pearson Correlation	1	.260*	.286**
	Sig. (2-tailed)		.011	.005
	N	94	94	94
MrkPosRecode	Pearson Correlation	.260*	1	.384**
	Sig. (2-tailed)	.011		.000
	N	94	94	94
radical	Pearson Correlation	.286**	.384**	1
	Sig. (2-tailed)	.005	.000	
	N	94	94	94

*. Correlation is significant at the 0.05 level (2-tailed).
**. Correlation is significant at the 0.01 level (2-tailed).

Total Sample usage v importance

		Z	Asymp. Sig. (2-tailed)
Test Statisticsb	Q21I - Q21U	-5.699	.000
	Q20I - Q20U	-6.168	.000
	Q19I - Q19U	-5.597	.000
	Q17I - Q17U	-5.756	.000
	Q4I - Q4U	-4.199	.000
	Q6I - Q6U	-3.355	.001
	Q5I - Q5U	-2.590	.010
	Q2I - Q2U	-3.173	.002
	Q3I - Q3U	-2.518	.012
	Q12I - Q12U	-5.534	.000
	Q7I - Q7U	-3.848	.000
	Q15I - Q15U	-3.919	.000
	Q10I - Q10U	-4.851	.000
	Q8I - Q8U	-4.469	.000

Innovator v Non innovator Usage of practices comparison

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Test Statisticsa	Q21U	549.500	1452.500	-3.591	.000
	Q20U	617.500	1652.500	-3.533	.000
	Q19U	587.000	1622.000	-3.925	.000
	Q17U	501.000	1404.000	-3.874	.000
	Q4U	795.500	1785.500	-1.824	.068
	Q6U	878.500	1913.500	-1.455	.146
	Q5U	690.500	1680.500	-2.696	.007
	Q2U	874.000	1909.000	-1.939	.053
	Q3U	809.000	1844.000	-2.453	.014
	Q12U	695.000	1641.000	-2.791	.005
	Q7U	426.500	1246.500	-3.945	.000
	Q15U	357.500	1177.500	-4.585	.000
	Q10U	480.000	1426.000	-4.314	.000
	Q8U	636.000	1497.000	-2.717	.007

Innovator v Non innovator Importance of practices comparison

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Test Statisticsa	Q21I	898.000	1801.000	-.622	.534
	Q20I	756.500	1746.500	-2.249	.025
	Q19I	896.000	1886.000	-1.244	.213
	Q17I	678.000	1539.000	-2.286	.022
	Q4I	756.500	1617.500	-1.551	.121
	Q6I	849.000	1710.000	-.491	.623
	Q5I	663.500	1524.500	-2.354	.019
	Q2I	972.500	1962.500	-.349	.727
	Q3I	966.000	1912.000	-.206	.837
	Q12I	961.000	2089.000	-.238	.812
	Q7I	677.000	1497.000	-1.590	.112
	Q15I	660.000	1440.000	-1.235	.217
	Q10I	789.000	1692.000	-1.583	.113
	Q8I	849.500	1752.500	-.695	.487

SME v Large

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Test Statisticsa	Q21U	900.000	2125.000	-.481	.630
	Q20U	908.500	2183.500	-1.140	.254
	Q19U	964.500	1867.500	-.851	.395
	Q17U	712.500	1453.500	-1.921	.055
	Q4U	942.000	1803.000	-.529	.597
	Q6U	853.500	1799.500	-1.629	.103
	Q5U	836.500	1739.500	-1.441	.150
	Q2U	811.000	1757.000	-2.429	.015
	Q3U	877.000	1823.000	-1.840	.066
	Q12U	861.000	1722.000	-1.363	.173
	Q7U	675.000	1416.000	-1.540	.124
	Q15U	604.500	1384.500	-2.225	.026
	Q10U	741.500	1602.500	-2.061	.039
	Q8U	729.000	1509.000	-1.839	.066

		Mann-Whitney U	Wilcoxon W	Z	Asymp. Sig. (2-tailed)
Test Statisticsa	Q21I	954.000	2130.000	-.055	.956
	Q20I	986.000	2162.000	-.194	.846
	Q19I	872.000	1775.000	-1.419	.156
	Q17I	901.000	1642.000	-.103	.918
	Q4I	847.000	1627.000	-.651	.515
	Q6I	835.000	1655.000	-.603	.546
	Q5I	794.000	1614.000	-1.147	.252
	Q2I	799.000	1702.000	-1.852	.064
	Q3I	874.000	1735.000	-.986	.324
	Q12I	901.500	1721.500	-.722	.470
	Q7I	829.500	1532.500	-.029	.977
	Q15I	668.000	1409.000	-1.143	.253
	Q10I	893.000	1754.000	-.631	.528
	Q8I	771.500	1551.500	-1.359	.174

Regressions: Selection v performance measures

Selection Model 1
Dependent Variable: Number of Radical Innovation
Independent Variables: 4 factors**: Innov, Proto, Flex, differ**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.630[a]	.397	.348	3.875	.397	8.153	5	62	.000

a. Predictors: (Constant), Flex, Innov, SMEStatus, Fact2proto, differ
b. Dependent Variable: radical

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	611.997	5	122.399	8.153	.000[a]
	Residual	930.768	62	15.012		
	Total	1542.765	67			

a. Predictors: (Constant), Flex, Innov, SMEStatus, Fact2proto, differ
b. Dependent Variable: radical

Coefficients[a]

Model	Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations			Collinearity Statistics	
	B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1 (Constant)	-3.926	2.330		-1.685	.097					
SMEStatus	1.859	.998	.195	1.862	.067	.259	.230	.184	.889	1.125
Innov	1.529	.579	.306	2.642	.010	.472	.318	.261	.726	1.378
Fact2proto	.994	.505	.205	1.967	.054	.351	.242	.194	.892	1.121
differ	-1.322	.559	-.278	-2.367	.021	-.502	-.288	-.233	.706	1.416
Flex	-.255	.574	-.048	-.445	.658	.201	-.056	-.044	.830	1.205

a. Dependent Variable: radical

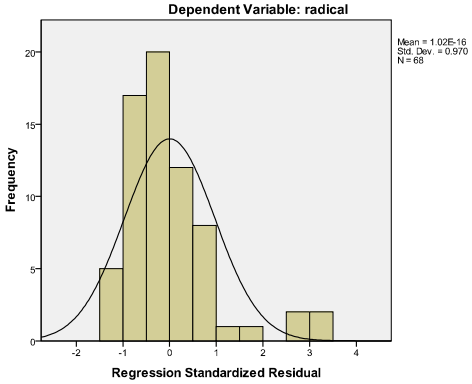
Residuals Statistics[a]

	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	-4.93	8.31	2.56	2.886	68
Std. Predicted Value	-2.595	1.992	.000	1.000	68
Standard Error of Predicted Value	.518	1.950	1.028	.307	68
Adjusted Predicted Value	-6.51	8.29	2.48	2.975	68
Residual	-4.584	13.350	.000	3.834	68
Std. Residual	-1.159	3.377	.000	.970	68
Stud. Residual	-1.209	3.528	.010	1.015	68
Deleted Residual	-4.981	14.576	.081	4.204	68
Stud. Deleted Residual	-1.213	3.908	.026	1.064	68
Mahal. Distance	.163	15.310	3.941	3.098	68
Cook's Distance	.000	.229	.020	.047	68
Centered Leverage Value	.002	.229	.059	.046	68

a. Dependent Variable: radical

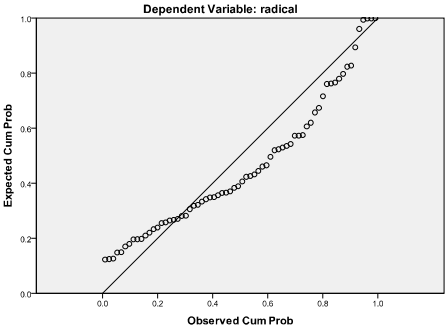
Histogram

Dependent Variable: radical



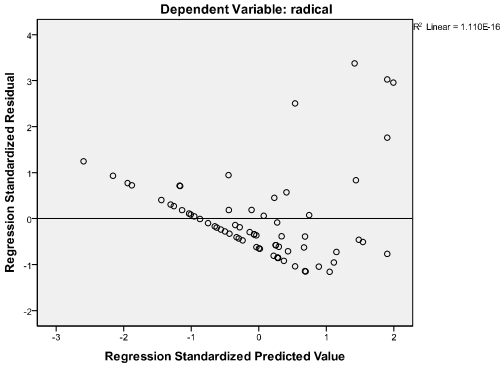
Normal P-P Plot of Regression Standardized Residual

Dependent Variable: radical



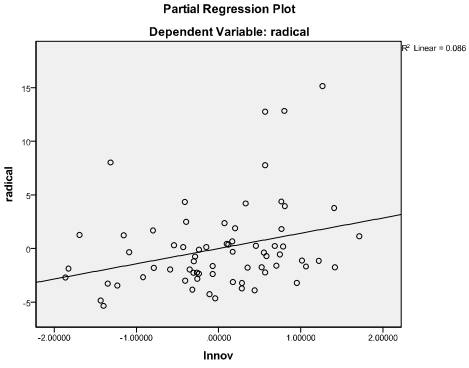
Scatterplot

Dependent Variable: radical



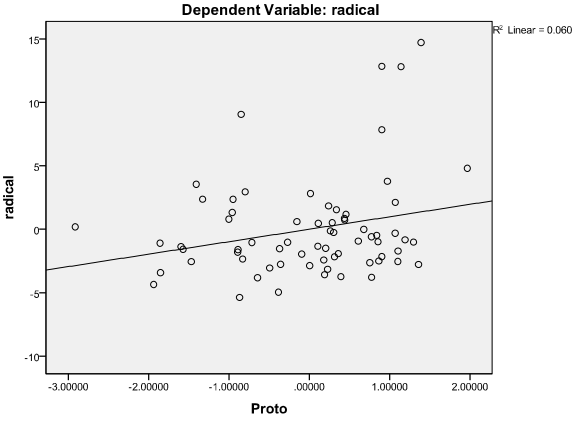
Partial Regression Plot

Dependent Variable: radical



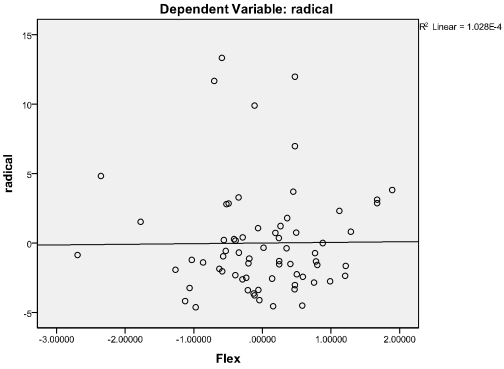
Partial Regression Plot

Dependent Variable: radical



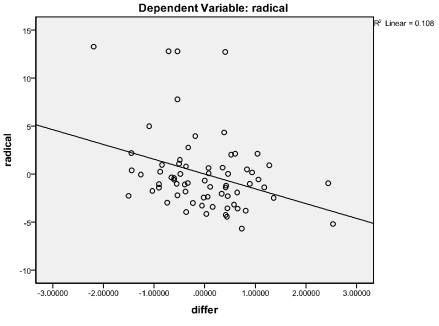
Partial Regression Plot

Dependent Variable: radical

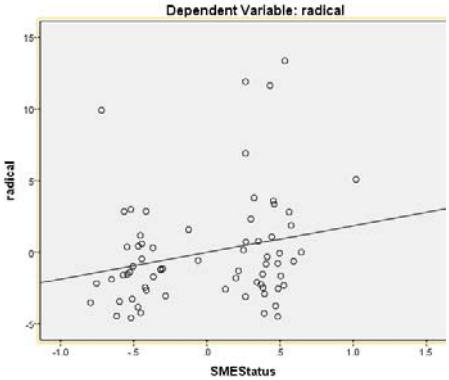


Partial Regression Plot

Dependent Variable: radical



Dependent Variable: radical



Selection Model 2

Dependent Variable: Market Position

Independent Variables: 4 factors**:**

Model Summary[b]

Model	R	R Square	Adjusted R Square	Std. Error of the Estimate	Change Statistics				
					R Square Change	F Change	df1	df2	Sig. F Change
1	.578[a]	.334	.281	1.14673	.334	6.227	5	62	.000

a. Predictors: (Constant), Flex, Proto, Innov, SMEStatus, differ

b. Dependent Variable: MrkPosRecode

ANOVA[b]

Model		Sum of Squares	df	Mean Square	F	Sig.
1	Regression	40.941	5	8.188	6.227	.000[a]
	Residual	81.530	62	1.315		
	Total	122.471	67			

a. Predictors: (Constant), Flex, Proto, Innov, SMEStatus, differ

b. Dependent Variable: MrkPosRecode

Coefficients[a]

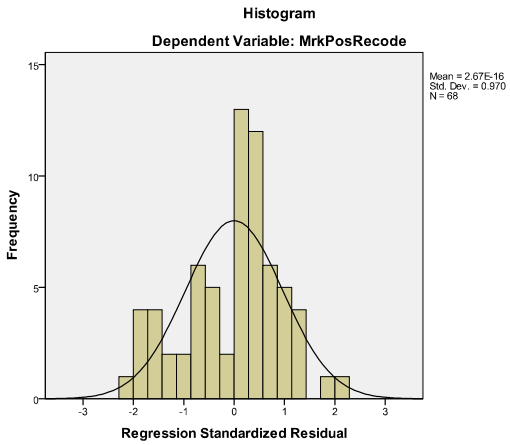
Model		Unstandardised Coefficients		Standardised Coefficients	t	Sig.	Correlations			Collinearity Statistics	
		B	Std. Error	Beta			Zero-order	Partial	Part	Tolerance	VIF
1	(Constant)	3.947	.474		8.333	.000					
	SMEStatus	1.052	.295	.391	3.563	.001	.391	.412	.369	.890	1.123
	Innov	.430	.171	.305	2.515	.015	.371	.304	.261	.729	1.372
	Proto	.085	.142	.064	.598	.552	.148	.076	.062	.940	1.064
	differ	-.254	.164	-.189	-1.543	.128	-.383	-.192	-.160	.713	1.402
	Flex	-.219	.169	-.147	-1.296	.200	.096	-.162	-.134	.836	1.196

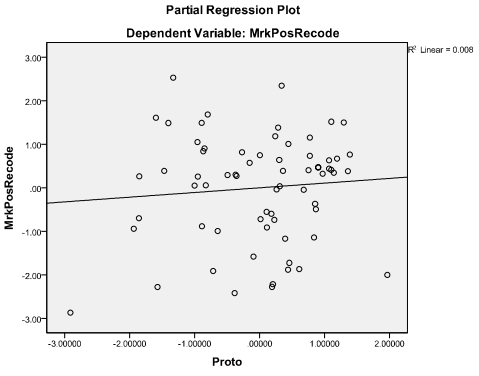
a. Dependent Variable: MrkPosRecode

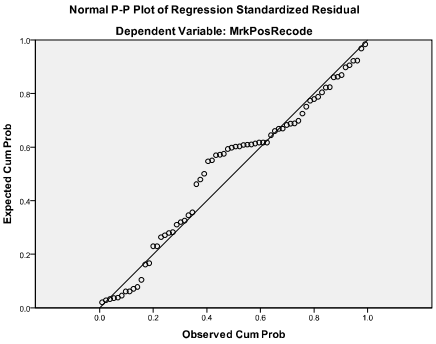
Residuals Statistics[a]

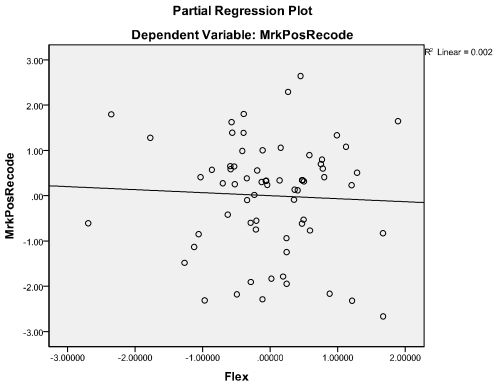
	Minimum	Maximum	Mean	Std. Deviation	N
Predicted Value	4.2144	6.7746	5.5882	.60154	68
Std. Predicted Value	-2.284	1.972	.000	1.000	68
Standard Error of Predicted Value	.163	.616	.325	.097	68
Adjusted Predicted Value	3.8339	6.7532	5.5970	.61177	68
Residual	-2.55354	2.67419	.00000	1.21081	68
Std. Residual	-2.045	2.142	.000	.970	68
Stud. Residual	-2.282	2.285	-.003	1.021	68
Deleted Residual	-3.17873	3.04374	-.00873	1.34426	68
Stud. Deleted Residual	-2.363	2.367	-.007	1.035	68
Mahal. Distance	.163	15.310	3.941	3.098	68
Cook's Distance	.000	.255	.023	.045	68
Centered Leverage Value	.002	.229	.059	.046	68

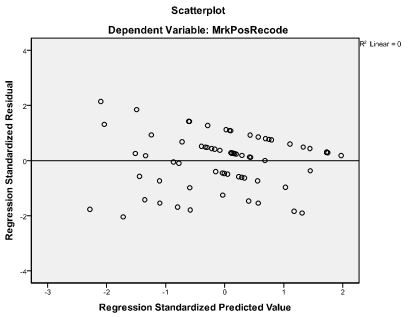
a. Dependent Variable: MrkPosRecode

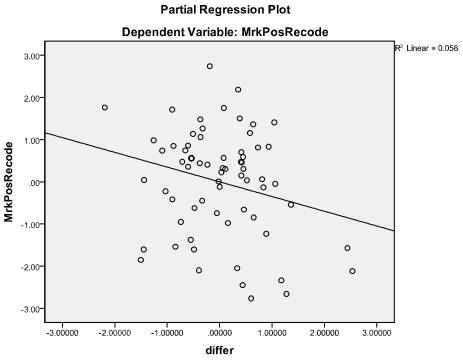

Histogram
Dependent Variable: MrkPosRecode
Mean = 2.67E-16
Std. Dev. = 0.970
N = 68
Frequency
Regression Standardized Residual

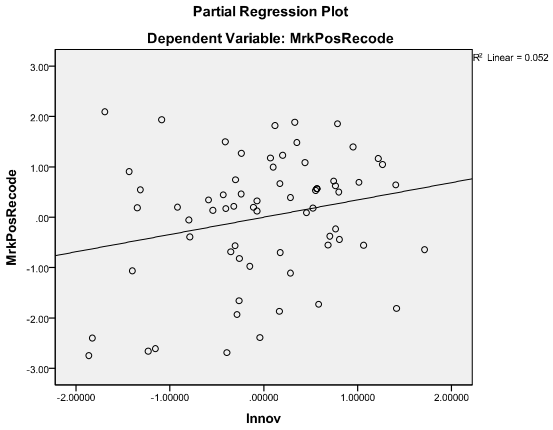

Partial Regression Plot
Dependent Variable: MrkPosRecode
R² Linear = 0.008
MrkPosRecode
Proto

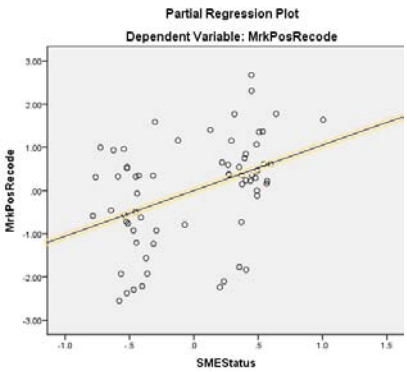

Normal P-P Plot of Regression Standardized Residual
Dependent Variable: MrkPosRecode
Expected Cum Prob
Observed Cum Prob


Partial Regression Plot
Dependent Variable: MrkPosRecode
R² Linear = 0.002
MrkPosRecode
Flex


Scatterplot
Dependent Variable: MrkPosRecode
Regression Standardized Residual
Regression Standardized Predicted Value


Partial Regression Plot
Dependent Variable: MrkPosRecode
R² Linear = 0.058
MrkPosRecode
differ


Partial Regression Plot
Dependent Variable: MrkPosRecode
R² Linear = 0.052
MrkPosRecode
Innov


Partial Regression Plot
Dependent Variable: MrkPosRecode
MrkPosRecode
SMEStatus

APPENDIX L: COMPARISON OF SURVEYS

Test of Homogeneity of Variances

	Levene Statistic	df1	df2	Sig.
Size	.050	2	266	.951
Radical	1.373	2	266	.255

ANOVA

		Sum of Squares	df	Mean Square	F	Sig.
Size	Between Groups	1.697	2	.849	.612	.543
	Within Groups	369.135	266	1.388		
	Total	370.833	268			
Radical	Between Groups	.409	2	.204	.814	.444
	Within Groups	66.795	266	.251		
	Total	67.204	268			

Robust Tests of Equality of Means

		Statistic[a]	df1	df2	Sig.
Size	Welch	.611	2	176.816	.544
	Brown-Forsythe	.611	2	265.123	.543
Radical	Welch	.816	2	176.880	.444
	Brown-Forsythe	.814	2	265.331	.444

a. Asymptotically F distributed.

Multiple Comparisons

Tukey HSD

Dependent Variable	(I) Group	(J) Group	Mean Difference (I-J)	Std. Error	Sig.	95% Confidence Interval	
						Lower Bound	Upper Bound
Size	SearchQ1	Selectq2	-.14490	.17525	.687	-.5580	.2682
		SearchSelectq3	-.18770	.17810	.544	-.6075	.2321
	Selectq2	SearchQ1	.14490	.17525	.687	-.2682	.5580
		SearchSelectq3	-.04279	.17474	.967	-.4546	.3690
	SearchSelectq3	SearchQ1	.18770	.17810	.544	-.2321	.6075
		Selectq2	.04279	.17474	.967	-.3690	.4546
Radical	SearchQ1	Selectq2	-.01553	.07455	.976	-.1912	.1602
		SearchSelectq3	.07393	.07576	.593	-.1046	.2525
	Selectq2	SearchQ1	.01553	.07455	.976	-.1602	.1912
		SearchSelectq3	.08946	.07433	.452	-.0857	.2646
	SearchSelectq3	SearchQ1	-.07393	.07576	.593	-.2525	.1046
		Selectq2	-.08946	.07433	.452	-.2646	.0857

APPENDIX M: SEARCHSELECTQ3 CONFIRMATORY FACTOR ANALYSIS- SPSS OUTPUT

SPSS CFA Search output

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.671
Bartlett's Test of Sphericity	Approx. Chi-Square	298.488
	df	66
	Sig.	.000

Communalities

	Initial	Extraction
search1buse	1.000	.852
search1cuse	1.000	.870
search1ause	1.000	.850
search3ause	1.000	.675
search3buse	1.000	.835
search5buse	1.000	.739
search5ause	1.000	.814
search2buse	1.000	.806
search2ause	1.000	.806
search4ause	1.000	.597
search4buse	1.000	.744
Search4extrause	1.000	.713

Extraction Method: Principal Component Analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	3.637	30.305	30.305	3.637	30.305	30.305	2.756
2	1.734	14.447	44.752	1.734	14.447	44.752	1.907
3	1.646	13.717	58.469	1.646	13.717	58.469	1.893
4	1.275	10.626	69.095	1.275	10.626	69.095	1.819
5	1.011	8.422	77.517	1.011	8.422	77.517	1.996
6	.656	5.463	82.980				
7	.580	4.834	87.814				
8	.457	3.810	91.625				
9	.367	3.062	94.687				
10	.283	2.356	97.043				
11	.183	1.526	98.569				
12	.172	1.431	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Component Matrix[a]

	Component				
	1	2	3	4	5
search1ause	.833	-.248	-.068	-.080	-.289
search1buse	.802	-.246	-.330	-.002	-.197
search1cuse	.722	-.371	-.312	-.224	-.253
search3ause	.626	.147	-.294	.265	.324
search4ause	.562	.357	.329	.186	.106
search3buse	.501	-.056	-.325	.477	.497
search5ause	.407	.596	-.035	-.540	.026
search4buse	.322	.549	.223	.206	-.497
search5buse	.400	.535	.008	-.431	.326
search2ause	.382	-.447	.656	-.099	.145
search2buse	.373	-.352	.653	-.246	.237
Search4extrause	.324	.233	.477	.545	-.172

Extraction Method: Principal Component Analysis.
a. 5 components extracted.

Pattern Matrix[a]

	Component				
	1	2	3	4	5
search1cuse	.908	.040	.065	-.127	.043
search1buse	.832	.010	-.012	.039	.242
search1ause	.825	.044	.183	.166	.060
search5ause	.125	.878	-.063	.049	-.111
search5buse	-.073	.841	.078	-.052	.152
search2buse	.038	.095	.890	-.031	-.041
search2ause	.103	-.089	.872	.056	-.027
search4buse	.144	.180	-.212	.801	-.199
Search4extrause	-.091	-.174	.167	.795	.140
search4ause	-.027	.291	.234	.506	.282
search3buse	.050	-.091	-.024	-.028	.911
search3ause	.183	.176	-.075	.079	.705

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 23 iterations.

Structure Matrix

	Component				
	1	2	3	4	5
search1cuse	.922	.139	.170	-.044	.242
search1buse	.890	.143	.111	.130	.438
search1ause	.879	.179	.309	.258	.284
search5ause	.203	.888	-.032	.166	.013
search5buse	.071	.842	.088	.093	.221
search2buse	.151	.108	.891	.070	.023
search2ause	.200	-.054	.888	.135	.043
Search4extrause	-.001	-.051	.241	.798	.211
search4buse	.152	.290	-.120	.791	-.058
search4ause	.139	.396	.303	.606	.384
search3buse	.242	.006	.028	.075	.908
search3ause	.362	.283	-.001	.200	.771

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.

SPSS CFA Select output

KMO and Bartlett's Test

Kaiser-Meyer-Olkin Measure of Sampling Adequacy.		.745
Bartlett's Test of Sphericity	Approx. Chi-Square	522.369
	df	91
	Sig.	.000

Communalities

	Initial	Extraction
select3ause	1.000	.907
select3buse	1.000	.871
select3cuse	1.000	.761
select2ause	1.000	.863
select2cuse	1.000	.757
select2buse	1.000	.838
select4ause	1.000	.732
select4duse	1.000	.823
select4cuse	1.000	.750
select4buse	1.000	.775
select1duse	1.000	.467
select1cuse	1.000	.752
select1buse	1.000	.804
select1ause	1.000	.850

Extraction Method: Principal Component Analysis.

Total Variance Explained

	Initial Eigenvalues			Extraction Sums of Squared Loadings			Rotation Sums of Squared Loadings[a]
Component	Total	% of Variance	Cumulative %	Total	% of Variance	Cumulative %	Total
1	4.893	34.952	34.952	4.893	34.952	34.952	3.383
2	2.740	19.573	54.525	2.740	19.573	54.525	3.167
3	1.750	12.498	67.023	1.750	12.498	67.023	2.844
4	1.567	11.193	78.216	1.567	11.193	78.216	2.973
5	.725	5.176	83.392				
6	.482	3.440	86.832				
7	.368	2.631	89.463				
8	.332	2.371	91.834				
9	.314	2.242	94.076				
10	.253	1.807	95.883				
11	.197	1.405	97.288				
12	.147	1.048	98.336				
13	.134	.954	99.290				
14	.099	.710	100.000				

Extraction Method: Principal Component Analysis.

a. When components are correlated, sums of squared loadings cannot be added to obtain a total variance.

Component Matrix[a]

	Component			
	1	2	3	4
select4buse	.732	-.387	-.208	-.213
select1cuse	.663	.437	.269	-.222
select3cuse	.662	-.256	.272	.428
select4duse	.639	-.444	-.335	-.324
select2cuse	.622	.389	-.331	.330
select2buse	.594	.403	-.334	.460
select4ause	.590	-.505	-.333	-.135
select1ause	.557	.449	.289	-.504
select4cuse	.556	-.538	-.301	-.246
select1duse	.536	.326	.108	-.247
select2ause	.523	.513	-.392	.415
select1buse	.516	.592	.310	-.301
select3ause	.557	-.433	.593	.239
select3buse	.474	-.412	.572	.386

Extraction Method: Principal Component Analysis.
a. 4 components extracted.

Pattern Matrix[a]

	Component			
	1	2	3	4
select4duse	.894	.087	-.005	.007
select4cuse	.855	-.034	.065	-.033
select4ause	.819	-.086	.101	.087
select4buse	.788	.144	.156	.076
select1ause	.082	.928	-.028	-.073
select1buse	-.124	.871	.025	.100
select1cuse	.023	.780	.150	.163
select1duse	.124	.611	.018	.131
select3buse	-.013	-.019	.940	-.042
select3ause	.095	.106	.917	-.128
select3cuse	.129	-.010	.758	.286
select2ause	-.023	.075	-.064	.915
select2buse	.024	.041	.068	.892
select2cuse	.103	.128	.017	.809

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.
a. Rotation converged in 19 iterations.

Structure Matrix

	Component			
	1	2	3	4
select4duse	.903	.177	.202	.136
select4cuse	.862	.050	.248	.069
select4buse	.846	.256	.352	.219
select4ause	.844	.027	.281	.175
select1ause	.160	.916	.081	.153
select1buse	-.020	.884	.097	.292
select1cuse	.153	.836	.251	.362
select1duse	.205	.656	.122	.291
select3ause	.292	.181	.937	-.011
select3buse	.187	.069	.932	.035
select3cuse	.330	.150	.811	.367
select2ause	.081	.281	.019	.924
select2buse	.151	.261	.157	.911
select2cuse	.217	.330	.125	.853

Extraction Method: Principal Component Analysis.
Rotation Method: Oblimin with Kaiser Normalisation.

APPENDIX N: LISREL OUTPUT FOR CONFIRMATORY FACTOR ANALYSIS

Search

DATE: 4/10/2014
TIME: 11:02

LISREL 8.80 (STUDENT EDITION)

BY

Karl G. Jöreskog & Dag Sörbom

This program is published exclusively by
Scientific Software International, Inc.
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Lincolnwood, IL 60712, U.S.A.
Phone: (800)247-6113, (847)675-0720, Fax: (847)675-2140


```
 The following lines were read from file C:\Documents and
Settings\John.Nicholas\Desktop\New Folder (2)\searchfinal.SPJ:

 Raw Data from file 'C:\Documents and
Settings\John.Nicholas\Desktop\New Folder (2)\SEARCHNOMISSING.psf'
 Latent Variables  s1 s2 s3 s4 s5
 Relationships
 SEARCH1B = s1
 SEARCH1C = s1
 SEARCH1A = s1
 SEARCH3A = s3
 SEARCH3B = s3
 SEARCH5B = s5
 SEARCH5A = s5
 SEARCH2B = s2
 SEARCH2A = s2
 SEARCH4A = s4
 SEARCH4B = s4
 SEARCH4E = s4
 Path Diagram
 End of Problem

 Sample Size =    84
```

Covariance Matrix

	SEARCH1B	SEARCH1C	SEARCH1A	SEARCH3A	SEARCH3B	SEARCH5B
SEARCH1B	1.49					
SEARCH1C	1.24	1.79				
SEARCH1A	1.22	1.25	1.65			
SEARCH3A	0.54	0.46	0.46	0.90		
SEARCH3B	0.56	0.40	0.40	0.58	1.13	
SEARCH5B	0.31	0.25	0.31	0.26	0.17	1.25
SEARCH5A	0.28	0.27	0.41	0.23	-0.08	0.80
SEARCH2B	0.29	0.48	0.59	0.03	-0.03	0.32
SEARCH2A	0.43	0.39	0.65	0.05	-0.04	0.16
SEARCH4A	0.34	0.23	0.53	0.36	0.24	0.25
SEARCH4B	0.18	0.18	0.25	0.22	-0.01	0.12
SEARCH4E	0.23	0.06	0.44	0.16	0.12	0.13

Covariance Matrix

	SEARCH5A	SEARCH2B	SEARCH2A	SEARCH4A	SEARCH4B	SEARCH4E
SEARCH5A	1.47					
SEARCH2B	0.30	1.69				
SEARCH2A	0.11	1.23	1.79			
SEARCH4A	0.42	0.27	0.44	1.49		
SEARCH4B	0.26	-0.01	-0.01	0.65	1.59	
SEARCH4E	0.11	0.48	0.43	0.64	0.68	1.62

Number of Iterations = 11

LISREL Estimates (Maximum Likelihood)

Measurement Equations

SEARCH1B = 1.10*s1, Errorvar.= 0.29 , R² = 0.81
(0.11) (0.082)
10.16 3.52

SEARCH1C = 1.11*s1, Errorvar.= 0.56 , R² = 0.69
(0.12) (0.11)
8.99 4.93

SEARCH1A = 1.12*s1, Errorvar.= 0.40 , R² = 0.76
(0.12) (0.095)

```
          9.67                4.21

SEARCH3A = 0.82*s3, Errorvar.= 0.23 , R² = 0.74
          (0.12)              (0.14)
           7.06                1.68

SEARCH3B = 0.71*s3, Errorvar.= 0.63 , R² = 0.44
          (0.12)              (0.14)
           5.68                4.50

SEARCH5B = 0.87*s5, Errorvar.= 0.49 , R² = 0.60
          (0.17)              (0.26)
           4.99                1.93

SEARCH5A = 0.92*s5, Errorvar.= 0.62 , R² = 0.58
          (0.19)              (0.29)
           4.93                2.13

SEARCH2B = 1.07*s2, Errorvar.= 0.56 , R² = 0.67
          (0.16)              (0.24)
           6.76                2.30

SEARCH2A = 1.16*s2, Errorvar.= 0.46 , R² = 0.74
          (0.16)              (0.28)
           7.05                1.66

SEARCH4A = 0.92*s4, Errorvar.= 0.63 , R² = 0.57
          (0.15)              (0.21)
           6.05                2.96

SEARCH4B = 0.71*s4, Errorvar.= 1.09 , R² = 0.31
          (0.15)              (0.21)
           4.59                5.20

SEARCH4E = 0.76*s4, Errorvar.= 1.04 , R² = 0.36
          (0.16)              (0.21)
           4.87                4.91
```

Correlation Matrix of Independent Variables

	s1	s2	s3	s4	s5
s1	1.00				
s2	0.38	1.00			
	(0.11)				
	3.39				
s3	0.56	0.03	1.00		
	(0.10)	(0.14)			
	5.44	0.19			
s4	0.33	0.33	0.37	1.00	
	(0.13)	(0.13)	(0.14)		
	2.63	2.45	2.76		
s5	0.31	0.21	0.28	0.33	1.00
	(0.12)	(0.14)	(0.14)	(0.14)	
	2.50	1.57	2.08	2.30	

Goodness of Fit Statistics

Degrees of Freedom = 44
Minimum Fit Function Chi-Square = 63.71 (P = 0.027)
Normal Theory Weighted Least Squares Chi-Square = 57.67 (P = 0.081)
Estimated Non-centrality Parameter (NCP) = 13.67
90 Percent Confidence Interval for NCP = (0.0 ; 37.45)

Minimum Fit Function Value = 0.77
Population Discrepancy Function Value (F0) = 0.16
90 Percent Confidence Interval for F0 = (0.0 ; 0.45)
Root Mean Square Error of Approximation (RMSEA) = 0.061
90 Percent Confidence Interval for RMSEA = (0.0 ; 0.10)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.32

Expected Cross-Validation Index (ECVI) = 1.51
90 Percent Confidence Interval for ECVI = (1.35 ; 1.80)
ECVI for Saturated Model = 1.88
ECVI for Independence Model = 6.44

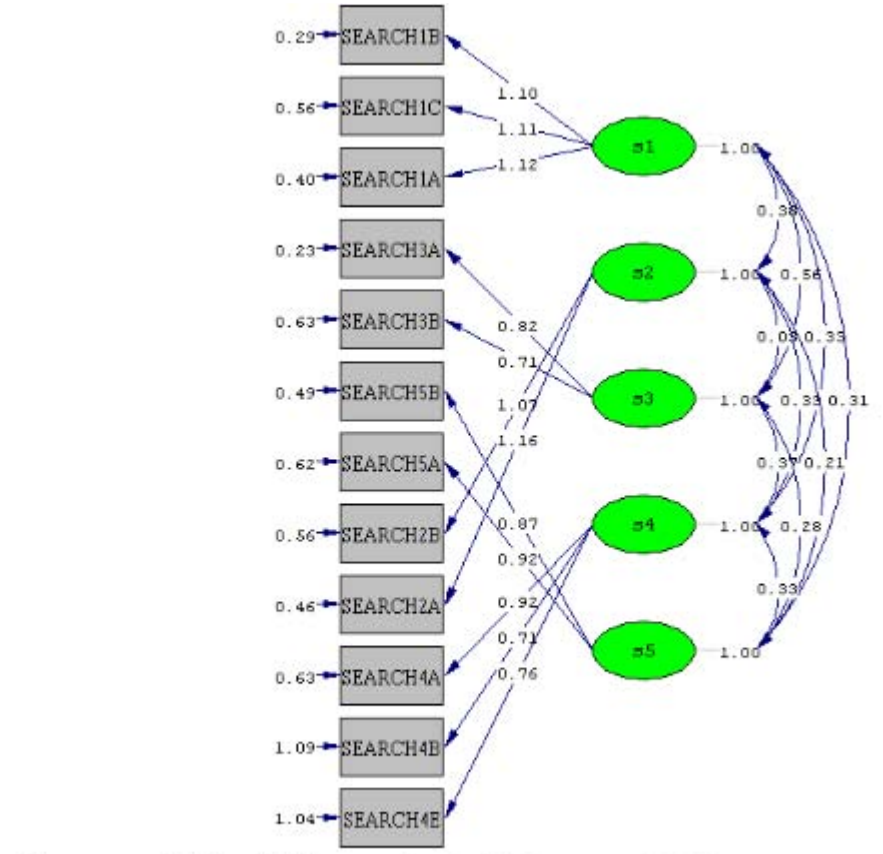
Chi-Square for Independence Model with 66 Degrees of Freedom = 510.83
Independence AIC = 534.83
Model AIC = 125.67
Saturated AIC = 156.00
Independence CAIC = 576.00
Model CAIC = 242.32
Saturated CAIC = 423.60

Normed Fit Index (NFI) = 0.88
Non-Normed Fit Index (NNFI) = 0.93
Parsimony Normed Fit Index (PNFI) = 0.58
Comparative Fit Index (CFI) = 0.96
Incremental Fit Index (IFI) = 0.96
Relative Fit Index (RFI) = 0.81

Critical N (CN) = 90.51

Root Mean Square Residual (RMR) = 0.096
Standardized RMR = 0.063
Goodness of Fit Index (GFI) = 0.90
Adjusted Goodness of Fit Index (AGFI) = 0.82
Parsimony Goodness of Fit Index (PGFI) = 0.51

Time used: 0.062 Seconds



Chi-Square=57.67, df=44, P-value=0.08103, RMSEA=0.061

Select

```
                                   DATE:  4/10/2014
                                     TIME: 11:20


                              LISREL 8.80 (STUDENT EDITION)

                                          BY

                              Karl G. Jöreskog & Dag Sörbom



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 The following lines were read from file C:\Documents and
Settings\John.Nicholas\Desktop\New Folder (3)\select1.LPJ:

 TI
 DA NI=14 NO=0 MA=CM
 RA FI='C:\Documents and Settings\John.Nicholas\Desktop\New Folder
(3)\SELECTIONNOMISSING1.psf'
 SE
 14 13 12 11 6 5 4 3 2 1 10 9 8 7 /
 MO NX=14 NK=4 TD=SY
 LK
 s1 s2 s3 s4
 FR LX(1,1) LX(2,1) LX(3,1) LX(4,1) LX(5,2) LX(6,2) LX(7,2) LX(8,3)
LX(9,3)
 FR LX(10,3) LX(11,4) LX(12,4) LX(13,4) LX(14,4)
 PD
 OU

 TI

                                Number of Input Variables 14
                                Number of Y - Variables    0
                                Number of X - Variables   14
                                Number of ETA - Variables  0
                                Number of KSI - Variables  4
                                Number of Observations    84

 TI

          Covariance Matrix

             SELECT1A   SELECT1B   SELECT1C   SELECT1D   SELECT2B
SELECT2C
```

SELECT1A	1.44					
SELECT1B	1.10	1.21				
SELECT1C	1.09	1.06	1.46			
SELECT1D	0.78	0.78	0.91	1.46		
SELECT2B	0.19	0.25	0.34	0.27	1.17	
SELECT2C	0.11	0.15	0.32	0.21	0.78	1.24
SELECT2A	0.21	0.36	0.40	0.32	0.86	0.90
SELECT3C	0.41	0.36	0.52	0.34	0.50	0.54
SELECT3B	0.14	0.22	0.40	0.34	0.24	0.17
SELECT3A	0.22	0.21	0.37	0.28	0.20	0.17
SELECT4B	0.39	0.36	0.47	0.65	0.32	0.43
SELECT4C	0.14	0.06	0.19	0.29	0.21	0.22
SELECT4D	0.37	0.22	0.42	0.38	0.17	0.31
SELECT4A	0.32	0.20	0.44	0.30	0.33	0.43

Covariance Matrix

	SELECT2A	SELECT3C	SELECT3B	SELECT3A	SELECT4B	SELECT4C
SELECT2A	1.21					
SELECT3C	0.53	1.67				
SELECT3B	0.19	0.96	1.31			
SELECT3A	0.13	0.89	0.90	1.08		
SELECT4B	0.42	0.73	0.50	0.59	1.64	
SELECT4C	0.24	0.62	0.37	0.52	1.14	1.55
SELECT4D	0.31	0.55	0.39	0.42	1.13	1.11
SELECT4A	0.37	0.66	0.40	0.44	1.05	0.84

Covariance Matrix

	SELECT4D	SELECT4A
SELECT4D	1.51	
SELECT4A	0.98	1.46

TI

Parameter Specifications

LAMBDA-X

	s1	s2	s3	s4

SELECT1A	1	0	0	0
SELECT1B	2	0	0	0
SELECT1C	3	0	0	0
SELECT1D	4	0	0	0
SELECT2B	0	5	0	0
SELECT2C	0	6	0	0
SELECT2A	0	7	0	0
SELECT3C	0	0	8	0
SELECT3B	0	0	9	0
SELECT3A	0	0	10	0
SELECT4B	0	0	0	11
SELECT4C	0	0	0	12
SELECT4D	0	0	0	13
SELECT4A	0	0	0	14

PHI

	s1	s2	s3	s4
s1	0			
s2	15	0		
s3	16	17	0	
s4	18	19	20	0

THETA-DELTA

SELECT1A	SELECT1B	SELECT1C	SELECT1D	SELECT2B	SELECT2C
21	22	23	24	25	26

THETA-DELTA

SELECT2A	SELECT3C	SELECT3B	SELECT3A	SELECT4B	SELECT4C
27	28	29	30	31	32

THETA-DELTA

SELECT4D	SELECT4A
33	34

TI

Number of Iterations = 10

LISREL Estimates (Maximum Likelihood)

LAMBDA-X

	s1	s2	s3	s4

SELECT1A	1.06	- -	- -	- -
	(0.11)			
	10.01			
SELECT1B	1.02	- -	- -	- -
	(0.09)			
	10.86			
SELECT1C	1.05	- -	- -	- -
	(0.11)			
	9.79			
SELECT1D	0.79	- -	- -	- -
	(0.12)			
	6.55			
SELECT2B	- -	0.86	- -	- -
		(0.10)		
		8.30		
SELECT2C	- -	0.90	- -	- -
		(0.11)		
		8.55		
SELECT2A	- -	1.00	- -	- -
		(0.10)		
		9.95		
SELECT3C	- -	- -	1.00	- -
			(0.13)	
			8.01	
SELECT3B	- -	- -	0.96	- -
			(0.11)	
			8.96	
SELECT3A	- -	- -	0.92	- -
			(0.10)	
			9.57	
SELECT4B	- -	- -	- -	1.13
				(0.11)
				9.80
SELECT4C	- -	- -	- -	1.01
				(0.12)
				8.63
SELECT4D	- -	- -	- -	1.04
				(0.11)
				9.21
SELECT4A	- -	- -	- -	0.92
				(0.12)
				7.93

PHI

	s1	s2	s3	s4
s1	1.00			
s2	0.29	1.00		
	(0.11)			
	2.57			
s3	0.29	0.27	1.00	
	(0.11)	(0.12)		
	2.62	2.33		
s4	0.29	0.33	0.51	1.00
	(0.11)	(0.11)	(0.09)	
	2.58	3.01	5.40	

THETA-DELTA

	SELECT1A	SELECT1B	SELECT1C	SELECT1D	SELECT2B	SELECT2C
	0.32	0.17	0.36	0.83	0.43	0.42
	(0.07)	(0.05)	(0.07)	(0.14)	(0.09)	(0.09)
	4.59	3.34	4.82	6.07	4.88	4.62

THETA-DELTA

	SELECT2A	SELECT3C	SELECT3B	SELECT3A	SELECT4B	SELECT4C
	0.22	0.66	0.38	0.24	0.38	0.54
	(0.08)	(0.13)	(0.09)	(0.07)	(0.09)	(0.11)
	2.62	5.09	4.13	3.26	4.04	5.11

THETA-DELTA

SELECT4D	SELECT4A
0.43	0.61
(0.09)	(0.11)
4.67	5.47

Squared Multiple Correlations for X - Variables

SELECT1A	SELECT1B	SELECT1C	SELECT1D	SELECT2B	SELECT2C
0.78	0.86	0.75	0.43	0.63	0.66

Squared Multiple Correlations for X - Variables

SELECT2A	SELECT3C	SELECT3B	SELECT3A	SELECT4B	SELECT4C
0.82	0.60	0.71	0.78	0.77	0.65

Squared Multiple Correlations for X - Variables

SELECT4D	SELECT4A
0.71	0.58

Goodness of Fit Statistics

Degrees of Freedom = 71

Minimum Fit Function Chi-Square = 97.54 (P = 0.020)
Normal Theory Weighted Least Squares Chi-Square = 87.31 (P = 0.092)
Estimated Non-centrality Parameter (NCP) = 16.31
90 Percent Confidence Interval for NCP = (0.0 ; 44.14)

Minimum Fit Function Value = 1.18
Population Discrepancy Function Value (F0) = 0.20
90 Percent Confidence Interval for F0 = (0.0 ; 0.53)
Root Mean Square Error of Approximation (RMSEA) = 0.053
90 Percent Confidence Interval for RMSEA = (0.0 ; 0.087)
P-Value for Test of Close Fit (RMSEA < 0.05) = 0.43

Expected Cross-Validation Index (ECVI) = 1.87
90 Percent Confidence Interval for ECVI = (1.67 ; 2.21)
ECVI for Saturated Model = 2.53
ECVI for Independence Model = 13.88

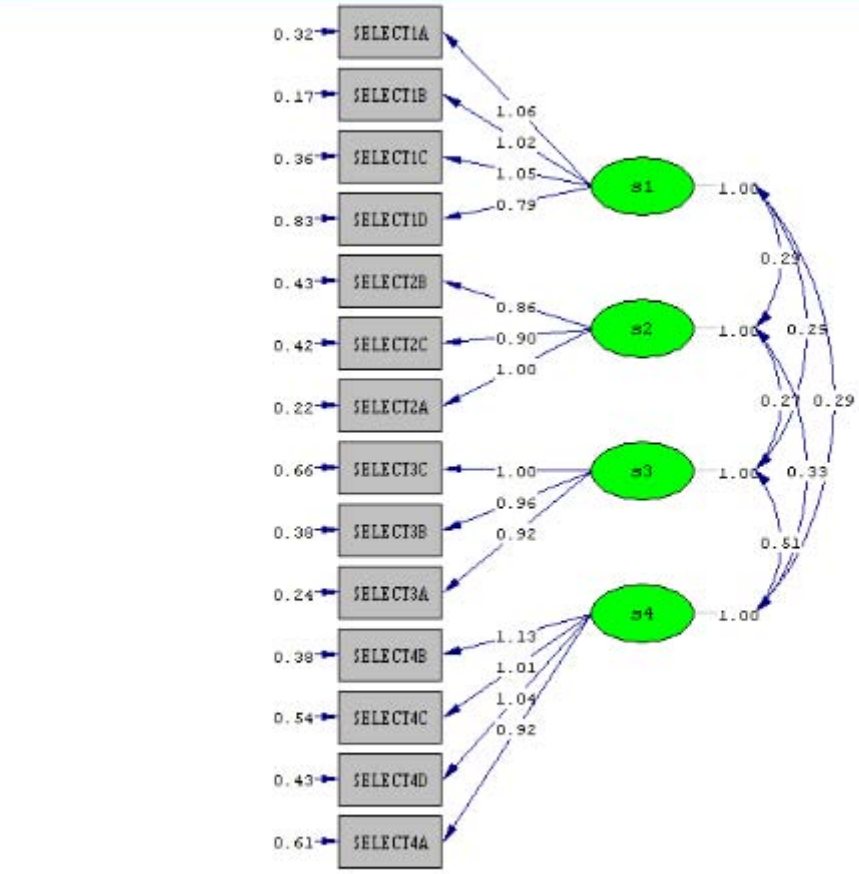
Chi-Square for Independence Model with 91 Degrees of Freedom = 1124.25
Independence AIC = 1152.25
Model AIC = 155.31
Saturated AIC = 210.00
Independence CAIC = 1200.28
Model CAIC = 271.96
Saturated CAIC = 570.24

Normed Fit Index (NFI) = 0.91
Non-Normed Fit Index (NNFI) = 0.97
Parsimony Normed Fit Index (PNFI) = 0.71
Comparative Fit Index (CFI) = 0.97
Incremental Fit Index (IFI) = 0.97
Relative Fit Index (RFI) = 0.89

Critical N (CN) = 87.48

Root Mean Square Residual (RMR) = 0.10
Standardized RMR = 0.071
Goodness of Fit Index (GFI) = 0.87
Adjusted Goodness of Fit Index (AGFI) = 0.81
Parsimony Goodness of Fit Index (PGFI) = 0.59

Time used: 0.031 Seconds



Chi-Square=87.31, df=71, P-value=0.09161, RMSEA=0.053