

Jan Edelmann

## **EXPERIENCES IN USING A STRUCTURED METHOD IN FINDING AND DEFINING NEW INNOVATIONS: THE STRATEGIC OPTIONS APPROACH**

Thesis for the degree of Doctor of Science (Strategy Research) to be presented with due permission for public examination and criticism in the Student Union House Ylioppilastalo at Lappeenranta University of Technology, Lappeenranta, Finland on the 10th of June, 2011 at noon.

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## **ABSTRACT**

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Investment decision-making on far-reaching innovation ideas is one of the key challenges practitioners and academics face in the field of innovation management. However, the management practices and theories strongly rely on evaluation systems that do not fit in well with this setting. These systems and practices normally cannot capture the value of future opportunities under high uncertainty because they ignore the firm's potential for growth and flexibility.

Real options theory and options-based methods have been offered as a solution to facilitate decision-making on highly uncertain investment objects. Much of the uncertainty inherent in these investment objects is attributable to unknown future events. In this setting, real options theory and methods have faced some challenges. First, the theory and its applications have largely been limited to market-priced real assets. Second, the options perspective has not proved as useful as anticipated because the tools it offers are perceived to be too complicated for managerial use. Third, there are challenges related to the type of uncertainty existing real options methods can handle: they are primarily limited to parametric uncertainty. Nevertheless, the theory is considered promising in the context of far-reaching and strategically important innovation ideas.

The objective of this dissertation is to clarify the potential of options-based methodology in the identification of innovation opportunities. The constructive research approach gives new insights into the development potential of real options theory under non-parametric and close-to-radical uncertainty. The distinction between real options and strategic options is presented as an explanans for the discovered limitations of the theory. The findings offer managers a new means of assessing future innovation ideas based on the frameworks constructed during the course of the study.

Keywords: Real options, strategic options, innovation, ideas, decision-making

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This has been a long project for a young man and I am proud to have accomplished it. Like other young men I tend to take an interest in many things. During my years away from thesis research I was working in management consulting. I enjoyed my journey in the corporate reality. It gave me a great opportunity to see how theories do or do not work in practice. I was constantly investigating how firm leaders were making decisions on routine and strategic business issues - I was doing undercover research.

I wish to thank my supervisor, Professor Kalevi Kyläheiko, for all his efforts and guidance during these years. When I was doing my Master's studies his marvelous lectures on economics inspired me to question how the theories explain the surrounding phenomena (if they do). Simple demand and supply curves and occurrences of disequilibrium made me interested in how firms operate and under what conditions they seize business opportunities.

I would also like to express my gratitude to the external examiners of the dissertation manuscript, Docent Mikael Collan and Professor Yuri Lawryshyn. Your comments and suggestions were invaluable. They helped me to separate the wood from the trees.

I am grateful to Professor Jaana Sandström, who helped me at the start over ten years ago. She was explaining in one of her lectures how net present valuation works. She caught my attention when she said: "There is no 'Mandrake the Magician' (*fin* Taika-Jim) to estimate [cash flows] over a ten-year period." Her metaphor had a great influence on this dissertation.

I have been privileged to work with really smart and hard-working people throughout my years at the university. Countless fruitful discussions with various colleagues have enlightened my worldview. I wish to thank all my colleagues in the TBRC and Nordi research centers.

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Tytti, my beloved wife: thank you for your unquestioning faith in me. During all these years you believed we would see this day. I'm looking forward to working together on our joint projects in the future!

*Writing is a thinking process.  
Thinking is about concentration.  
Concentration is a state of mind.  
The state of mind looms in writing.*



*Jan Edelmann  
on a Sunny Day on May 20, 2011*

*Open your mind*  
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### PART II – Publications



## **THIS DISSERTATION CONSISTS OF THE FOLLOWING RESEARCH ARTICLES:**

1. Edelmann Jan, Kyläheiko Kalevi, Laaksonen Petteri and Sandström Jaana (2004). "Facing the future: competitive situation in telecommunications in terms of real options". Published in IAMOT 2002 book Internet Economy: Opportunities and Challenges for Developed and Developing Regions of the World, ISBN: 0080442145, Elsevier Science Ltd, 2004, pp. 69-82.
2. Edelmann Jan, Koivuniemi Jouni, Laaksonen Petteri and Sissonen Antti (2003). "Decision making process combined with strategic options approach in innovation proposal selection". Published in the proceedings of The R&D Management Conference 2003, ISBN: 0954001648 (Compact Disc), Implementing the theories of R&D management – advancing the state of the art, Manchester, Great Britain, 8 p.
3. Edelmann Jan (2004). "A strategic investment case in wood procurement in Finnish paper industry: real options perspective". Published in the proceedings of the 11th annual EUROMA conference: Operations Management as a Change Agent, INSEAD, Fontainebleau, France, pp. 165-173.
4. Edelmann Jan, Bergman Jukka and Jantunen Ari (2005). "Managing R&D with normative scenarios". Published in the International Journal of Foresight and Innovation Policy (IJFIP) 2005, vol. 2, no. 1, pp. 69-83.
5. Edelmann Jan and Sintonen Sanna (2006). "Adoption of electronic invoicing in Finnish SMEs: two complementary perspectives". Published in the International Journal of Enterprise Network Management (IJENM) 2006, vol. 1, no. 1, pp. 79-98.

## **THE CONTRIBUTION OF THE AUTHOR TO THE PUBLICATIONS**

1. Joint author. Responsible for the collection and analysis of the case material and the presentation of the real options framework.
2. Main author. Coordinated the writing of the paper, wrote most of the manuscript, and built and tested the presented model.
3. Sole author.
4. Main author. Coordinated the writing of the paper. Wrote most of the manuscript, excluding sections 2.2, 2.3 and 4.1. The main creator of the model. The development of the model and the analysis of the results were carried out in collaboration between the author and the co-authors.
5. Main author. Made the research plan and coordinated the collection and analysis of the data, and the writing of the paper. Wrote most of the paper.



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## **LIST OF ABBREVIATIONS**

Acronym	Definition
AHP	Active Hierarchy Process
ANP	Analytic Network Process
B-S	Black and Scholes
DCF	Discounted Cash Flow
ICT	Information and Communication Technology
NPD	New Product Development
NPV	Net Present Value
R&D	Research and Development
RO	Real Options
ROA	Real Options Approach
ROV	Real Options Valuation
SMEs	Small and Medium Enterprises
SNPV	Strategic Net Present Value
SOA	Strategic Options Approach
STAR	Strategic Technology Assessment Review

## **PART I: OVERVIEW OF THE DISSERTATION**



## **PREFACE**

This study has its roots in a research project (New Business Models Arising from the Convergence of the e-Business and Mobility in the USA and Europe, 2001-2004) aimed at identifying new business opportunities related to the convergence of Internet and wireless technologies. Various ways of generating new ideas were used, of which the most important were the innovation sessions that proved to be effective in fostering opportunity recognition and idea creation.

During these one-day-sessions groups of five to ten company representatives collected between fifty and one hundred ideas, and assessed their importance to the business of each industry in question. Roughly ten percent of the ideas involved a new business model or were perceived to be strategically important. The rest of them were mostly incremental, having a direct link to existing products or services.

We observed that many of these strategically important ideas were very difficult to assess. Future events seemed to be too far away to make predictions about which ideas would be worth investing in. The difficulty in analyzing the initial ideas was most often related to the uncertainty concerning the future outcomes. Even if the decision makers intuitively perceived an idea as great, substantiating the perception was much more difficult.

The emerging real options research tradition and the researcher's experiences of weaknesses in valuation systems triggered the idea that future-related, strategically important innovation investment ideas could and should be evaluated by means of the real options approach. This idea motivated and drove this dissertation.



## 1. INTRODUCTION

The dissertation is positioned within the field of strategy and innovation research. It examines *how an options-based theory can be utilized in finding and defining new innovations* and addresses the question of *how the strategic options approach, an extension of real options theory, enhances understanding of perceived innovation opportunities (i.e., innovation ideas) in conditions of pervasive uncertainty*. The key argument is that *the approach facilitates the strategic management of innovation investments under high uncertainty*.

### 1.1. Research motivation

Innovation is seen as a source of economic growth and organizational success in the knowledge-based economy (Lawson & Samson, 2001; Baumol, 2002). When it comes to investing in innovation, in something truly new, and “seizing the opportunity” (Teece, 2007), firms often have difficulties evaluating the potential and the sustainability of radical ideas for their future business strategy (Miller & Morris, 1999; Grant, 2003). Invented ideas may be complex<sup>1</sup> and uncertain due to a high dependence on the long and winding development paths of the future, and many other interrelated aspects (e.g., the strategic moves of rivals). Thus, it is difficult to recognize a potential innovation’s significance and value simply because there is not enough information available.

Most management practices originate in neoclassical investment theories that help investors to make exact calculations of future profitability (e.g., Pindyck, 1991; Farranger et al., 1999; Ryan & Ryan, 2002). However, conventional intertemporal pricing systems do not work for complex and long-lasting innovation projects (Myers, 1984; Kasanen, 1986; Sharp, 1991). Traditionally, far-reaching, innovative business ideas are treated like any other investment ideas on the decision-making level. Decisions are strongly based on static discounted cash flow (DCF) valuation systems such as net-present-valuation (NPV). Unfortunately, these systems are incapable of evaluating investments that are highly risky and take place far ahead in the future (e.g., Sharp, 1991; Trigeorgis, 1993a; Trigeorgis, 1996). They cannot capture the value of future opportunities under high uncertainty because they ignore the firm’s growth-generating potential, for instance, in the form of learning or other options (Dixit & Pindyck, 1995; Trigeorgis, 1996; Scarso, 1996; Campbell, 2001).

Formalized methods such as “logically-justified, error-free and ‘right first time’ analytical cognition” do not work as they should when the problem is ill-defined and ill-structured (Hodgkinson et al., 2009, p. 290), thus intuition (subconscious cognitive frameworks, mental models or pattern recognition) and judgment are often used in strategic innovation-based decision-making (Bazerman, 2002; Baron, 2006). Examples of more formal and systematic approaches include scenario methods (Masini & Vasques, 2000), and information-collection methods such as Delphi (Linstone & Turoff, 1975) and Peste analysis. All of these have been used to clarify complexity and overcome the defects of investment-management systems and intuition, but they have not thus far proved to be a workable solution to investment-decision-making problems under high uncertainty.

Options-based methods have been put forward as a potential solution to this problem with regard to highly uncertain investment objects (Hubbard, 1994; Anderson, 2000). The basic tenets of theories of financial options (Black & Scholes, 1973; Merton, 1973) were applied to real assets, called real options (Myers, 1977; McDonald & Siegel, 1986), with a view to easing managerial decision-making concerning real investments (Trigeorgis, 1993a; McGrath

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<sup>1</sup> Complexity refers to “a large number of parts that interact in a non-simple way” (Simon, 1969, p. 195).

& MacMillan, 1997). The real options approach offers managerial applications that make it possible to analyze issues that are beyond the scope of conventional cash-flow-based investment methods (e.g., Amram & Kulatilaka, 1999), and sometimes to evaluate investments that incorporate managerial flexibility and opportunities. However, there are many problems.

## 1.2. Research gap

The research gap addressed in this thesis originates from two main sources. *First*, the use of the real options approach has been primarily limited to investments in market-priced real assets. Most of the literature thus far concentrates on option valuation, neglecting the most important aspects in strategic terms. Unique and strategically significant real investments (such as in future innovations) do not fit into the narrow limits of the pricing schemes that presuppose efficient (i.e., thick) markets for underlying assets and the known distribution of future uncertainties (see, e.g., Miller & Park, 2002). Interestingly, the strategic aspect of the options approach has received far less attention, even if it clearly extends the thinking and provides an analytical framework for the proactive management of uncertainties, which is to the firm's advantage in the long run.

Sanchez (1993), either on purpose or intuitively, introduced the idea of strategic options, which give firms the flexibility to respond to the changing environment. Later, some studies on real options referred to the exploration of strategically important investment decisions as strategic options analysis (Foss, 1998; Slater et al., 1998; Andersen, 1999). Perlitz et al. (1999) identified strategic real options and operative real options as two different option types, but did not offer any explanation for this distinction. Surprisingly, this view on strategic real options has attracted little attention or interest among academics.

*Second*, strategic planning and project (idea) selection are considered the most critical issues in innovation management (Scott, 2000), and new methods are being sought (Lawson et al., 2006). Despite the fact that a great number of management methods have been developed (Porter et al., 1991; Martino, 1995), there is a lack of simple and flexible methods for evaluating complex and far-reaching investment ideas.

The adoption of the options perspective has not taken place as anticipated, and many researchers report a lack of practical solutions and their wider application (Mokenela, 2006; Weeds, 2006; Reuer & Tong, 2007; Krychowski & Que, 2010). It seems from the empirical evidence that the use of real-options-based tools has been inhibited by a "lack of top management support" and "require[ment of] too much sophistication" (Block, 2007, p. 265). Instead of being easier to use, they are often even more difficult because of over-complicated options valuation.

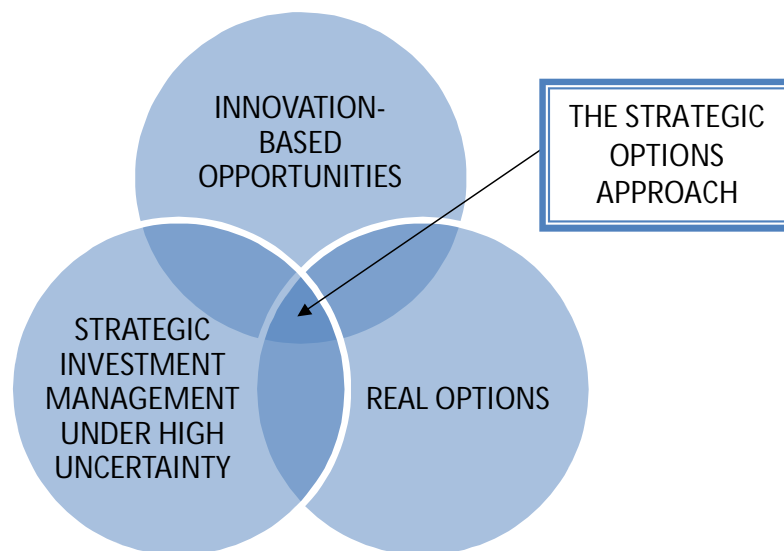
Lander and Pinches (1998) combine these two problems as follows: "there is a need for alternative modeling and valuing frameworks that may be less precise but are more readily implementable for real option analyses to move out of the academic world and become the decision-making frameworks employed in practice".

The aim in this thesis is thus to narrow the defined research gap by extending the research on real options to issues of strategic innovation management, and to identify ways of using the theory in the management of innovation investment. The view adopted is the strategic options approach. It focuses on complex and strategically important innovation-investment opportunities, and largely ignores exact, quantitative option valuation. The focus and objectives of the study are defined more specifically in the following section.

### 1.3. The focus and objectives of the study

The main aim of the study is to shed light on how management can evaluate future-related strategic-innovation ideas, and adopt options-based methodology in finding and defining new innovation opportunities. It is explored the strategic options approach as a method for finding and defining new innovations in conditions in which future markets are not efficient or are even non-existent. Options-based frameworks are therefore constructed and introduced in the publications that comprise part of the thesis.

A further aim is to provide firms with tools that facilitate the exploitation of future business opportunities. In brief, the objective is to enhance knowledge of the strategic options approach in relation to innovation-related investment opportunities under conditions of prevalent uncertainty and complexity, and to give a new perspective on the theoretical discussion (Figure 1).



**Figure 1: The focus area of the study**

The main research question, which is addressed in different innovation cases, is as follows:

- *How does the strategic options approach facilitate the exploitation of perceived innovation opportunities (i.e., ideas) under conditions of pervasive uncertainty?*

In addressing this question I divided it further into the following three sub-questions:

1. *What are strategic (real) options?*
2. *How can ideas about future-related innovations be assessed in terms of strategic options?*
3. *How can the strategic options approach be applied to finding, defining, and evaluating new innovations?*

I believe that answering these research questions represents a modest attempt to enhance theoretical and managerial knowledge of strategic management, real options, and innovation research. The set of objectives are examined more thoroughly in the publications comprising Part II of the dissertation, the aim of which is to provide new theoretical and empirical insights into the literature on strategic options. The main contributions of this dissertation are the following:

CONTRIBUTION
1. The distinction between real options and strategic (real) options
2. A method for valuing strategic options
3. The use of the strategic options approach in finding and defining new innovations

#### 1.4. Outline of the study

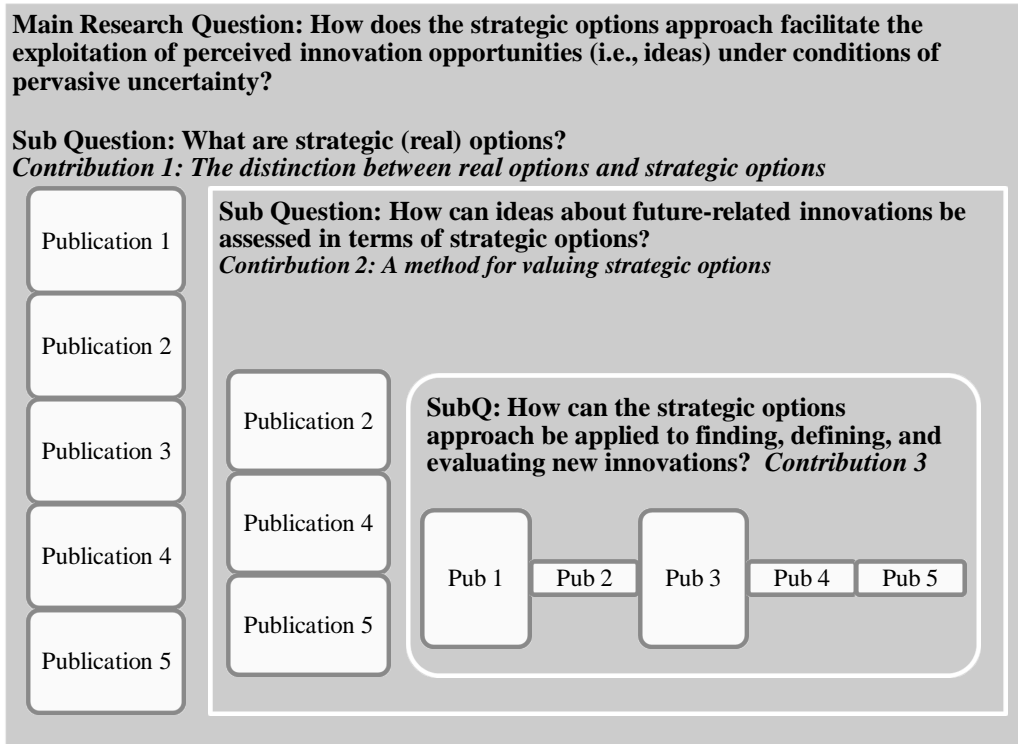
This dissertation is divided into two parts (Table 1). The first part introduces the research topic and the second part comprises five research publications, of which two are published in double peer blind-reviewed academic journals, one in a refereed conference book of selected papers, and two in refereed conference proceedings.

**Table 1: The structure of the dissertation**

<b>PART I</b>		<b>PART II</b>	
<b>1. Introduction, Motivation and Research questions</b>		<b>Presents five research publications published in academic arenas</b>	
<b>2. Theoretical background</b>			
<b>3. Research design and methodologies</b>			
<b>4. Summary of the publications</b>			
<b>5. Key results</b> Answering the research questions Theoretical contributions Managerial implications Discussion and conclusions			

Part I of the dissertation comprises five chapters. The first Chapter presents the background and motivation for the research, the research objectives, the structure of the study, and the assumptions and limitations. The second Chapter gives the theoretical background and identifies the discussion to which this study will contribute. Chapter 3 describes the research design and methodologies used, and Chapters 4 and 5 summarize the publications and the main results. The final Chapter discusses the theoretical and managerial contributions of the study, and the limitations, and launches further research ideas.

Part II consists of five publications. All of the papers have been reviewed and are published in academic journals, books or conference publications. The papers are presented chronologically, thus following the order of the research process. The research questions covered in the publications are set out in Figure 2 below.



<b>Publication 1</b>	Facing the future: competitive situation in telecommunications in terms of real options
<b>Publication 2</b>	Decision-making process combined with strategic options approach in innovation proposal selection
<b>Publication 3</b>	A strategic investment case in wood procurement in Finnish paper industry: real options perspective
<b>Publication 4</b>	Managing R&D with normative scenarios
<b>Publication 5</b>	Adoption of electronic invoicing in Finnish SMEs: two complementary perspectives

**Figure 2: The linkage between the research questions and the publications**

## 1.5. Assumptions and limitations

The study is strongly influenced by the existing theories of strategic management, strategic investment decision-making, and real options. Other theoretical foundations of high significance include the theory of the firm (e.g., Coase, 1937; Holmström & Tirole, 1989; Langlois & Foss, 1999), ideas on the growth of the firm put forward by Penrose (1959), the resource-based view developed by Wernerfelt (1984), Rumelt (1984), Barney (1991), and Peteraf (1993), and the dynamic capability view launched by Teece et al. (1997). Each of these theoretical approaches had a profound effect on this research, but deeper discussion on these lies beyond the focus of the thesis.

The main assumptions concerning innovation and strategic investments used in this study are the following:

- Firms that sense and recognize new business opportunities are able to create ideas for new products, services, processes and business models if they have the capability to obtain and utilize old and new bits of knowledge.
- Highly uncertain innovation ideas are the firm's strategic investment opportunities that are analyzed here. Such ideas can pave the way to future innovations, which are valuable only if they can be executed successfully in financial terms in the long run.
- Investments in innovation come from research and development (R&D) activities that are considered strategic. From this perspective, R&D creates new information and ideas for future innovations.
- Strategic investments help firms to achieve long-term goals and to sustain or reinforce their competitive position. Such investments are considered from the perspective of a firm of any size that aims at profiting in the business environment in the long run via unique innovation ideas. Operational investments are not analyzed.
- Strategic investments in innovation represent future opportunities and assets in competition against other companies, thus offering new sources of competitive advantage and profit (discussed in more detail in Chapter 2.1).
- Strategic investments in innovation are made under conditions of pervasive uncertainty (discussed in more detail in Chapter 2.4).
- Uncertain innovation ideas are treated as strategic investment objects. The focus is on single rather than portfolios of innovation ideas.



## **2. THEORETICAL BACKGROUND**

This chapter gives the theoretical background and explains the essential concepts used in the research in more detail than is possible in scientific publication arenas given the limited space. I will begin with the four main concepts, innovation, knowledge, uncertainty and investment. Section five deals with options theory and introduces the terminology, and the basic concepts. The final section focuses on strategic opportunities.

### **2.1. Innovation, competitive advantage and profit**

Innovation seems to be a major source of competitive advantage in dynamic environments such as the knowledge-based economy of today, and thus to generate higher profits, on average, than the existing repertoire of products and services (e.g., Barney, 1986; Bettis & Hitt, 1995; Mahoney, 1995; Winter, 1995; Quinn, 2000; Nobelius, 2004; Teece, 2007).

Competition between firms tends to decrease above-average profits to the level of other trades over time (Smith, 1776, p. 48). However, as long as the firm is the sole possessor of its innovation, it is able to enjoy temporary Schumpeterian monopoly advantages in the form of above-average profit (e.g., Baumol, 1993, p. 6; Winter, 1995), for example. When rivals discover the higher profits or profit potential of the innovation they try to replicate the value-creating resources. The rate of competition and the effectiveness of protection mechanisms (i.e., the tightness of the appropriability regime) mainly determine how long this profit opportunity will last (see, e.g., Arrow, 1962; Teece, 1986; 2000; Jones et al., 2000; Teece, 2006; Kyläheiko et al., 2010). Firms therefore constantly need to seek new sources of competitive advantage and profit.

Sources of innovation include unexpected events, technological change and/or changes in consumer preferences or in regulations (Rumelt, 1984; Barney, 1995). Firms that sense and are aware of potential new opportunities can differentiate themselves from other market players by creating something that does not yet exist, in other words innovations responding to perceived market opportunities. In this context, a firm wishing to generate higher innovation-based profits than its competitors needs to invest in the creation of new bits of knowledge concerning future business opportunities, in other words in future-related innovations. Thus, alert, proactive, and innovative firms will recognize new business opportunities and create new ideas (i.e., new knowledge) based on business models, products, processes, and services (Kirzner, 1997; Gaglio, 2001; Park, 2005).

### **2.2. Knowledge as a commodity**

The creation of new knowledge is one of the primary processes through which companies find ideas for new products, services, business models, and profit-generating strategies (Foray, 2004). Firms are repositories of productive knowledge (Kyläheiko et al., 2002) and specialize in its coordination and accumulation (Kogut & Zander, 1993), doing it more successfully than open markets (Kogut & Zander, 1992) in the economic environment. Further knowledge is accumulated by building on the existing knowledge base through cumulative learning and specialization (Harris, 2001; Saarenketo et al., 2004).

Knowledge is a commodity with special characteristics and distinct forms. It is an inherently abundant resource and its value does not deplete with use. The literature on strategic management typically classifies knowledge in four categories: tacit, codified, firm-specific (localized), and generic (often scientific) knowledge (Polanyi, 1967; Winter, 1987; Cowan et al., 2000; Grimaldi & Torrisi, 2001; Foray, 2004; Kyläheiko et al., 2011).

Tacit and codified pieces of knowledge are regarded as the ends of the knowledge continuum, and firm-specific and generic knowledge are placed in between. Codified (and articulated) knowledge is usually in the form of a manual or a blueprint, which is easy to copy and transfer but hard to protect. On the opposite end of the continuum is tacit knowledge, which is embedded in organizations, teams, or individuals and is thereby more difficult to transfer and replicate but easier to protect. Table 2 below lists the different characteristics of knowledge.

**Table 2: The idiosyncratic nature of knowledge**

	<b>TACIT KNOWLEDGE</b>	<b>FIRM- SPECIFIC KNOWLEDGE</b>	<b>GENERAL OR CONTEXT- SPECIFIC KNOWLEDGE</b>	<b>CODIFIED KNOWLEDGE</b>
<b>Embodied in</b>	Individuals, teams and/or the whole organization as skills, habits, routines and capabilities	The organizational culture in the form of organizational routines and capabilities	The databases of a scientific community, for instance	Manuals, written texts, blueprints or digitalized pieces of information
<b>Structure</b>	Unstructured		Structured	
<b>Transferring</b>	Hard	Fairly hard	Fairly easy if there is absorptive capacity <sup>2</sup>	Easy
<b>Appropriability</b>	Easy to protect	Fairly easy to protect	Fairly hard to protect	Very hard to protect
<b>Cost of articulating and replicating</b>	Expensive	Quite expensive	Quite inexpensive	Inexpensive
<b>Source of competitive advantage</b>	Primary sources		Complementary sources	

*Tacit knowledge*, or ‘know-how’, is embodied in personal or team skills, is unstructured, and can, in part, be transferred through personal contacts (Nelson & Winter, 1982; Winter, 1987; Haldin-Herrgard, 2000). The holder of this type of (procedural) knowledge asset knows how, or at least has the skills, to perform the given tasks or solve the given problem, but does not necessarily understand the reasons behind it (Grimaldi & Torrasi, 2001). Tacit knowledge has inherently strong appropriability and it cannot easily be transferred or imitated. Know-how is typically associated with routines or procedural rules that can be shared by learning and

<sup>2</sup> Absorptive capacity refers to “the ability of a firm to recognize the value of new, external information, assimilate it, and apply it to commercial ends” (Cohen & Levinthal, 1990:128).

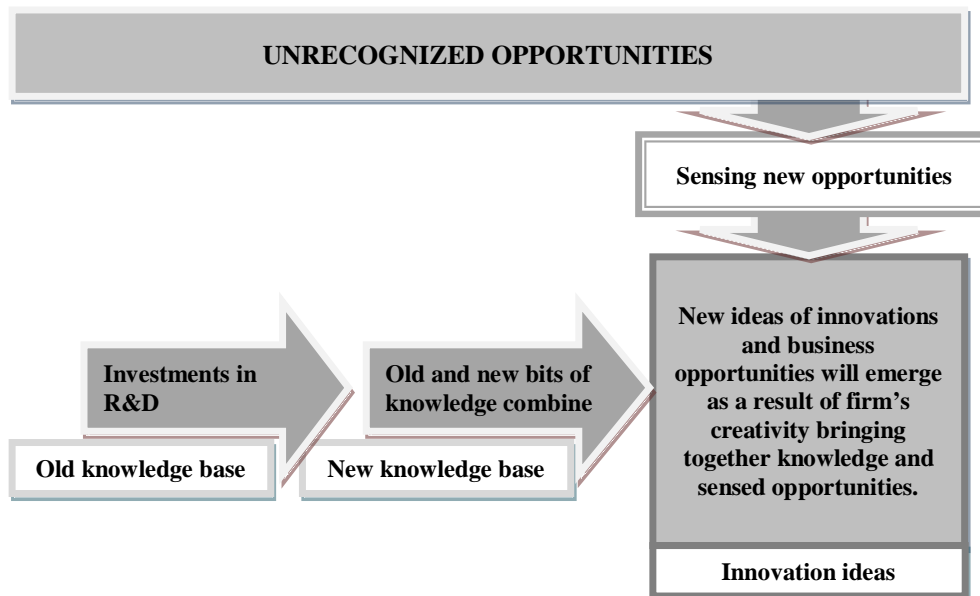
imitating rather than with the help of written guidelines (Torrise, 1998; Grimaldi & Torrisi, 2001). The markets for know-how are necessarily imperfect, and for that reason firm-specific knowledge has to be created independently or in collaboration with partner firms through licensing or making acquisitions: the difficulty lies in transferring this type of knowledge (Blomqvist et al., 2002; Kyläheiko, 2006). The creation of tacit knowledge can take a huge amount of time and other resources, and thus is a significant entry barrier (Barney, 2002).

*Codified knowledge*, or ‘know that’, is usually classified as a written form of knowledge with a structure (Haldin-Herrgard, 2000). Fully codified (and articulated) bits of knowledge can be infinitely re-used at zero marginal cost, and can be copied and transferred easily. Codified knowledge is a non-rival good<sup>3</sup> that can be used and possessed by many economic entities when once produced. It is not exclusive, and can spill over even if property rights are held. In other words, it is non-excludable, and once revealed the producer has no means of preventing others from having access to it without charge. When this happens, the exclusive right to it is lost, meaning that it is very difficult to stop its use once it is in the public domain. If codified knowledge is to remain with the possessor there have to be strong measures of appropriability. The best solution is to keep it in isolation (maintain secrecy) or to use legal protection (such as patents, copyrights, or non-disclosure agreements).

New innovation ideas arise from a combination of old and new knowledge that investments in R&D generate (Figure 3). R&D produces new information and enhances the firm's ability to assimilate it into existing information (Cohen & Levinthal, 1989). From this perspective, a firm's knowledge base could be described as its “portfolio of options, or platforms, on future developments” (Kogut & Zander, 1992). Every new piece of knowledge facilitates the recognition of existing opportunities and the creation of new ones. As a result, new business ideas emerge as a combination of ‘creativity’ capabilities and the knowledge the firm possesses (Amabile et al., 1996; Gurteen, 1998), which connects them to the opportunities awaiting recognition (Bowman & Hurry, 1993).

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<sup>3</sup> Rivalry and excludability are key attributes that distinguish different types of economic goods (Nelson & Romer, 1996).



**Figure 3: R&D investment as a driver of innovation opportunities**

The more tacit and rare pieces of knowledge and ideas R&D produces, the better the competitive advantage it brings to the firm. Knowledge may be the primary or a complementary source of competitive advantage, but it must be supported by a strong appropriability regime (Teece, 2000). Moreover, as long as a piece of knowledge has not become obsolete, it has value in the market and can be used to create competitive advantage. For instance, companies with the know-how to sense and process weak signals of future businesses (and articulate them as ideas) are likely to achieve competitive advantage over rivals that do not have that skill. In such a case the firm can be proactive in facing the future by obtaining the necessary competences and resources.

Initial R&D-related ideas are very often tacit in nature. Often innovators may not be able to articulate them fully, or then some important bits of knowledge are missing. An innovation is the result of the innovator's ability to resolve complexity and uncertainty, and also to generate new, unexpected events in the environment. The complexity of the ideas (and the inability to express them) offers natural protection and rare business opportunities. The idea generation that leads the innovation process (see, e.g., McAdam & McClland, 2002) could be characterized as pervasive uncertainty, meaning (i) a lack of necessary and complete information, and (ii) the limitations of the decision maker's computational and cognitive capabilities with regard to interpreting the information (Dosi & Egidi, 1991). It makes the evaluation of ideas very difficult because of missing information, and is usually perceived as uncertainty or risk. It is worth pointing out here that most evaluation methods cannot handle imprecise levels of knowledge, and thus it is crucial to understand the kind of knowledge and uncertainty types that are involved. The concept of uncertainty, which is closely connected to the concept of knowledge, is discussed in the next section.

### 2.3. Uncertainty

There is a range of multiform and nuanced, partially overlapping and interdependent definitions of uncertainty as a concept, which has made its use somewhat problematic in the evaluation of investment opportunities. Given that technological development and innovation often take place in conditions of prevalent uncertainty and complexity, however, the terminology requires clarification.

Pascal and Fermat's (1654) discussion of the problem of mathematical risk (in the case of a dice game) could be considered the first modern endeavors in this field. Knight's (1921) categorization is probably the most well-known and frequently used typology of uncertainty for strategic management, and distinguishes risk from uncertainty. Knight defined risk as (quantitative) "measurable" uncertainty and uncertainty as (non-quantitative) "unmeasurable" uncertainty when only partial knowledge of outcomes such as beliefs and opinions are available (Knight, 1921)<sup>4</sup>.

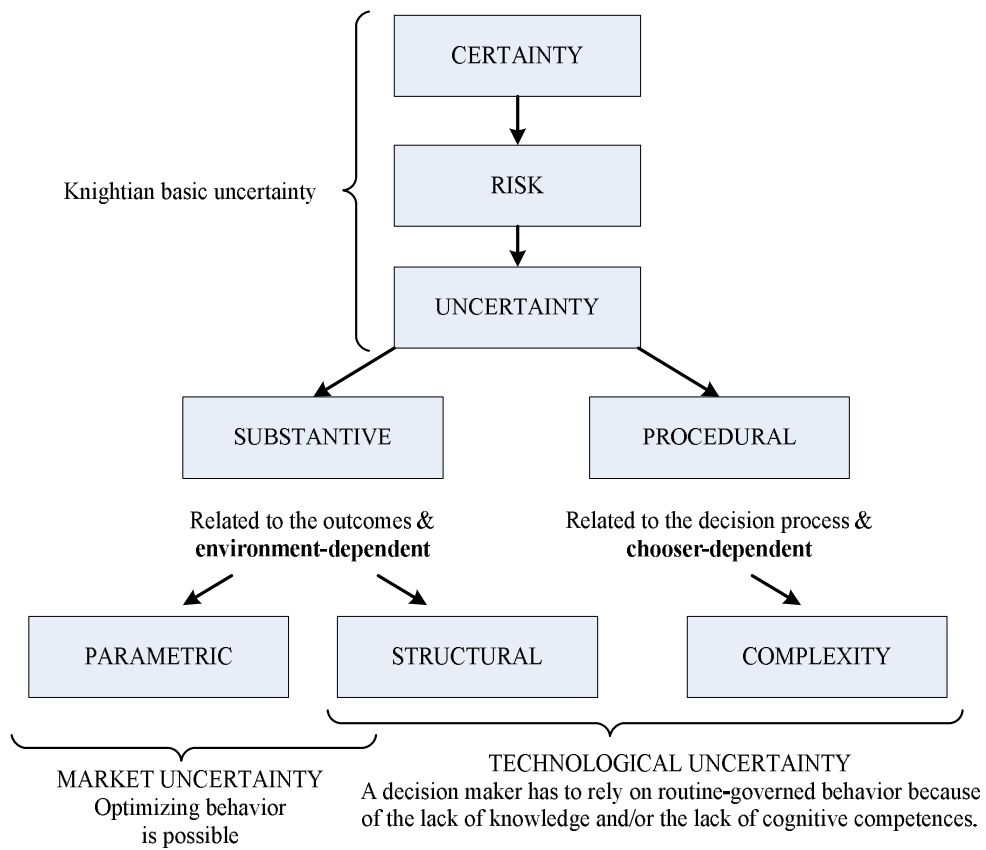
The literature on strategic management often refers to technical uncertainty (Dixit & Pindyck, 1994) and market uncertainty (Ansoff, 1965; Ansoff & McDonnell, 1988), and sometimes also to profit-flow uncertainty (Dixit & Pindyck, 1994) and environmental uncertainty (Bowman & Hurry, 1993). However, these types of distinction focus only on the subject of the uncertainty regardless of the cause.

Koopmans (1957) distinguishes between primary uncertainty, which arises from environment-related random events and unpredictable changes over which the decision maker has no power, and secondary uncertainty that comes from decision makers' lack of knowledge of the possible actions of others. He is referring to exogenous and endogenous uncertainty, respectively. The decision maker has no power over exogenous uncertainty, but can affect endogenous uncertainty (which in this case is connected to the learning capabilities and absorptive capacity of the firm). Exogenous uncertainty is thus largely unaffected by the actions of the firm and is mainly resolved over time, whereas endogenous uncertainty is related to its learning inputs (Folta, 1998).

Dosi and Egidi (1991, pp. 145-146) introduce the concepts of substantive and procedural uncertainty, which are analogous to Simon's (1976) rationality concepts. Substantive uncertainty derives from the "incompleteness of the information set", and is related to a "lack of information about environmental events" and "all the information which would be necessary to make decisions with certain outcomes". Procedural uncertainty, in turn, arises "from the inability of the agents to recognize and interpret the relevant information, even when available." It "concerns the competence gap in problem-solving" and relates to "limitations on the computational and cognitive capabilities of the agents to pursue unambiguously their objectives, given the available information".

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<sup>4</sup> It is worth noting that Knight's terminology is not as clearly presented in his writing and is often misrepresented. Langlois and Cosgel (1993) give a clear analysis of the concepts in their paper.



**Figure 4: Forms of uncertainty (Kyläheiko et al., 2002:76, explanations extended from original)**

In my view, this classification (see Figure 4) of uncertainty as *parametric* and *structural* (i.e., environment-dependent) and *procedural* (i.e., dependent on the decision maker) provides a useful perspective on the categories that are relevant to decision-making in the context of innovation investment (Langlois, 1984; Dosi & Egidi, 1991; Kyläheiko, 1995; Kyläheiko et al., 2002). In each of these categories the decision maker has a different amount of knowledge about the state of the world and its events, and therefore different kinds of resources to cope with uncertainty. Uncertainty may also be radical when all the pieces of knowledge are imperfect, and there is no knowledge about the structure or probabilities of future events (Loasby, 1976; Kyläheiko, 1995). This is typical of far-reaching innovation ideas. Table 3 explains the distinction between certainty and radical uncertainty in more detail.

**Table 3: On defining uncertainty (adapted from 1: Kyläheiko, 1995; 2: 1998, pp. 323-324)**

	<b>Certainty</b>	<b>Risk</b>	<b>Parametric uncertainty</b>	<b>Structural uncertainty</b>	<b>Procedural uncertainty / complexity</b>	<b>Radical uncertainty</b>
<b>The knowledge the decision maker holds related to the decision problem.</b> <sup>1</sup>	Every piece of relevant knowledge is known.	The future states and the structure of the decision situation are known. The probability of each future event is objectively known.	The future structure is known. The probability parameters are not certain.	Imperfect knowledge of the potential future structure.	Knowledge of the decision maker's cognitive ability is imperfect.	All pieces of knowledge are imperfect, sometimes even close to ignorance.
<b>Knowledge of the occurrence probabilities of possible states of the world, possible actions and consequences.</b> <sup>1</sup>	Complete knowledge.	Objective knowledge of probabilities.	Subjective degrees of belief as to the probabilities of events and the consequences of individual actions.	Subjective beliefs.	Incomplete knowledge about events.	No knowledge at all.
<b>With uncertainty isolation terms.</b> <sup>2</sup>	(i) Parametric, (ii) structural and (iii) procedural types of uncertainty are idealized to be nil, and all the events are assumed to be (iv) known and (v) independent of the choices and actions.	Retains assumptions (i)-(iii) and (v) but replaces perfect knowledge (iv) with (objectively) known probabilities of the events.	Assumptions (ii), (iii) and (v) are retained but the probabilities of the events (i) are supposed to be based on subjective degrees of belief.	Assumptions (i), (ii), (iv), and (v) can be relaxed but the idealizing procedural certainty assumption (iii) is retained.	Procedural certainty assumption (iii) leads to procedural uncertainty (complexity). Other assumptions play no role in this category.	Finally, when all the assumptions (i-v) are relaxed, it is a question of radical uncertainty.

When companies are considering new innovative business ideas they often experience either procedural or radical uncertainty, especially with ideas that could be considered strategic investments. This puts the firm into the area of the unknown. It may even face radical uncertainty, and often the only guideline for decision makers is unarticulated tacit knowledge. There is thus a great danger that ideas will be turned down in conditions of severe uncertainty (i.e., a severe lack of knowledge), and/or that investments will be wrongly allocated. This puts traditional investment decision-making in trouble: either there are no attributes available, or those that are to be used for evaluation are beyond the limits of the decision maker's knowledge. The concept of investment is discussed in a relation to the concept of uncertainty in the next section.

## **2.4. Investments and uncertainty**

Investment is a commitment of resources for future profit generation (Briston & Liversidge, 1979). An objective-based classification (Table 4) clarifies the distinction between *operating investments* (e.g., investments for the purpose of cost reduction), *expansion investments*, and *strategic investments* (Kasanen, 1993). There is a clear relation between different investment types and uncertainty categories. The degree of uncertainty seems to increase the more it is a question of strategic investments. Operating investments are often made in conditions of near certainty: if a machine is not working and the repair costs are higher than the replacement cost, the investment decision is rather easy to make. Of course, a long payback time requires long-lasting cash flows or a market for investments. Neglecting statutory investments may lead to additional costs such as conditional fines. On the other end of the continuum, investments in basic research are costly, and most of them do not yield any profit.

**Table 4: An objective-based classification of investments and uncertainty**  
(adapted from Kasanen, 1993; Maccarone, 1996)

INVESTMENT CATEGORY	INVESTMENT OBJECTIVE	THE NATURE OF UNCERTAINTY	
Operating investments	Compulsory investments (according to specific laws)	Close to certainty or risk.	C E R T A I N T Y
	Investments in existing business: • Replacement investments  • Rationalization investments aimed at modifying the firm's competitive positioning (cost reduction, quality/service improvement, flexibility, etc.)	Uncertainty is parametric in nature.  Uncertainty is structural in nature.	
Expansion investments	• Expansion investments (internal growth)  • New product investments	Uncertainty is structural or procedural in nature.	
Strategic investments	Acquisitions	Uncertainty is major and often structural and procedural in nature.	U N C E R T A I N T Y
	Investments in new business areas		
	R&D investments	Uncertainty may even be radical in nature. The investment decision-making becomes difficult and the probability of losses is high. However, the payoff potential is also high.	

When strategic investments are in future innovations it is difficult or impossible to calculate the expected rate of return beforehand. Such investments are often termed 'faith-alone' investments, and are decided at top-management level. The benefits are expected to spread over many phases of the firm's activities and to stretch into the distant future, and the main objective may be "a strategic defense or attack" (Dean, 1951; Kasanen, 1993). Large-scale investments (or giga-investments, Carlsson & Fullér, 2003; Collan, 2004) are often considered strategic investments that are highly irreversible and uncertain in nature.

Strategic investments could also be regarded as collections of embedded options, the exercise of one option often creating new ones (Slater et al., 1998). The value of spawning projects such as investments in a new technology platform lies in the potential growth opportunities or

options (Kasanen, 1986; Brabazon, 1999). Investments may be aimed at helping firms to achieve long-term goals and sustain or reinforce their competitive position through the development of new product-market activities and the capabilities to ensure more sustainable performance (Marsh et al., 1988; Butler, 1993). Strategic investments can create built-in strategic options and flexibility. For instance, investments in R&D may lead to valuable follow-on contingent investment opportunities. However, it is impossible to be absolutely (or in any way) certain about the outcomes of these investments beforehand.

## 2.5. Idea selection

Idea selection is a crucial part of the firm's fuzzy front end and investment decision-making (Koen et al., 2002; Koivuniemi, 2008), the aim being to come up with ideas that are valuable. In this phase the firm considers the feasibility of each idea in terms of organizational fit, market fit, technological fit and strategic fit (Shum & Lin, 2007; Koivuniemi, 2008; Kurkkio, 2011).

There are dozens of different screening methods aimed at cutting down the number of ideas, which can be grouped in categories in accordance with method logic (Henriksen & Traynor, 1999; Verbano & Nosella, 2010). Each category contains examples of the methods and the authors who have studied them:

- Mathematical methods: Linear, Non-linear, and Integer linear programming, Goal and dynamic programming, Fuzzy sets; (Büyükoğkan & Feyzolu, 2003)
- Economic methods: Present value index, Net present value, Internal rate of return, Expected Net present value, Calculation of specific economic indices, real options; (Schneider et al., 2008)
- Decision analysis: Active Hierarchy Process (AHP), Analytic Network Process (ANP), Multi Attribute Utility Technique (MAUT), Decision trees; (Meade & Presley, 2002; Cho, 2004)
- Interactive methods: Delphi, Q.sort, Group decision techniques; (Elfvingren et al., 2009)
- Scoring methods: Check lists, Scoring algorithms, Intellectual Capital Scorecards; (Rengarajan & Jagannathan, 1997; Henriksen & Traynor, 1999; Cooper et al., 2001; Huchzermeier & Loch, 2001; Baier et al., 2008)
- Strategic models: Boston Consulting Group matrix, Strategic buckets; (Chao & Kavadias, 2007)
- Portfolio optimization: bubble diagrams; (Chien, 2002; Mathews, 2010)
- Stage-Gate, Funnel; (Cooper et al., 2000; Cooper et al., 2001; Huchzermeier & Loch, 2001)
- Unstructured methods: Intuition, Experience, Peer review; (Feng et al., 2011)

Various methods and models are often used in combination because different ones serve different purposes. Scoring is often utilized as a preliminary tool for screening the ideas because of its ease of use compared with many other models and methods (Henriksen & Traynor, 1999). Most of the above-mentioned methods are considered too heavy for large numbers of ideas. Of the many idea-screening alternatives available, this study concentrates on the real options method.

## 2.6. Option theories and the basic concepts

### 2.6.1. Financial options

According to previous work, option prices are determined “by discounting the expected value of the stock at the expiration date using arbitrary risk premiums as a discount factor that were to reflect the volatility of the stock” (Brach, 2003:20). Black and Scholes (1973) were able to remove these arbitrary parameters in their presentation of a method and complete formula to determine the value of derivatives concentrating on pricing financial options (options on stock shares). Merton (1973) further developed the B-S model, extending it to take dividend payments into account.

The original B-S formula calculates the theoretical option value, in other words the current value of the expected payoff under the risk-neutral measure under the assumption of no dividend payments, taxes, or transaction costs. Merton’s (1973) modification incorporates dividends ( $\delta$ ), thus reducing both the value of the share to the option holder by the current value of the forgone dividend, and the cost of holding a share by the dividend stream that would be received. (Leslie & Michaels, 1997)

Financial options can be defined as contracts of financial assets that give the holder or buyer the right, but not the obligation, to purchase or sell an underlying financial asset at a given price over a specific period of time. If the expected payoff of an option is zero, the option has no surplus value for its holder. Thus, the holder of a standard call option can (but is not obligated to) buy a fixed number of shares at the exercise price ( $x$ ) on the specific maturity date ( $t$ ) (i.e., a so-called European option). If the stock price is ( $s$ ), the B-S formula incorporated into Merton’s dividends enhancement gives the following value for a European<sup>5</sup> call option ( $c$ ):

$$c = se^{-\delta t} \cdot \{N(d_1)\} - xe^{-rt} \cdot \{N(d_2)\} \quad [1]$$

where

$$d_1 = \frac{\ln\left(\frac{s}{x}\right) + \left(r - \delta + \frac{\sigma^2}{2}\right)t}{\sigma \cdot \sqrt{t}} \quad [2]$$

$$d_2 = d_1 - \sigma \cdot \sqrt{t} \quad [3]$$

and

$c$  = the price of the call,  $s$  = the price of the underlying stock,  $x$  = the exercise price,  $r$  = the continuously compounded risk-free interest rate,  $t$  = time to expiration,  $\sigma$  = the implied volatility of the underlying stock,  $\delta$  = dividend yield,  $N(d_1)$  = the proportion of shares required to replicate the call option, and  $N(d_2)$  = the probability that the call option will be exercised on expiry.

The B-S model was launched in order to show how, in theory, call options can be priced in ideal conditions – in which uncertainty is *parametric*. However, the idealized assumptions alone made its real-world use problematic outside the domain of well-defined financial assets. For instance, many parameters remain constant even though in the real world neither

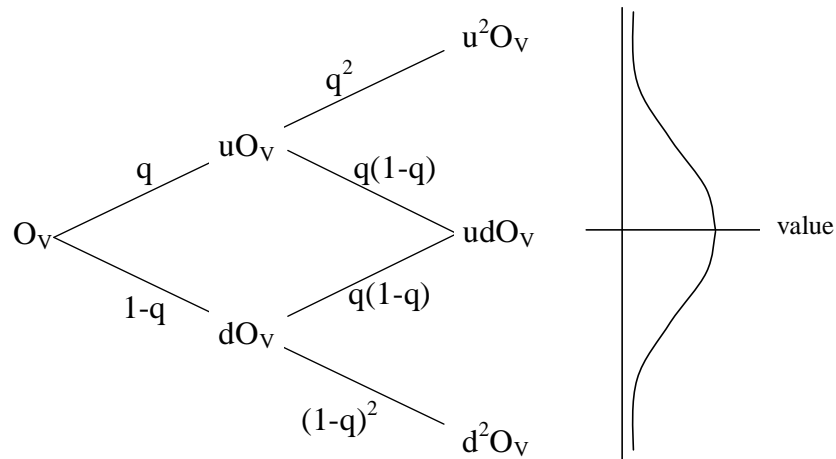
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<sup>5</sup> A European-type option can be exercised only on its expiration date, whereas an American-type option can be exercised at any time up to the expiration date.

volatility nor dividend payments are known with certainty, and also vary over time. In addition, the model cannot handle dividends that are shared during the option lifetime: uncertainty is attached only to one parameter even if the real-world uncertainty derives from technology and market uncertainties at the same time, for instance. Furthermore, the original model cannot value the so-called compound options, which are options on options – conditions that entail different and interrelated sources of uncertainty.

The recognition that an option can be replicated from an equivalent portfolio of traded securities had a great impact on the valuation of options in practice (Cox & Ross, 1976). In another development, by Cox et al. (1979) introduced a much more simplified method for depicting option valuation: a discrete time<sup>6</sup> (binomial) option-pricing formula. Only basic algebra was needed, rather than the arduous calculus based on the B-S model. The binomial lattice (or price tree) turned out to be well suited to the valuation of real assets, presenting the option value in the form of a decision tree.

The binomial price tree moves forward from the valuation date to the expiration date. The option value is connected to the underlying instrument uncertainty, going up with risk-neutral probability  $q$  or down with probability  $1 - q$ . Figure 5 shows the value-generating process for two periods:  $O_v$  = the option value,  $q$  = the risk-neutral probability of an upward change in value,  $u$  = multiplicative upward movement,  $d$  = multiplicative downward movement.



**Figure 5: The value-generation process of a two-period option in accordance with the binomial option model**

The binomial option model is visually practical, and it works well when the underlying asset has a well-defined market price (as financial stocks normally have) and uncertainty is parametric in nature.

<sup>6</sup> The time period may be a year, a month, or any other time scale.

The third option valuation method is simulation-based modeling of which the Monte Carlo method is probably the most commonly utilized.<sup>7</sup> Boyle (1977) presented the first Monte Carlo option pricing application in order to price European options, and it is applicable in cases of multiple sources of uncertainty or increasing complexity. In general, simulation gives the same results as the B-S model and the binominal option valuation model. The simulation of option value entails the generation of several tens of thousands of possible random price paths for the underlying asset, then the associated exercise value (i.e., payoff) of the option for each path is calculated, averaged, and finally discounted at a risk-free rate (Chance & Brook, 2009). So far, the disadvantage of utilizing simulation methods has been their slowness.

### 2.6.2. Real options

The work of Black, Merton, and Scholes (1973) is acknowledged as a solid basis on which to develop the theory of valuing options on real assets. The relation between financial option contracts and the choice involved in real investments was soon discovered. It was understood that some of a firm's real assets, particularly its growth opportunities, could be considered call options: the firm simply holds options on real assets. Myers (1977, p. 163) described them as "opportunities to purchase real assets on possibly favorable terms". He was probably one of the first to call these discretionary investment opportunities *real options*.

The similarity between the two option types is apparent: the exercise price of a growth option is dependent on the discretionary future investment; the future value defines the current option value; and the firm has a free choice to exercise an option. Consequently, real options could be defined as follows:

A real option is a right but not an obligation, to take action at a predetermined cost called the exercise price, during the lifetime of the option. (Adapted from Copeland & Antikarov, 2001)

In a narrow sense, real options could be regarded as an extension of the financial options theory to incorporate real (non-financial) assets (Amram & Kulatilaka, 1999). Primarily "[a] real option is the investment in physical and human assets that provides the opportunity to respond to future contingent events" (Kogut & Kulatilaka, 2001:745). Real options are opportunities to undertake different courses of action in the real asset market.

Real options are exercised by making a real investment, the cost of which is the strike price of the option. Hence, the value of an option can be defined in accordance with standard techniques taken from financial economics. In terms of investment decision-making it has been suggested that the value of the real option can be added to the standard NPV value (Trigeorgis, 1993a). This strategic net present value (SNPV) derives from two factors: the static (passive) NPV of expected cash flows and the value of options from active management (Ov). Thus,

$$\text{SNPV} = \text{NPV} + \text{O}_v$$

---

<sup>7</sup> "Simulation is a procedure in which random numbers are generated according to probabilities assumed to be associated with a source of uncertainty.. Outcomes associated with these random drawings are then analyzed to determine the likely results and the associated risk." (Chance & Brook, 2009)

It is easy to claim that advanced financial option theories in effect gave new ideas concerning the firm's growth options and the role of managerial flexibility in relation to the use of models that do not take into account the value of flexibility (e.g., Myers, 1984; Kester, 1984; Trigeorgis, 1986). It soon became apparent that choice-related flexibility in the face of uncertainty indeed had a value that conventional investment-valuation methods dealing with real investments could not properly take into account. The extension of financial option valuation to options on real assets finally opened up a new perspective on capital budgeting: management was offered an alternative way of analyzing the value of future project-related cash flows.

Real options are usually valued in accordance with financial options methods (B-S, the binomial lattice), Monte Carlo-based simulation, and methods that have been further developed from them (Collan et al., 2009). Borison (2005) categorizes real options methods in five different approaches: the classic, the subjective, the marketed asset claimer, the revised classic, and the integrated approach (Table 5).

Borison's typology has some shortcomings. It does not present compound options or cash-flow/pay-off scenario approaches. The valuation of multiple (i.e., compound) options has challenged classic methods, and attempts have been made to make the valuation of compound options possible (Geske, 1979; Herath & Park, 2002). Another stream the typology does not identify comprises models that utilize cash-flow/pay-off scenarios (e.g., Panayi & Trigeorgis, 1998).

Mathews et al. (2007; Mathews, 2009) present a simulation-based Datar-Mathews method for valuing projects involving risky new technologies or markets. It simplifies the calculation of the real option value by means of projection: optimistic, most-likely and pessimistic scenarios are created and Monte Carlo (simulation) range forecasts are executed. Fuzzy-logic-based methods are gaining ground. Collan et al. (2009) advocate the fuzzy pay-off method, which has several advantages: it is intuitively easy to understand, no simulation is required, and compound options can be evaluated. Jaimungal & Lawryshyn (2011) are working on a model that will take into account practical and theoretical aspects. For instance, it links cash flows from different periods through the Markov process, which neither the DM nor the Fuzzy pay-off method takes into account. These types of methods could be categorized as the projection approach. Projection methods are a vast improvement on all other options approaches from the perspective of R&D and innovation management. However, as the following table shows, they are not capable of addressing procedural and radical uncertainty.

**Table 5: Real option approaches (1: Borison, 2005; 2: Jaimungal & Lawryshyn, 2011)**

Approach	The Classic	The Subjective	The Marketed Asset Disclaimer	The Revised Classic	The Integrated	The Projection
<b>Description</b>	The direct application of classic option pricing from finance theory	Subjective data utilized	Equilibrium-based and subjective data	Considers two types of investments	Considers both market and private risk	Pay-off & cash-flow distribution scenarios / projections / simulations
<b>Authors</b>	(Geske, 1979; Amram & Kulatilaka, 1999)	(Luehrman, 1997a; 1997b; 1998a; 1998b)	(Copeland & Antikarov, 2001; Brandão et al., 2005)	(Dixit & Pindyck, 1994; Amram & Kulatilaka, 2000)	(Nau & McCardle, 1991; Smith & Nau, 1995; Smith & McCardle, 1998)	(Mathews et al., 2007; Collan et al., 2009; Jaimungal & Lawryshyn, 2011)
<b>Assumptions</b>	The value of the cash flows can be replicated by <i>known</i> traded asset market parameter values. <sup>2</sup>	The value of the cash flows can be replicated by a traded asset, but relies on subjective assumptions of market parameter values. <sup>2</sup>	The NPV of the cash flows of a project without flexibility is considered the best unbiased estimate of the market value. <sup>2</sup>	If there is endogenous market uncertainty the classic approach is applied. If there is endogenous uncertainty, decision analysis is applied. <sup>2</sup>	For public (market) risks, the replicating portfolio is utilized, and for private risks subjective probabilities are assigned. <sup>1</sup>	The value of the cash flows can be projected.
<b>Valuation Methods</b>	Standard financial option methods	Standard financial option methods	Binomial lattice	Classic methods / Decision analysis	Decision tree / Binomial lattice	Triangular distributions / Risk-adjusted probability / Fuzzy NPV
<b>Market and Private Risk</b>	No separation	No separation	Either or	Either or	Both considered	No separation / Both considered
<b>Uncertainty</b>	Parametric	Parametric	Parametric	Parametric	Parametric	Parametric-Structural
<b>Data</b>	Objective market data	Subjective data	Subjective data	Objective and Subjective data	Objective and Subjective data	Objective and Subjective data
<b>Challenge</b>	To find a traded asset that will reasonably replicate the project value	Subjectivity	The subjectivity of inputs, the use of GBM leading to consistently increasing real option value as volatility increases	One risk type at a time	Each individual risk must be evaluated and modeled separately	To separate the different risk types and address procedural and radical uncertainty.
<b>Evaluation</b>	Significant problems with inaccurate and inconsistent assumptions that make them effectively unacceptable for practical use in valuation or strategy applications. <sup>1</sup>			Useful if approximate results are acceptable and resources are limited. <sup>1</sup>	Accurate and consistent theoretical foundation. Toilsome. <sup>1</sup>	The most realistic approach from the innovation investment perspective.

There are certain fundamental differences between financial and real options that make the use of valuation problematic in many cases (Boer, 2002, pp. 117-118):

**(1) The exercise of a real option is not necessarily instantaneous.**

**(2) Real options usually do not have a fixed strike price; the cost of exercising them has its own stochastic pattern.**

**(3) Real options do not expire on a certain date, as financial options do.**

**(4) Real options often have very limited liquidity.**

**(5) Transaction costs for real options are higher than for financial options.**

**(6) The underlying uncertainty of real options is often structural rather than parametric in nature.**

Table 6 below shows how financial-options thinking can be transferred to real assets, and the effect the option value will have. According to real options theory, based on the Black-Scholes model, the more the real-option value increases, the greater is the uncertainty (Leslie & Michaels, 1997; Perlitz et al., 1999), with the exception of valuation models for incomplete markets, which can show the opposite. On the other hand, being able to delay the project and wait for further information before making an irreversible investment decision has value, as well as reducing the downside risks related to high uncertainty (Herath & Park, 2001). If the investment could in any likelihood result in a loss, the opportunity to delay the decision to keep the real option alive has value, too (Dixit & Pindyck, 1995).

**Table 6: The major drivers of option value (Kasanen, 1993; Trigeorgis, 1993b; Benaroch & Kauffman, 1999; Perlitz et al., 1999; Brabazon, 1999)**

VALUE DRIVER	OPERATIONALIZED CONCEPT	INTERPRETATION
(1) The current value of the asset, i.e., the price of the underlying asset (s)	The current value of the future cash flows expected from the investment. (+)	The higher the current value, the higher the value of the option.
(2) The cost of exercising the option, i.e., the exercise price (x)	The current value of making the investment. (-)  Expected investment/ implementation cost.	The higher the costs, the lower the value of the option.
(3) The length of an option's life, i.e., time to maturity (t)	The time within which the investment can be made. (+)  (i.e., time until the opportunity disappears)	The longer the lifetime of the option, the more it is worth.
(4) Uncertainty (measured by volatility) of future asset price, i.e., the implied volatility ( $\sigma$ )	The unpredictability of future cash flows associated with the investment.  Market uncertainty (+) Technological uncertainty (+/-), depending on the utilized RO model.	The more uncertain these cash flows are, the more valuable the option because the firm then has full exposure to the upside but only limited exposure to the downside.
(5) Interest rate (r)	The risk-free interest rate (+)	The higher the interest rate, the more valuable is the option.

Regardless of some problems concerning its use, the real options approach could sometimes be useful as an analytic valuation tool (Dixit & Pindyck, 1994; Trigeorgis, 1996), and more often as a strategic heuristic tool (Sanchez, 1993; McGrath, 1997; Luehrman, 1998a). As Kogut and Kulatilaka (2001, p. 744) point out, “the theory of real options provides the appropriate heuristic framing of competencies and exploratory search. A real options approach marries the theory of financial options to foundational ideas in strategy, organizational theory, and complex systems.” Instead, its use for quantitative option valuation has dominated over its use as a strategy tool. The main focus has been on cases in which the

market value of real assets can easily be identified, namely when the markets are well behaved and “thick” enough to be analyzed by means of valuation methods based on parametric uncertainty.

As the name suggests, real options are entrenched in real assets, for example in the form of an option to expand, to abandon, or to defer the real investment decision (Dias & Ryals, 2002). Different kinds of real options are distinguished in the literature, and are briefly described in Table 7 below.

**Table 7: Common types of real options (adapted from Trigeorgis, 1993a, p. 204; Lander & Pinches, 1998)**

CATEGORY	DESCRIPTION	IMPORTANT IN	ANALYZED BY
<b>Option to defer</b>	Management holds an option to buy new technology or to launch a new product or service in the market. It can wait (x years) to see if output prices justify constructing products on that technology, or launch new products.	All R&D-intensive industries; product launches; all natural resource-extraction industries; real-estate development; farming; pulp and paper products.	(Tourinho, 1979; Bernanke, 1983; Titman, 1985; McDonald & Siegel, 1986; Lee, 1988; Paddock et al., 1988; Pindyck, 1991; Ingersoll & Ross, 1992; Dixit & Pindyck, 1994; Kulatilaka, 1995; Quigg, 1995; Lee, 1997; McGrath, 1997; Dukukaakyire, 2004)
<b>Time-to-build option (in the case of staged investment)</b>	Staging an investment as a series of outlays creates the option to abandon the enterprise in midstream if new information is unfavorable. Each stage can be viewed as an option on the value of subsequent stages and valued as a compound option.	All R&D-intensive industries, especially pharmaceuticals; long-development capital-intensive projects (e.g., large-scale construction or energy-generating plants); startup ventures.	(Baldwin, 1987; Majd & Pindyck, 1987; Carr, 1988; Trigeorgis, 1991; Trigeorgis, 1993b; Kulatilaka, 1995; Milne & Whalley, 2000; Smit & Moraitis, 2010)

<b>Option to alter the operating scale (e.g., to expand; to contract; to shut down and restart)</b>	If market conditions are more favorable than expected, the firm can expand the scale of production or accelerate resource utilization. Conversely, if conditions are less favorable than expected, it can reduce the operational scale. In extreme cases, production may be halted and restarted.	Natural-resource industries such as mine operations; facilities planning and construction in cyclical industries; fashion apparel; consumer goods; commercial real estate.	(McDonald & Siegel, 1985; Brennan & Schwartz, 1985; Pindyck, 1988; Kogut, 1991; Kulatilaka, 1995; Dukukaakyire, 2004)
<b>Option to abandon</b>	If market conditions decline severely, management can abandon current operations permanently and realize the resale value of capital equipment and other assets on second-hand markets.	Capital-intensive industries (e.g., airlines, mines, railroads); financial services; new-product introductions in uncertain markets.	(Bonini, 1977; Howe & McCabe, 1983; McDonald & Siegel, 1986; Kulatilaka, 1995; Berger et al., 1996; Dukukaakyire, 2004)
<b>Option to switch (e.g., outputs or inputs)</b>	If prices or demand change, management can change the output mix of the facility (product flexibility). Alternatively, the same outputs can be produced using different types of inputs (process flexibility).	Output shifts: any product sought in small batches or subject to volatile demand: e.g., consumer electronics; toys; specialty paper; machine parts; autos. Input shifts: all feedstock-dependent facilities such as oil; electric power; chemicals; crop switching; sourcing.	(Margrabe, 1978; Stulz, 1982; Baldwin & Ruback, 1986; Kulatilaka, 1995; Ford et al., 2002; Copeland & Antikarov, 2005)
<b>Growth options</b> (often learning options giving an opportunity to increase knowledge)	<b>An early investment (e.g., R&amp;D, lease on undeveloped land or oil reserves, strategic acquisition, information network) is a prerequisite or a link in a chain of interrelated projects, opening up future growth opportunities (e.g., new product or process, oil reserves, access to new markets, strengthening core capabilities). Like inter-project compound options.</b>	<b>All infrastructure-based or strategic industries, especially high-tech, R&amp;D, and industries with multiple product generations or applications (e.g., computers, pharmaceuticals); multinational operations; strategic acquisitions.</b>	(Myers, 1977; Kester, 1984; Pindyck, 1988; Chung & Charoenwong, 1991; Kulatilaka, 1995; Willner, 1995; Berk et al., 1999; Dukukaakyire, 2004; Childs et al., 2005; Latypov, 2009)

Multiple interacting options	Real-life projects often involve a collection of various options. Upward potential-enhancing and downward protection options are present in combination. Their combined value may differ from the sum of their separate values, i.e., they interact. They must also interact with financial flexibility options.	Real-life projects in most of the industries listed above.	(Brennan & Schwartz, 1985; Childs et al., 1988; Trigeorgis, 1993b; Laamanen, 1999; Anderson, 2000; Dukukaakyire, 2004)
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In the late 1990s in particular, real options theory provoked some heated debate among academics and practitioners in the fields of investment valuation and strategic management (Trigeorgis, 1993a; Dixit & Pindyck, 1994; Copeland & Keenan, 1998; Amram & Kulatilaka, 1999; Kyläheiko et al., 2002; Adner & Levinthal, 2004; McGrath et al., 2004). On the one hand, it was perceived as a potential next revolutionary trend in the economic sciences (Merton, 1998), which together with the “high theory” behind it were supposed to ease the more complex decision-making about investments in real assets. It was also put forward as a tool to facilitate project selection (Martino, 1995) and avoid the dilemma of having to choose from among the best ideas. On the other hand, there was also concern about the approach “becoming a fad with limited economic impact” (Andersen et al., 2001, p. 2): the applications did not prove to work as well as had been suggested on the basis of the theories (Barnett, 2003; 2005). Despite the criticism, which related to strategic management, most of the research on real options has concentrated on valuation, even if most of the R&D projects do not incorporate any appropriate market-based prices, not to mention any clearly defined measures of volatility. In other words, the theoretical ideals often do not correspond to the reality, which may be very dangerous for the firm: it could easily value its options far too optimistically, or base them on wrong assumptions that could lead to real investments that would not be made in other circumstances. This problem also relates to widely used DCF methods.

In sum, at least the following factors have hindered the wide applicability of the real options approach.

1) The approach requires calculation of each option separately. The options can be presented as a tree in which the steps are dependent on each other. Each step requires the decision maker first to estimate the possible future events and actions related to them repetitively. If the conditions are likely to change, the calculations have to be started again. This means that time-taking evaluation and calculation have to be done multiple times and in multiple combinations.

2) Most importantly, the use of options-based approaches has primarily been limited to investments in market-priced financial or real assets. In brief, the problem is that unique and strategically important real investments very often do not fit into the narrow limits of the standard valuation models that presuppose well-behaved and well-working (i.e., thick) markets for underlying assets. In that regard, the theory must change.

### 2.6.3. The strategic options approach

The similarities between financial and real options are well documented (Luehrman, 1998b; Benaroch & Kauffman, 1999), but as yet there is no deep comparison between real and strategic options in the modern literature on strategic management. Option types are often divided into financial and real options, and the third type, strategic options, is commonly neglected as a separate entity and is normally included in real options. Financial options are contracts between investors, whereas real options are usually one-sided contracts with a holder of an option on a real asset but no buyer. Contrary to the emphasis on strategic opportunities and flexibility, real options rather focus on market-priced real assets. However, there are exceptions: some of the literature portrays strategic options as real options that are strategic in nature, and calls them strategic real options (Bowman & Moskowitz, 2001). However, as Sanchez (1993) stresses, it is possible to identify an option type that really describes the fundamental role of managerial flexibility that is so relevant in strategic decision-making. Such an option type has a strong link to the firm's strategy, and extends from the domain of operative management to strategic management. From this perspective and in the context of strategic management, real options should in fact be considered special cases of strategic (real) options, and not vice versa.

Kyläheiko et al. (2008) propose the following definition: "strategic options are the *contracts* of strategic tangible and intangible assets that give their holder or buyer the right, but not the obligation, to exercise the strategic opportunity on or before the exercise date or expiry." The word *contract* is the challenge here. In situations in which the company possesses or obtains a strategic new-business opportunity, for example, it has no involving *agreement* with an outsider. The opportunity is valid as long as it has value for its possessor, the possessing firm. Thus, I suggest that the definition could be modified as follows:

Strategic options are the *unilateral* contracts of strategic tangible and intangible assets, which give the holder or buyer the right but not the obligation to exercise the strategic opportunity before its expiry.

Real options valuation could easily be used in accordance with the logic of financial options if the asset market works well and the perceived uncertainty is parametric in nature. In other words, the volatility of future cash flows is known, as are the beliefs of the probabilities as a result of the consequences of possible actions in each state of the world. Unfortunately, this premise fits poorly in most decision situations characterized by strategic options. The antecedents of real options simply do not hold in the valuation of genuinely strategic opportunities.

There are significant differences between the suitable premises for real and strategic option valuation, which concern the very nature of uncertainty and the thickness of the market for underlying assets. In the case of strategic options, such as launching a genuinely new product or establishing a new business in a new region, the market is usually extremely thin (i.e., non-existent) and the uncertainty is radical or at least structural in nature. In brief, more often than not, strategic opportunities (e.g., rare innovation ideas) are unique and the volatility or other valuation factors cannot be defined at all. In such cases, the approach, at best, only allows strategic thinking in a common language.

One important difference between real and strategic option types is that the value of genuinely strategic options (i.e., options with real strategic importance) is extremely difficult to define due to the contingent and structurally uncertain future and the uniqueness of emerging opportunities. The reason is that future cash flows may derive from the compound of options, and the markets may be extremely thin, or even non-existent, if the value of a strategic option lies in the creation of competitive advantage. In such cases, the option pricing methods become unreliable. The less accurate the knowledge of prevailing uncertainty and market thickness, the lower is the value of traditional option-pricing methods. If all the pieces of knowledge are imperfect – more like subjective guesses – results based on real option pricing may even be worthless. Table 8 summarizes the differences between the option types.

**Table 8: The differences between financial, real and strategic options**

	<b>FINANCIAL OPTION</b>	<b>REAL OPTION</b>	<b>STRATEGIC OPTION</b>
<b>ASSET</b>	Financial assets: e.g., stock shares	Real assets, mainly tangibles: e.g., raw materials, production lines, or land.	Strategic assets, both intangibles and tangibles
<b>MARKET FOR THE UNDERLYING ASSET</b>	Thick and well-defined	Thin and often “badly-behaved” and ill-defined	Thin/Non-existent and severely ill-defined and “badly-behaved”
<b>NATURE OF UNCERTAINTY</b>	Parametric	Parametric and structural	Structural, procedural or even radical (comes close to ignorance)
<b>VALUATION</b>	Options pricing methods usable	Options pricing methods sometimes usable	No options pricing methods available
<b>TIME TO EXECUTION</b>	Well defined	Definable	Unknown
<b>OPTION TYPES AND EXAMPLES</b>	Call and Put options, i.e., right to buy shares from stock exchange.	Timing and flexibility options: e.g., delay or expansion type of options.	Learning and growth options: e.g., entry into a new business or country, development of a radical innovation, or new discoveries from R&D, skills or routines.

The differences between strategic options and real options are explained in more detail below with regard to the six aspects mentioned in the table.

**(i) The underlying asset is strategic**

Amit and Schoemaker (1993, p. 36) define a firm's strategic assets as “the set of difficult to trade and imitate, scarce, appropriable and specialized resources and capabilities that bestow the firm's competitive advantage”. For instance, R&D creates intangibles such as new knowledge of future opportunities that may be strategically valuable to the firm even if the underlying asset (the future business) is not even close to existence. Moreover, as a tangible, a strategic option could be new technology (or knowledge that works as a production good) in an area of future opportunity. If it is attached to future technologies and has no other use, it might not have any market value in itself.

In the case of real options, the underlying asset often has a definable value because it is attached to real assets. It might be a production line, for example, with market value in some other form, or at least as scrap metal. Strategic assets, on the other hand, are mostly firm-specific, and have value only for their primary holder.

**(ii) The market for the underlying asset is thin or non-existent**

If it exists, the market for the underlying strategic asset is normally very thin. As mentioned above, the value of strategic assets is largely firm-specific and rarely extends to other parties because of the tight connection to the holder's resource base. Further, the value of a strategic option that is still in the form of an idea will only become apparent over time. Ideas about future technologies are more difficult to sell than prototypes with an existing form: there is no well-functioning market for ideas or not-yet-existing business. However, the idea (i.e., new knowledge) may be extremely important to the firm's future success, and thereby invaluable.

**(iii) The nature of uncertainty is structural or deeper**

Uncertainty refers to how much knowledge a decision maker holds or lacks of possible actions, states of the world, probable consequences, and events. There are several categories (see Section 2.4.): certainty, risk, parametric uncertainty, structural uncertainty, procedural uncertainty, and radical uncertainty. The nature of uncertainty partly determines the precision of the available information, and thus also determines which options approach works best.

Common real options valuation methods can handle parametric and sometimes procedural uncertainty given that in the case of strategic options the nature of the uncertainty is usually deeper: structural, procedural or even radical (which comes close to ignorance). This means that, for valuation purposes, the uncertainty parameter is a highly unreliable variable and makes standard real-option valuation somewhat pointless. Therefore, the use of less precise methods may help management to evaluate the options it has.

**(iv) Time to execution is not pre-definable**

Time to execution is not as straightforward with a strategic option as it is with real options. According to the basic definition, every option has a known lifetime. This is not the case with strategic options. The decision maker cannot know how the future will evolve beforehand, nor for how long the options will be executable. The lifetime of strategic options depends very much on how the future pans out

Real options could be seen as waiting-to-invest options, and strategic options as growth options (Lin & Kulatilaka, 2007). Real options allow the decision maker to change production output immediately (by executing the option), for example, whereas holders of

strategic options have the opportunity to start production sometime in the future without knowing exactly when. In both the cases, management can set certain triggers that determine when an option could or should be executed. In sum, the time to execution is often indefinable for strategic options, and more clearly definable for real options.

**(v) No options-pricing methods available**

Conventional real options valuation models that require precise numerical values of future events do not work for strategic options. Option valuation works fine if the uncertainty is parametric in nature, but unfortunately this is not typical of future innovations. In the case of real options, the valuation systems count on isolated and fixed estimates of value attributes (e.g., cash flows), but the problem is that decision makers tend to evaluate future outcomes (input values) wrongly and therefore obtain distorted results. They cannot accurately evaluate future events and states beforehand.

**(vi) Strategic options are often compounded and sequential growth and learning options**

As claimed above, real options are options over which management has virtually continuous executive power, whereas it can affect the evolution of strategic options only indirectly. Learning and growth options enable management to increase its level of knowledge and open up future opportunities, but not to generate any direct cash flows.

For instance, R&D is a compounded learning and growth option that can decrease technology-related uncertainties and generate new opportunities (or test market-related uncertainties and opportunities). Thus, a firm with strategic options is able to simultaneously decrease the degree of uncertainty and find new market opportunities. In committing its resources to strategic options, it will lose some of its flexibility, but will find new flexibility in exchange.

Moreover, investing in totally new markets or technologies may create future growth opportunities, i.e. growth options. The firm will then gain access to markets that would not otherwise be reachable. However, the execution of this type of growth option does not guarantee a direct path to success.

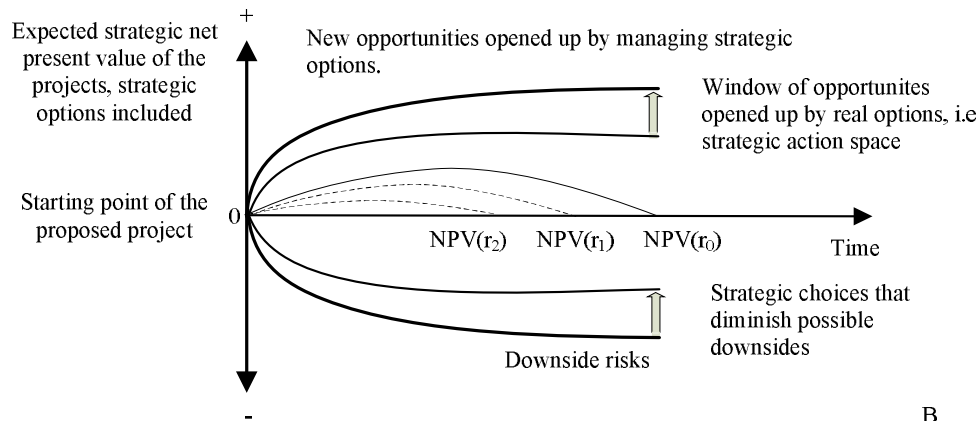
## **2.7. Strategic opportunities and value**

In following the more strategy-based line in options research, Jantunen et al. (2006) show (see Figure 6) how new options open the window of opportunities (A) and how strategic choices diminish possible downsides (B). Conventionally, an increase in the discount rate ( $r_i$ ) (reflecting the increase in uncertainty) decreases the attractiveness of investments by reducing the expected net current value. In brief, the simple logic of the conventional method is this: the higher the uncertainty, the less attractive investing becomes. Interestingly, however, strategic options in the form of learning or growth options open up a window of opportunity for the firm resulting from its changing operating environment, its assets and capabilities possessing positive value. The creation of new opportunities, in turn, shifts the frontier upwards.

The creation of new ideas increases the number of opportunities, thereby also shifting the opportunity frontier upwards. A downward shift is also possible, however, if the firm fails to maintain its capability stock in line with the opportunities. The aim is to open up a real window of opportunity and to make decision makers aware of the downside risks involved.

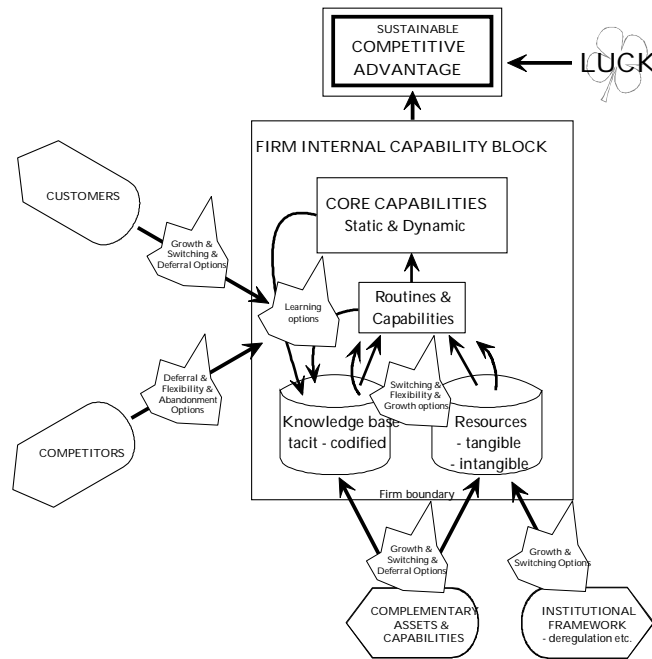
These may be avoided by first identifying and then striking the (strategic) option to wait, or using available hedging methods.

A



**Figure 6: The strategic opportunity frontier and the downside risks (Jantunen et al., 2006)**

Bowman and Hurry (1993) draw attention to two factors that shape the attractiveness of strategic opportunities: the extent to which the firm can 1) preserve or sustain its preferential access to a future source of competitive advantage, and 2) create a long-term stream of above-normal returns or rents. *Strategic options often extend much further into the future than real options and include a higher degree of uncertainty.* Strategic opportunities may also be vague, and the causal relations behind them hard to recognize. The creation of a strategic option may require unique capabilities that simply cannot be bought in a thin market and might also be difficult to produce within the firm (see Figure 7). Thus, if a firm is able to obtain a capability (based on organizational and technological skills and routines) that is unique and cannot be easily imitated, it has the opportunity to create above-normal rents and thus sustainable advantage. In order to enjoy competitive advantage the firm needs the flexibility to create rare and unique capabilities that differentiate it from its rivals. Further potential sources of competitive advantage include asymmetric information with regard to opportunities and the possession of complementary capabilities that make the firm's knowledge and resource base unique, but at the same time, strategically flexible.



**Figure 7: Strategic options as results of interplay between internal capabilities, the external market and the institutional environment (Edelmann et al., 2004, Pub 1)**

There is a remarkable difference in the valuation of strategic and real options. With strategic investments there are usually no prior or parallel cases for comparison, and hence the value is unique. In that case, one option may be valueless in isolation, but carry a very high value in combination with other options (or investments). In other words, a strategic option cannot be valued in the same way as a real option. If the related uncertainty cannot be defined precisely (i.e., it is non-parametric), an option-based valuation is problematic. The strategic value is linked to the very same value components as in real options, but may include others such as market demand, technical fitness and competition, as Helfat et al. (2007) claim. Publications 2 and 5 in Part II examine these value factors.

The strategic options approach allows the investment decision-making problem to be approached in stages, thus allowing management to try out things, and to see when the alternatives seem to be too uncertain. The small steps taken at this stage can give the firm an advantage over its competitors by making it much better prepared for the future. In a way, it is a means of tackling uncertainty related to investment proposals in which higher levels of uncertainty mean greater potential gains or losses.

### 3. RESEARCH DESIGN AND METHODOLOGY

This chapter introduces the research paradigm and strategy, and the methodological and analytical approaches used in the study. Research is often depicted as a process with progressive phases, as in Table 9 (Denzin & Lincoln, 2000). It starts from the researcher's conception of reality and the disciplinary tradition. The second phase, which involves establishing the theoretical paradigms and perspectives, shows how the researcher approaches the world and develops the relevant frameworks. The research strategy, meaning the methods of inquiry and the interpretive paradigms, is formulated in the third phase: triangulation was adopted in this case. Fourthly, the researcher chooses from several possible alternatives the preferred methods for collecting and analyzing the empirical data. The emphasis in the fifth and last phase is on interpretation, which is a continuous and constructive part of the process that is conducted in accordance with academic rules of evaluation covering validity, for example.

**Table 9: The Research Process (adapted from, Denzin & Lincoln, 2000)**

RESEARCH AS A PROCESS
Phase 1: The researcher
Phase 2: Theoretical paradigms and perspectives
Phase 3: Research strategy
Phase 4: Methods of collecting and analyzing data
Phase 5: The art and politics of interpretation and evaluation

#### 3.1. The research paradigm, design and methodology

The research paradigm<sup>8</sup> in this case is (critical) realism, and acknowledgement of the importance of science in describing the reality as well as possible. The aim in the theoretical framework is therefore to illustrate the reality as it is and to take into account the fact that all observation is imperfect and prone to error. Realists believe in the progress of science, and in the continuous development of theories and their capacity to answer more questions. In their view, what we believe now is just an approximation of the reality, and every new scientific discovery will take us closer to a full understanding. (Guba & Lincoln, 1994; Sobh & Perry, 2006)

The design of this research was strongly motivated by a practical problem. Figure 8 illustrates how such a problem can trigger the definition of the research question (Booth, 1995). Our research group was confronting a practical problem concerning the evaluation of highly uncertain investment ideas and opportunities. Conventional valuation systems were found to be unsuited to the evaluation of innovation ideas. The impetus for the study was found in the

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<sup>8</sup> A paradigm could be described as the basic belief system or worldview that guides the researcher. It has three elements and derives from ontology, epistemology and methodology (Guba & Lincoln, 1994). Ontology is "reality" and how we understand the research target, epistemology refers to the relationship between that reality and the researcher, and methodology comprises the techniques the researcher uses to discover that reality (Hirsjärvi et al., 1997; Sobh & Perry, 2006).

academic literature on the applicability of the real options approach to investment decision-making. The question was whether such an approach could help in that process.

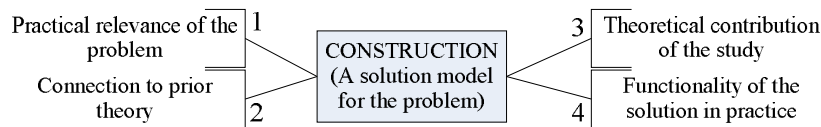


**Figure 8: The research process starting from a practical problem (Booth et al., 1995, p. 49)**

The research problem was defined as establishing the extent to which the real options approach could help in finding and defining innovations from innovative ideas. According to the literature review there is no similar research to be replicated, and the approach is new in the field of strategic innovation. The problem concerns how well the theory reflects the reality. It appears that the existing theory and its applications mainly concentrate on market-priced assets, thus in order to achieve a better fit with reality a new construct, the strategic options approach, was defined during the research process.

### 3.2. The research strategy

The constructive approach is a research stream within the literature on management research that is tied to practical problems (Kasanen et al., 1993; Lukka, 2000). The aim is to solve real-world managerial problems by implementing new constructs of theoretical relevance (Lukka, 2000). This is clearly close to the paradigm of realism. Constructive research strives to construct the world step by step with accumulated theoretical knowledge acquired through the construction of a model (Kasanen et al., 1993). Theoretical realists see models as steps towards theories describing reality, their construction as the pre-phase of theory building, and theory building as a method for aiming at the truth (Niiniluoto, 1984).

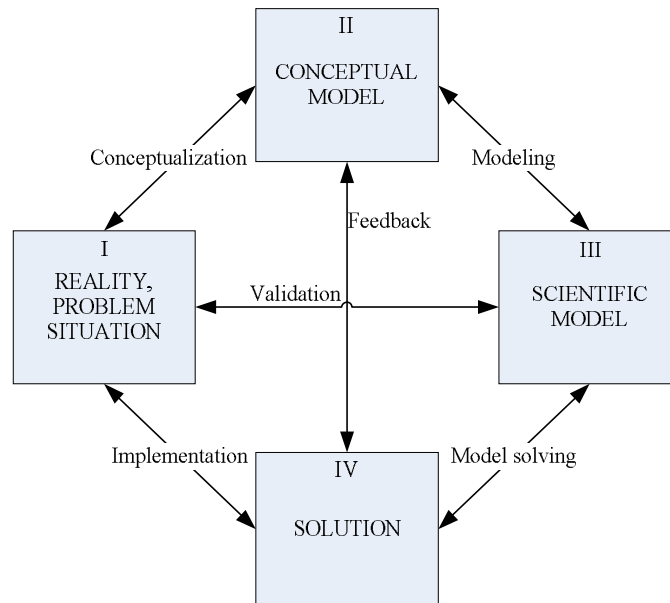


**Figure 9: The main elements of constructive research (adopted from Kasanen et al., 1993; Lukka & Tuomela, 1998)**

The research strategy adopted in this study is based on constructive research and analysis, the aim being to create a model for the evaluation of innovation ideas. Constructive research has four main defining elements (Figure 9). In terms of this research, first, there is a need for better tools with which to manage investments in uncertain ideas. Second, the connection to existing real options theory is clear. Third, this study represents one of the few attempts to explore the problem in terms of strategic options, as defined above. Fourth, the practical functionality of the presented solution (the so-called market test) will be revealed over time<sup>9</sup>.

General systems theory can be used to explain the relationships between different constructive research phases (Figure 10). The overall aim is to find scientific models (III) and solutions (IV) in order to solve problems in reality (I) (Sagasti & Mitroff, 1973; Mitroff et al., 1974). During the reality phase the researcher connects an existing phenomenon or problem to the current knowledge. The conceptual model (II) follows, which defines in broad terms the particular problem to be solved. It also specifies the variables that will be used to define the nature of the problem and the level at which they will be treated. It thus provides a basis for the scientific model, which can usually be presented as a mathematical formula. The validation path from Scientific Model to Reality shows the degree of correspondence between them. (Mitroff et al., 1974)

<sup>9</sup> Only few studies can show strong functionality during the research process (Kasanen et al., 1993).

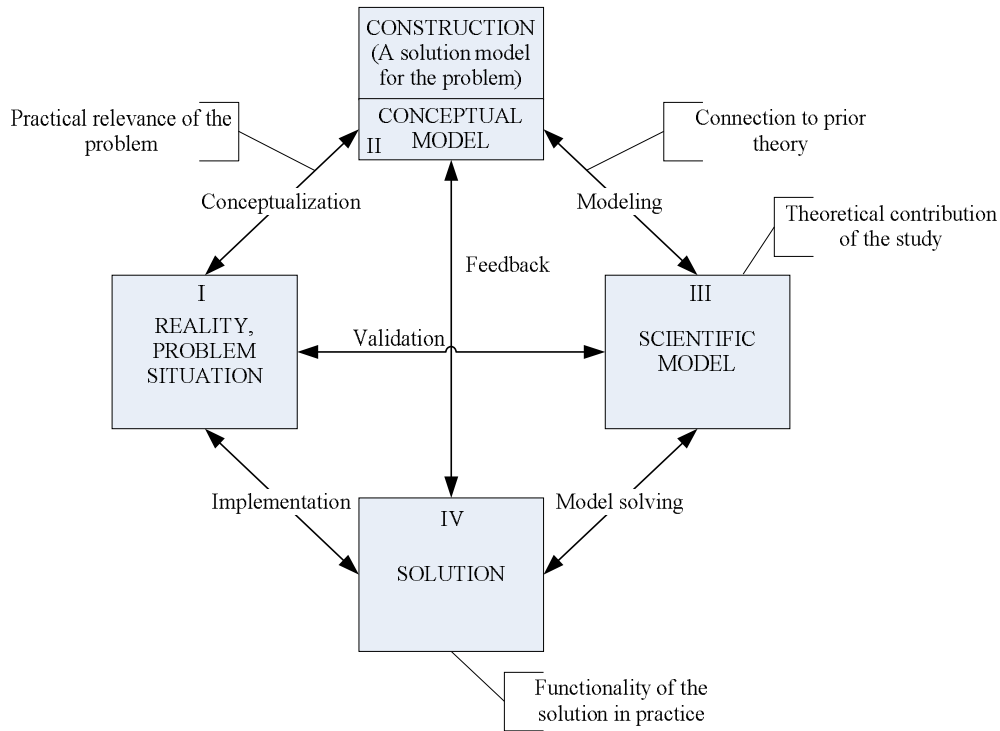


**Figure 10: The components of the research process (Mitroff et al., 1974, p. 48)**

The research for this study started with a comparison between the reality and scientific models. It comprised the following phases.

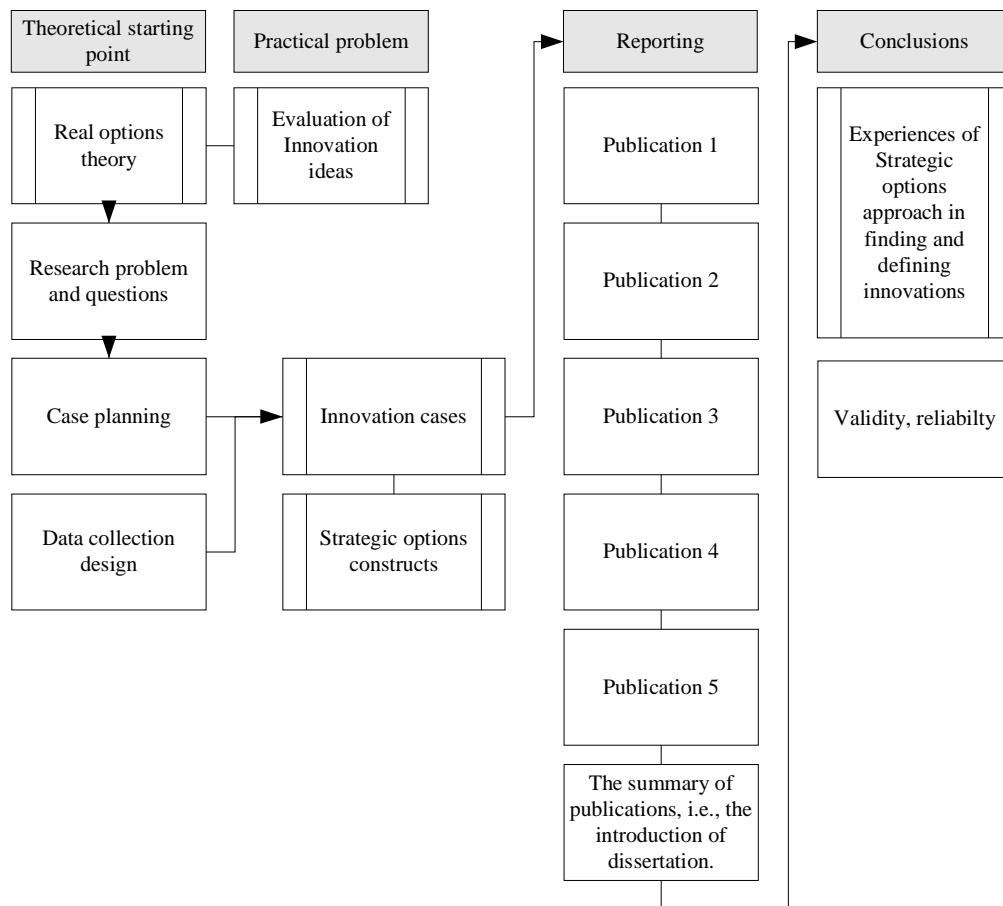
- 1) Reality (I): The inconsistency between scientific (valuation) models and reality (the evaluation of ideas for decision-making) was recognized. Proper, if any, evaluation of highly uncertain innovation is impossible with DCF valuation systems that fail to take account of managerial flexibility (for instance, the possibility to stop investing) and cannot easily handle high (i.e., radical) uncertainty.
- 2) An existing scientific model (III), the real options valuation model, has been proposed as suitable for the evaluation of innovation ideas, but the validation path to reality often fails. Decision makers can only give imprecise input variables, if any at all, for real option valuation when the ideas are connected to the remote future and uncertainty is non-parametric. Then again, in reality innovative companies need to have a view on which ideas to invest in (even in small proportions) in order to start building the dependency path to future capabilities.
- 3) The construction of the conceptual model was based on the reality and the variables presented in the scientific model. The logic of the real options approach was found to work well (Publication 1) for the identification of strategic options. Option valuation was found to suffer from the same problems as conventional models when it came to the reliability of the input variables.
- 4) The process continued, and during the iteration phase the conceptual model, the strategic options approach, was formalized, and the value attributes that show if the

idea is strategically potential or valuable to the firm were defined. These value attributes are presented in Publication 2.



**Figure 11: The two above models combined**

Figure 12 shows how the practical problem and the theoretical premises worked as the starting point for the study. They directed the definition of the research problem and of the research questions on which the case planning built. The reporting was done in the academic publications that are presented in Chapter 4. Each publication reported on a different innovation case and presented the propositions that are summarized in this introductory part of the dissertation. For validation and reliability purposes, the research results were exposed to open scientific examination and discussion in academic conferences and journals. As a result, two of the five papers are published in a blind-reviewed academic journal, one in a refereed conference publication of selected papers, and two in blind-reviewed conference proceedings. The conclusions of the research are presented and suggestions for future research discussed in Chapter 5.



**Figure 12: The research steps**

In order to gain new insights, exploratory cases were used for an empirical inquiry that “investigates a contemporary phenomenon within [...] real-life context” (Yin, 1994, p. 13) and suits “research areas for which existing theory seems inadequate” (Eisenhardt, 1989, pp. 548-549). This type of research strategy is assumed to rely on ‘how’ and ‘what’ questions (Yin, 1994), which focus on the dynamics present within single settings (Eisenhardt, 1989).

Triangulation can be used in a case-study setting in order to improve validity and understanding (Yin, 1994; Denzin & Lincoln, 2000). The term refers to the use of multiple data sources (interviews, questionnaires, documents), multiple theory perspectives on the same data set, and multiple methods applied to the research problem (Patton, 2002). Exploring the research problem from more than one angle required a combination of methods and data sources.

The applicability of real options theory under structural and even radical uncertainty was examined through the use of the strategic options approach in the case construction. The frameworks were built on the existing literature, and on the deductive premises of the research process in which existing theory has an important role.

### 3.3. Data collection and analysis

The research data was collected from four main sources: literary resources (academic publications, research reports, annual reports, and industry news), interviews, innovation sessions, and a survey. Each data source offered a case to be analyzed in the context of strategic options. The four publications represent methodologically unique perspectives and cases. The choice of data sources and angles of analysis reflected the aim to cumulatively enhance knowledge of the strategic options approach. Table 10, below, summarizes the publications in terms of the main objectives, the data sources, the theoretical approaches, and the methods of analysis used.

**Table 10: Objectives, data sources, theoretical approaches and methods of analysis**

Pub	Objectives	Case data source	Theoretical approaches	Methods
1	To analyze the possibilities of utilizing the real options approach in a competitive situation in the ICT sector and in technology selection.	Industry reports and news	Real options studies	Literature review Industry analysis, Real options approach
2	To find out how the options approach can be used in idea selection as a ranking tool.	Innovation-session data	Real options studies, Innovation studies	Literature review Constructive approach, Strategic options approach
3	To show how the ROA reflects reality and to find out how a real options approach would change the decision-making around an innovative idea.	Case interviews	Real options studies, Investment studies, Case-study research, Innovation studies	Case-study approach, Constructive approach, Strategic options approach, Literature review
4	To clarify how normative scenarios and the strategic options approach can support the sense-making process in an innovation.	Case interviews	Real options studies	Case-study approach, Constructive approach, Scenario method, Strategic options approach
5	To find out how the slow diffusion of an innovation can be explained by combining the strategic options approach and quantitative analysis.	Survey data	Real options studies, Innovation studies, Adoption and diffusion studies	Survey and analysis, Case study, Strategic options approach, Data triangulation

The use of interviews as a data-collection technique caused problems at the beginning of the research. We were not able to locate people who could tell us about the use of the real options approach as a strategic appraisal method. It was in use in some companies, but only to evaluate the option values of market-priced assets such as oil and gas.

The first step in the research process was to review the academic literature so as to understand the current state of the real options approach. Most of the research concentrated on option valuation, and only a minor part on strategic questions (Sanchez, 1993; Bowman & Hurry, 1993; Sanchez, 1997a; Sanchez, 1997b; Bowman & Moskowitz, 2001). The review of previous studies helped in formalizing the research target and strategy. The weaknesses of the approach in terms of its applicability to strategic investment decision-making were discovered, which led to the decision to take an explorative approach in order to overcome this shortcoming.

An explicit review of new developments in the field of information and communications technology (ICT) technology was carried out for the first publication. The current market situation and trends were used as firm-level options and as a case, and the competitive setting and strategic options were analyzed in an options framework. The publication shows how the competitive situation at the intersection between Internet-based and telecommunications industries could be viewed in terms of real options.

The focus in the second publication is on developing the framework for evaluating strategic value. For this purpose a relativistic appraisal tool (i.e., a construction) was developed to demonstrate how single ideas can be assessed from the decision maker's point of view, and the strategic value they contain. One data source was the literature on real option valuation, from where the initial value components were adopted.

The innovation sessions, which are described in detail at the beginning of the dissertation preface, were used as case data. The data mostly comprised innovative ideas that were then evaluated within the limits of real options theory. We found that it was not possible to give accurate enough input data for the real options model, and redefined the value attributes in terms of strategic value.

The third paper presents a case study of a forest-industry investment originating in the 1980s-1990s. The research problem was viewed as a real-world investment case. Semi-structured interviews were conducted with the people involved in the strategic investment decision-making. The aim was to show how decision makers manage innovative ideas compared with the theory, and also to produce a richer view of the research problem than quantitative methods could offer. The idea was to demonstrate how strategic options as a method could work in practice, and the kind of value it might produce.

We interviewed people who were making investment decisions at that time, then recorded the interviews and transcribed them. The fact that the company representatives were able to talk about the decision-making process concerning an innovative investment idea from start to finish was of crucial importance. We were able to analyze the whole process and compare it with real options theory. The interviews thus provided a setting to be used as a case in the construction of the concept of strategic options. Data from the firm's annual reports was also used in the analysis.

The same data was exploited in the fourth paper, and a new case construct based on the literature and our research was launched. The applicability of the construct as complementary to normative scenarios was evaluated. We concluded that strategic options could be useful in different scenarios, and that investment decision-making may be easier than in a one-scenario world. The decision maker finds out what options the firm has, and what kind of options it could create if normative scenarios were followed.

The data for the fifth publication comprised a survey that was part of a research project concerning the diffusion of electronic invoicing. This data was treated as a case of innovation-based investment. The aim of the project in question was to find out why that specific technology has not diffused as expected, which was why the survey data was collected. The author later analyzed the raw data, first quantitatively and then qualitatively. The results showed that the strategic options approach could extend the quantitative analysis and offer explanations that were beyond its scope. The resulting analysis explained why electronic invoicing did not diffuse as quickly as expected. The paper thus demonstrates that the approach can be used as a complementary analytical tool.

### **3.4. Validity and reliability**

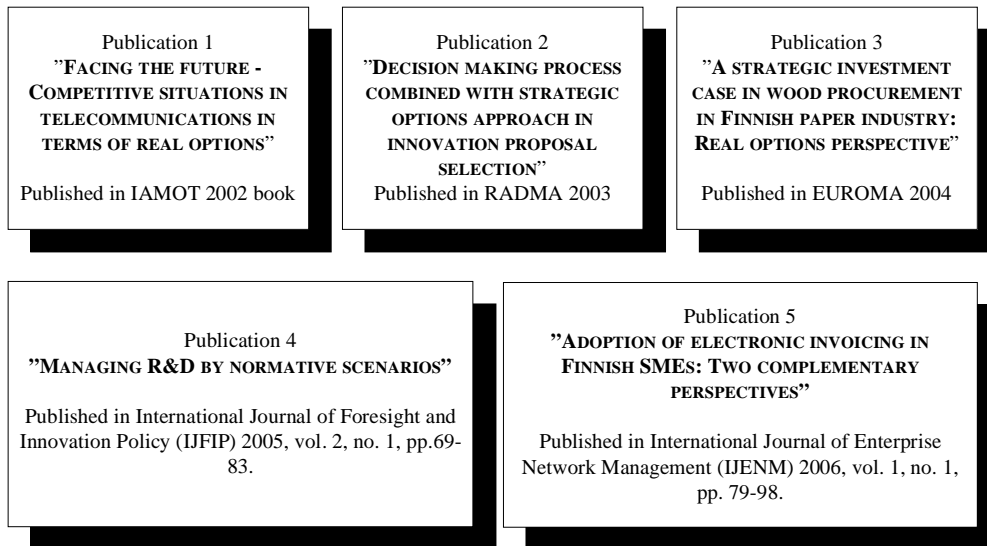
All academic research should meet the requirements of scientific validity and reliability. Validity is often classified as internal (credibility) and external (Eisenhardt, 1989; Yin, 1994). In order to meet the requirement of internal validity the theoretical conclusions, the concepts, and the hypotheses have to be logically constructed (Grönfors, 1982). The present study builds internal validity through the use of different types of data and methodology, constantly assesses the consistency of the research results, and seeks comparison with the literature. The external validity, the generalizability of the results and the conclusions are not limited to the strategic-innovation opportunities in question, and the findings should also be valid in other investment decision-making and planning situations.

The question of reliability concerns the consistency and replicability of the research and its results. Thus, it should be possible for someone other than the author to conduct similar research by collecting a similar data set, and obtaining similar findings (Gummesson, 1991). It is thus claimed that any investment data covering long-term, uncertain and strategic projects should produce the same conclusions as this research.



#### 4. THE RESEARCH PAPERS

The study comprises five papers published in academic journals and refereed conference proceedings. Figure 13 shows the respective track, title and publication forum, presented in chronological order. Each publication examines the research questions presented in Section 1.3 from a different perspective.



**Figure 13: The research publications**

Following a chronological order makes it easier to follow the development of the study and of the author's thinking. For instance, the terminology related to real options and strategic options varies slightly. When the first paper was published, for example, the two concepts were still being used in an overlapping manner, but became more clearly separated during the research process. Even though the terminology was not entirely definitive, it was clear that all options called *real options* simply could not be accommodated in the traditional Black-Scholes options valuation model. It was also evident that options on real assets that included high (non-parametric) uncertainty could not be evaluated by means of valuation models that require exact values for uncertainty measures, such as volatility and cash flows.

Above all else, the real options approach was considered incompetent as a valuation method when uncertainty was found to be deep (structural or radical) in nature, although the basic logic was still useful. However, the terminological fixation on real options probably created some ambiguity in the research, which could have been avoided if the typology presented in the later papers, and especially in Section 2.6.3, had been used.

The following sections describe the overall objectives and contributions of each paper in detail. Overall, they show how strategic investments can be managed by means of strategic options tools. Each one includes a model, or at least a conceptual framework, which will be examined in order to determine how innovations and strategic opportunities can be evaluated. Table 11 summarizes the content of the publications.

**Table 11: A summary of the publications**

	<b>Publication 1</b>	<b>Publication 2</b>	<b>Publication 3</b>	<b>Publication 4</b>	<b>Publication 5</b>
<b>Title</b>	Facing the future: competitive situation in telecommunications in terms of real options	Decision-making process combined with strategic options approach in innovation proposal selection	A strategic investment case in wood procurement in Finnish paper industry: real options perspective	Managing R&D with normative scenarios	Adoption of electronic invoicing in Finnish SMEs: two complementary perspectives
<b>Objectives</b>	To analyze the possibilities of utilizing the real options approach in a competitive situation in the ICT sector.	To find out how the options approach can be used in idea selection as a ranking tool.	To show how the ROA reflects reality, and to find out how it can change the decision-making around an innovative idea.	To clarify how normative scenarios can support the sense-making process in an innovation.	To find out how a combination of the strategic options approach and quantitative analysis can explain the slow diffusion of an innovation.
<b>Main results</b>	An analysis of the potential of the real options approach in terms of shedding light on the complicated issues of strategic alternatives in the ICT sector.	A scoring tool that helps the decision maker to identify the characteristics and the relational value of investment ideas.	Explains some of the applicability of ROA in the decision-making process concerning strategic IT investments. Introduces the ROA application framework.	Shows how the strategic options approach can be used in the creation of normative scenarios.	Shows that the use of the value components of strategic options can extend quantitative analysis.

#### 4.1. Publication 1 - Facing the future: competitive situation in telecommunications in terms of real option

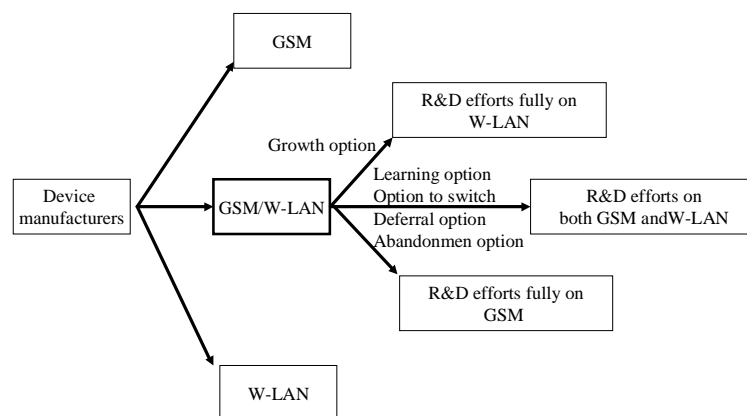
*Edelmann Jan, Kyläheiko Kalevi, Laaksonen Petteri and Sandström Jaana*

The first paper examines the ways in which strategic options can be used in the information and communication technology (ICT) sector to enhance strategic flexibility. The potential use of the real options approach is analyzed in order to shed light on the strategic alternatives.

The paper illustrates the importance of strategic options as a source of flexibility, and presents a real options tool for analyzing competitive situations in the telecommunications industry with a view to gaining competitive advantage. It is among the earliest papers to extend the application of the real options approach to the area of telecommunications within the ICT sector (see also Benaroch & Kauffman, 1999). It identifies (in terms of real options in the strategic context) some basic strategic interactions and interdependencies among operators, manufacturers and software providers, and extends traditional strategic analysis in showing how strategic flexibility can be created by means of strategic options.

The real options approach was acknowledged as an interesting way of analyzing ICT industries after the rapid decline in market value of firms in the field. The use of the approach in the analysis of changing market situations and opportunities is novel, and it is rarely used as proposed in the paper in industrial analysis and technology selection.

This paper was our first endeavor to see how the real options approach could be used differently than in traditional real options valuation analysis. However, it has to be said that there is some lack of depth because the research process had just started and the final form and terminological choices were not yet established. Nevertheless, the work was of significance in terms of understanding the approach and moving the study in that direction. Whereas most research on real options concentrates on cases in which they can easily be evaluated, this study offers a new perspective in showing the value of the strategic options approach as an analytical tool without the need for exact valuation. At the time, technological development was very fast and high uncertainty characterized investment decisions. The study showed that the options approach could be used in the analysis of competitive market entry and technology choice (Figure 14).



**Figure 14: A decision framework for the technology choice of device/network manufacturers**

#### 4.2. Publication 2 - Decision-making process combined with strategic options approach in innovation proposal selection

*Edelmann Jan, Koivuniemi Jouni, Laaksonen Petteri and Sissonen Antti*

The aim in the second paper was to construct a method for assessing the value of innovation ideas. A tool based on strategic options value attributes was used in examining one way of choosing R&D innovation proposals from a portfolio of ideas.

For assessment purposes the first stage was to develop a preliminary idea-selection tool (the questionnaire presented in Table 12) that included twelve questions in nine attribute groups. The primary objective was to give the ideas a relative strategic-option value, and the secondary aim was to discard all the ideas that could be better evaluated by means of other selection methods. In addition, ideas that were not justified from the firm's point of view could be identified and put aside, thereby allowing those offering valuable options to stand out better. The purpose is not to select the best idea, but to allow identification of the most promising ones that would be worth further development or assessment. The ideas are given values that determine whether they have any inherent option value, whether they should be evaluated by other means or whether they should be abandoned for now.

**Table 12: Preliminary idea appraisal form**

IDEA: _____	Very high	High	Average	Low	Very low
1a) TECHNOLOGICAL UNCERTAINTY How significant do you see the risk of failing in <i>technological</i> terms?					
1b) MARKET UNCERTAINTY How significant do you see the risk of failing in <i>market</i> terms?					
2) IRREVERSIBILITY Rate the <i>possibility of recovering</i> the invested assets.					
3) MARKET VALUE Rate the <i>business impact</i> of the idea in its final form.					
4) GROWTH What is the <i>significance of this idea</i> for further investments or upgrading?					
5a) FLEXIBILITY1 What is the <i>difference between the business</i> based on the idea and your current business?					
5b) FLEXIBILITY2 How would you rate the idea in terms of increased <i>operational potential</i> ?					
6) IMPACT What might be the <i>impact on the current value chain</i> ?					
7a) TIME1 What is the <i>likelihood of postponing the investments in order</i> to acquire additional information? (rivals, own business, etc)					
7b) TIME2 What is the likelihood of achieving <i>technical and market success</i> during the next three years?					
8) SCALE OF INVESTMENT Rate the <i>size of the investment</i> compared to your company's size.					
9) STAGING Rate the <i>possibility of conducting</i> the development process in phases.					

Despite the great variety of idea evaluation methods and techniques, their applicability in cases involving high strategic value is questionable. Most of them assume precise estimates on which to base the final evaluation and comparison, and do not offer much help with far-reaching strategic decisions. McGrath and MacMillan (2000) present a scaling method based on real-options reasoning (strategic technology assessment review, STAR) for evaluating initial technology-project ideas and their strategic value. With its 166 questions in 15 different sectors it is considered too time-consuming when hundreds of new ideas need to be evaluated. Our model has the capacity to cut down the number of initial ideas considered to have some strategic value. The STAR method, on the other hand, is more suitable for projects that are in the final stage of the investment decision-making process. Determining the value attributes of the strategic options was found to make the evaluation process easier at the initial stage.

#### **4.3. Publication 3 - A strategic investment case in wood procurement in Finnish paper industry: real options perspective<sup>10</sup>**

*Edelmann Jan*

The third paper analyzes an investment case in a Finnish paper-industry firm carried out during the years 1988–1996. The case, an innovative and strategic IT-system investment in wood procurement, is approached from the real options perspective, the aim being to show how this kind of innovative investment idea could be illustrated and managed. The analysis demonstrates how to outline the complexity of the world and strategic opportunities, and how to use strategic option analysis as decision-making input with regard to innovation investment.

It was found that, to some extent, the decision-making in the firm already followed the steps outlined in the options approach. For instance, the investment was staggered to allow the accumulation of knowledge about technological uncertainties. However, the strategic approach would have been helpful when the case investment was being planned, and would have made it easier for the decision makers to see what kind of options the firm had and how valuable they would have been.

A simplified options framework is presented to show how the innovative case idea could have been evaluated through the identification of the upside opportunities, the downside risks, and the available real options. Management is offered an opportunity map that functions as a decision tree in facilitating decision-making with regard to striking options and/or making investments that give the firm the rights to the underlying securities.

The study shows that the strategic options framework would have been advantageous over the methods the company actually used. The traditional perspective would have been widened and the investment approached in a way that corresponded with the reality. The decision makers would have been systematically challenged to identify all possible uncertainties and opportunities, the real options would have been detected during this process, and management would have obtained a better picture of the strategic value of their project idea. This information would have enabled them to understand the value of the flexibility they possessed as opposed to making now-or-never decisions.

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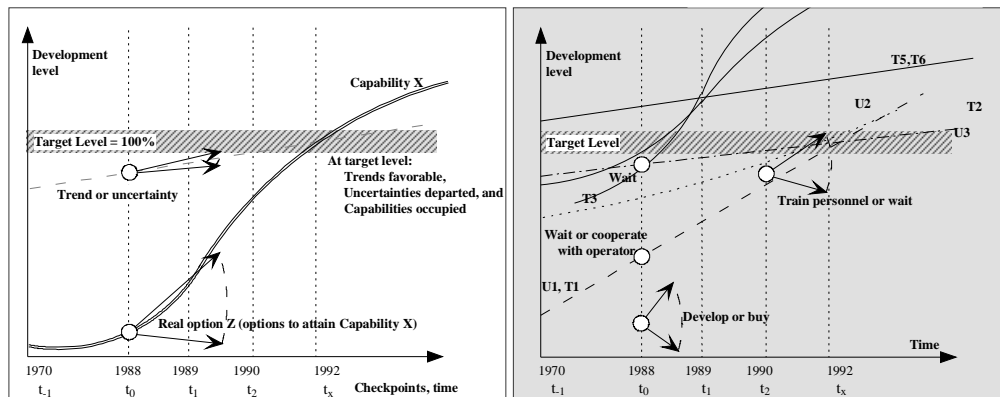
<sup>10</sup> A more accurate term is the strategic options approach.

#### 4.4. Publication 4 - Managing R&D with normative scenarios

*Edelmann Jan, Bergman Jukka and Jantunen Ari*

The fourth paper examines how R&D management can analyze complex ideas and recognize strategic opportunities under high uncertainty. The constructed model integrates two qualitative methods – the scenario technique and the real options approach – with the dynamic capability view in order to manage the strategic investment process.

The model is illustrated by means of an investment case (Figure 15), and the factors derived are retrospectively analyzed in order to show how it helps firms to sense and seize innovative ideas that are strategic in nature. It was found that a visualized framework helps firms to assess uncertainties and opportunities related to innovative and strategic ideas and investments. The model gives decision makers guidelines for timing critical questions, and allows the monitoring of changes in the firm's internal and external operating environment, its future investment requirements and its strategic potential. The investment decision-making process will be more reliable because most of the factors can be examined dynamically.



**Figure 15: The normative scenario viewed at  $t_0$ : the basic model (left) and the Case**

This study demonstrates the effectiveness of the normative scenario approach in establishing a structured process to support the management of R&D. The process was perceived to be helpful as it provided explicit assumptions of the changing environment in a narrative and illustrative form. It facilitated collective learning and strategic thinking, resulting in long-term strategic visions of the emerging future. The main advantage of the approach lies in the simplification of decision-making through visualization because of our incapability to handle complexity (Dörner, 1997; Bazerman, 2002). This means that the overlapping uncertainties and trends of different ideas are easier to monitor and options to manage.

The limitations of the approach are that it is rather time-consuming and subjective. However, it is useful when the amount of historical and future-oriented data is adequate for building scenarios, defining target levels, and identifying the real options. It is aimed at long-term and high-risk projects that traditional methods cannot handle. Further studies and more empirical evidence are needed in order to validate the relevance of this paper in the field of innovation management, and particularly in the light of decision-making theory.

#### **4.5. Publication 5 - Adoption of electronic invoicing in Finnish SMEs: two complementary perspectives**

*Edelmann Jan and Sintonen Sanna*

The fifth paper examines the adoption of electronic invoicing, an innovation in the field of electronic business solutions, in South Karelian companies (Finland) that send invoices to the largest companies and local municipalities in the area. The strategic options approach was used as an option lens (Bowman & Hurry, 1993) through which to analyze the reasons for the slow adoption rates among small and medium-sized firms, and the diffusion rates.

The results of the survey<sup>11</sup> analysis presented in this paper show that there are clear reasons for the slow adoption of e-invoicing in Finnish small and medium-sized enterprises. For one thing, the perceived uncertainty is relatively high, secondly, the supply chain has not demanded its use, and thirdly, there is a lack of practical know-how. The strategic options approach was adopted to complement the quantitative study and thereby gather more information about the adoption decision.

The framework of value attributes presented in the second paper was used to analyze the survey results. The strategic options perspective was found to be valuable and capable of yielding richer results than mere quantitative analysis. The findings suggest that SMEs base their adoption decisions on the strategic options they possess. We learned that strategic options are sometimes very effective in explaining the results of quantitative analysis together with survey data. The low demand for e-invoices, in this case, could be attributed to the fact that SMEs are able to wait and see what happens, or that they are not offered any special growth options that would promote diffusion. In fact, large invoicing entities started to force their vendors to use electric invoicing in 2010.

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<sup>11</sup> Ms. Hennariina Pulli, the research team's research assistant collected the data, and the authors of this study analyzed it.

## 5. THE KEY RESULTS

The aim of this dissertation was to show how a firm could use a structured options-based method for examining future-related innovation ideas as part of its investment decision-making. This final chapter presents the key results and contributions of the study in terms of the research questions, and assesses the theoretical contribution, the managerial implications, and the limitations.

### 5.1. Answering the research questions

The main research question was divided into three sub-questions. The main contributions are as follows:

RESEARCH QUESTION	CONTRIBUTION
<b>Sub-Question 1</b> What are strategic (real) options?	1. The distinction between real options and strategic (real) options
<b>Sub-Question 2</b> How can ideas about future-related innovations be assessed in terms of strategic options?	2. A method for valuing strategic options
<b>Sub-Question 3</b> How can the strategic options approach be applied to finding, defining, and evaluating new innovations?  <b>Main question</b> How does the strategic options approach facilitate the exploitation of perceived innovation opportunities (i.e., ideas) under conditions of pervasive uncertainty?	3. The use of the strategic options approach in finding and defining new innovations

#### 5.1.1. The distinction between real options and strategic (real) options

*The first of the sub-questions* addressed the concept of strategic options. Although the basic notion of strategic options is mentioned in the existing literature on real options (Sanchez, 1993; Trigeorgis, 1993a; Bowman & Moskowitz, 2001; Mun, 2002; MacDougall, 2003; Brydon, 2006; Kyläheiko & Sandström, 2007; Smit & Trigeorgis, 2007), there has been no clear and solid distinction between the concepts of “real options” and “strategic options”. The strategic aspects have not been isolated from the real options approach, which has dominated the research, and thus the research object has been ill-defined in the strategic management research field in particular.

This study puts forward the idea that real options could be classified as: (i) real options and (ii) strategic (real) options. An extensive literature review did not reveal any previous organized attempt to establish the difference between real and strategic options. Such a distinction could offer something new to strategic-management theory and practice, making options analysis more suitable to complex and highly uncertain situations in which the real options approach cannot currently be utilized.

The following definition is put forward to distinguish between strategic and real options:

*Strategic options are unilateral contracts covering strategic tangible and intangible assets, which give the holder or buyer the right but not the obligation to exploit the strategic opportunity before its expiry, whereas real options give the right to take action on real assets.*

The following differences seem to distinguish strategic from real options (which are discussed in more detail in Section 2.6.3):

- (i) **The underlying asset is strategic:** Strategic options are attached to strategic assets, and the value is mostly firm-specific, whereas real options are usually attached to real assets and have a more easily definable market-based value.
- (ii) **The market for the underlying asset is thin or non-existent:** The thickness of the market for the underlying asset largely determines the kind of options approach that works best. When the market is thin or non-existent the real options approach does not work well and more imprecise systems are required.
- (iii) **The nature of uncertainty is structural or deeper:** Real options valuation assumes that uncertainty is parametric in nature and can be clearly defined. The strategic options approach is suitable when uncertainty is structural, procedural, or even radical.
- (iv) **Time to execution is not pre-definable:** According to the basic definition, every option has a known lifetime. In contrast, the lifetime of a strategic option depends greatly on future events. The decision maker cannot know beforehand how the future will evolve or how much time remains in which to exercise the option.
- (v) **No options-pricing methods are available:** Because the standard valuation of real options is not applicable in conditions of non-parametric uncertainty, an alternative form of pricing is required.
- (vi) **Strategic options are often compounded and sequential growth and learning options:** Management has virtually continuous executive power over real options, whereas its effect on strategic options can only be indirect because of their compounded and sequential nature.

In sum, the strategic options approach works with tangible and intangible strategic assets, whereas the real options approach struggles with intangibles, and especially with strategic assets that have no existing market. When the market for the underlying asset is thin or non-existent, the strategic approach is the more useful.

### 5.1.2. A method for valuing strategic options

*The second sub-question* concerned the evaluation of ideas for future innovations in terms of strategic options, in other words how the strategic-option value of the ideas could be assessed.

The proposition was that the variables used in classic real-options valuation also apply to strategic options. The aim was to fit the value attributes to the premises of less precise information and illustrate the relative option value of each innovation idea. Attributes are derived from the methods presented in the publications. It was posited that the strategic value of far-reaching ideas could be evaluated in accordance with the following variables: A) perceived uncertainty, B) required investments, C) opportunities and flexibilities, and D) time to realization. These are described in more detail below.

- A) Perceived uncertainty: Uncertainty is probably the main factor affecting option value. Two primary sources of uncertainty were found to be most suitable for evaluation purposes at the initial stages: technological uncertainty (Dixit & Pindyck, 1994) and market uncertainty (Ansoff, 1965; Ansoff & McDonnell, 1988).
- B) Required investments: Firms wishing to gain access to innovation ideas have to make investments at some point in time. Investment irreversibility decreases management's flexibility to operate however, thus the ability to stage and postpone investments needs to be assessed when ideas are examined.
- C) Possible opportunities and flexibilities: When companies identify business opportunities and/or get innovation ideas they need to analyze the potential market value, growth and staging opportunities. These all affect the strategic option value of innovation ideas.
- D) Time to realization: Option-based investment decision-making is not based on now-or-never decisions, hence time information is important. The option to wait and see is therefore valuable.

The above variables allow management to assess future innovation ideas in terms of the strategic options approach. They can be utilized for assessing the value embedded in innovation ideas, and thus give a better picture of the strategic value of each one. Because the number of ideas may be high, the evaluation system needs to be light enough in practice. Answering simple questions will give management a much clearer picture than resorting to the evaluator's personal gut feeling or an unsuitable valuation system.

The presented approach has some fundamental advantages over former methods. First, the dozens of available idea-selection methods (in the public domain) have not thus far advocated this type of approach for the initial phase of innovation (i.e., the fuzzy front end). This study shows how the potential option value of ideas in terms of real options theory can be revealed. None of the other scoring methods aimed at identifying promising ideas has concentrated on the real options approach.

Idea scoring has distinct advantages over other screening methods: it is quantitative enough and it is fast to use even with a great number of ideas (Henriksen & Traynor, 1999). The scoring tool presented in Publication 2 differs in one major respect from other scoring tools: it is able to attach real options to a method utilized at least since the 1950s. It is shown that real options valuation is also possible by other means than through standard valuation. It is not claimed that the tool is ready – as is the case with most idea-selection and investment-valuation tools.

Second, standard real options models are too heavy for large numbers of ideas because the initial idea can and will turn into new forms: it is definitely not in its final form when it is presented for the first time. If the whole project is evaluated against all possible outcomes and the idea changes, the same thing has to be done again. In addition, the information related to far-reaching innovation ideas suffers from great uncertainty. All existing valuation models require information that is not normally available at the initial stage. The information that is available is mostly intuitive and definitely imprecise. The strategic options approach offers an easier way of adjusting and applying changes in an ever-changing and uncertain environment.

Third, other methods available for identifying the potential value of innovation ideas do not have the necessary strong theoretical foundation for identifying potential value. For instance, the concept of 'strategic arenas' plots potential innovations based on two dimensions: 1) technology and marketing leverage and competitive advantage, and 2) market and technological opportunities (Cooper & Edgett, 2010). This type of method is visually

attractive, but closer examination reveals that much of the information does not facilitate idea selection. There is no time information available, for instance. Nevertheless, the approach advocated in this study makes it possible for management to monitor the time component all the time.

### **5.1.3. The use of the strategic options approach in finding and defining new innovations**

*The third sub-question* concerned how the strategic options approach could be applied in finding and defining new innovations. It was found that its use could enhance understanding of the strategic value of potential innovations.

When the initial idea for an innovation is received there may be no understanding of the potential future market. What is acknowledged is that the idea or invention is something new. The decision maker has only some unconnected bits of knowledge about future events. It can take years for an idea to be transformed into an innovation and to find success in the market place. There are examples of innovations struggling for decades before being adopted.

For instance, the idea of the light-emitting diode (i.e., LED lights) was first mooted over 100 years ago (Round, 1907), but it was not until 1962 that Nick Holonyak Jr. presented the first practical LED (Lemelson-MIT, 2004). Even though there are many signs of market penetration by LED technology in other solutions, we just cannot be sure how the future will evolve from the investment decision makers' point of view.

A look at real options valuation from the classic approach to the latest stream of projection methods reveals that there is something it cannot handle – procedural and radical uncertainty. It could be concluded from the above discussion that there is room for methods that could bridge options valuation and future innovations (i.e., innovation ideas) under great uncertainty. The dissertation at hand takes a step in this direction. Future options methods must be able to handle constantly changing and imprecise information in an ever-changing environment.

The study shows how illustrative constructs based on theories of real options and scenario methods foster recognition of the critical aspects of innovation. The use of normative scenarios combined with the options perspective may show management how far they are from the possible execution point of different real and strategic options, and in the context of real options offer tools the earlier literature could not provide. It is shown that innovation analysis is not a one-off occasion, but a continuous process that is constantly being specified. The market and technological uncertainties attached to the initial ideas and required investments can be assessed against current and future circumstances.

Firm management could utilize the strategic options approach in order to:

- Evaluate what kind of strategic opportunities it has and how they relate to the existing form of the firm: this will enhance understanding of what needs to be done to find new innovations and strategic directions. (Publication 1)
- Utilize an idea-selection method for analyzing strategic opportunities (i.e., innovation ideas). (Publication 2)
- Understand how the real options approach can be applied in managing the innovation process. (Publication 3)

- Outline and monitor visually perceived uncertainties, required capabilities, and technologies. (Publication 4)
- Obtain information about the strategic-option value of the innovation. (Publications 2,5)

In conclusion, and in response to *the main research problem* concerning how the strategic options approach facilitates and makes sense of perceived innovation opportunities under pervasive uncertainty, the following points are made.

- The approach allows and compels decision makers to take into account the impact of strategic opportunities on the competitive setting.
- Future investment requirements can be identified, and the development and attractiveness of strategic opportunities can be monitored.
- The investment decision-making process becomes more reliable because important value factors can be examined dynamically.
- The approach is suitable for assessing the value of initial innovation ideas and of the strategic option.

## 5.2. Theoretical contribution

The theoretical contribution of this study lies at the intersection of innovation management, investment management, strategic management and real options theory.

Innovation management:

- The study offers innovation and investment management new insights into idea evaluation and selection based on real options, which has been identified as a need (Henriksen & Traynor, 1999; Cooper, 2009).
- The use of the strategic options approach to overcome limitations imposed by market-priced assets and high uncertainty strengthens the applicability of real options theory to innovation management, and allows the analysis of both negative and positive effects to be taken into consideration.

Investment management:

- The strategic options approach can explain the behavior of entrepreneurs adopting and investing in new technologies. This is in line with the view that growth options support adoption, whereas waiting options have the opposite effect and learning and staging options have no significant effect (Goswami et al., 2008). Hence, the options management holds may partially explain the failure to diffuse even good technological innovations.

Strategic management:

- A substantial amount of earlier research has concentrated on the valuation of real options and has neglected strategic questions. In terms of constructive research, this study offers new options frameworks for the strategic management of innovation.
- The integration of strategic options with dynamic capabilities and scenarios offers a new perspective on theories of strategic management. It could also give new insight into the discussion on competitive advantage and dynamic resource-based responsiveness in the ever-changing competitive environment (Barney, 2001; Priem & Butler, 2001; Foss & Roemer, 2010; Wang & Chen, 2010).

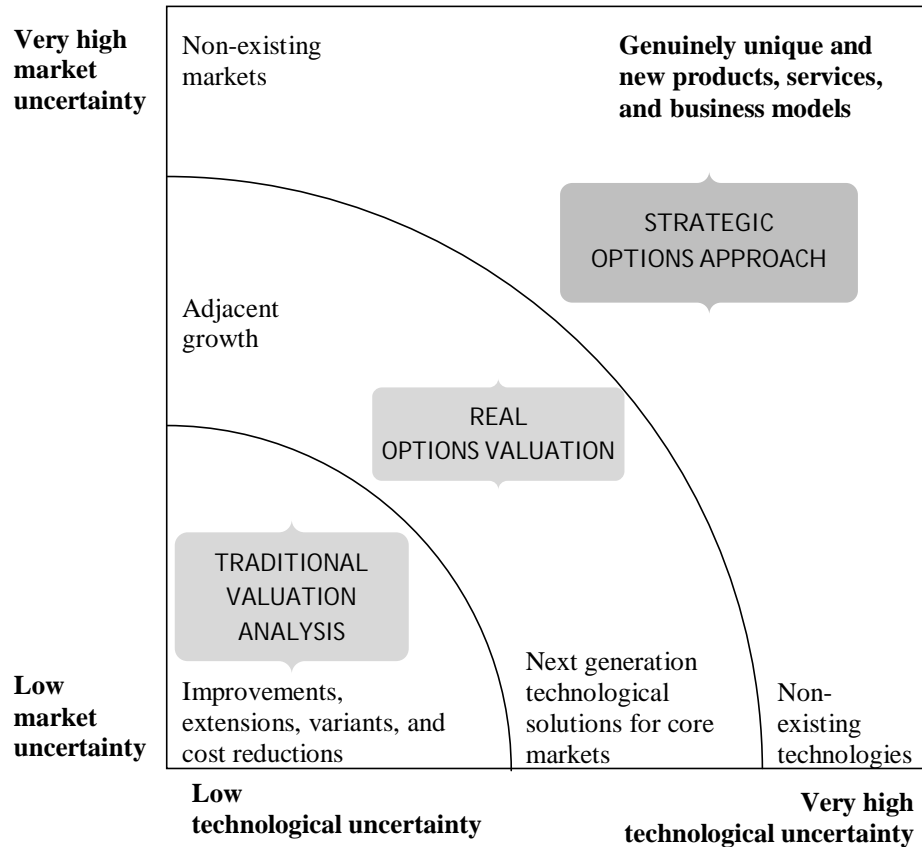
Real options theory:

- This study contributes new knowledge concerning the development opportunities of real options theory and the problems related to it in highly uncertain settings. The theoretical question of the differences between real and strategic options is raised, and the need for a systematic approach to a new kind of theory building is identified.

### **5.3. Managerial implications**

Managerial implications matter in constructive research. This study offers some tools for solving problems related to idea selection in the context of innovation, as listed below:

- It is shown that the real options approach is applicable to analyzing innovation opportunities in situations in which accurate information is missing: strategic innovation-investment decision-making under uncertainty is connected to real options.
- It is shown that even if the information required for option valuation is simplified, it can help management to find the strongest ideas.
- Management is challenged to think about how to approach future innovation opportunities under prevalent uncertainty and complexity.
- The study offers a perspective that helps management to develop the flexibility to respond more quickly to contingent future events.
- Thus, managers are able to obtain information about the capabilities and resources that are required by mapping the perceived uncertainties and trends against the possessed options, as normative scenarios, for example. They can literally see where they are and thus create a road map setting out the steps to be taken. In terms of technology selection, they can utilize decision-making trees that also support an illustrative way of thinking. The combination of real options, normative scenarios, trends and uncertainties with dynamic capabilities extends the work of Miller and Waller (2003).
- Figure 16 draws the boundaries between different views on investment analysis in which uncertainty is proposed as the determinant of the analytical method. It is suggested that management should utilize strategic options in situations of very high market or technological uncertainty.



**Figure 16: The boundaries of analytical methods (adapted from Terwiesch and Ulrich (2009))**

#### 5.4. Limitations

The methodological limitations of this study stem from the issues related to the case construction and the constructive research approach applied.

First, the presented cases concern only individual innovation ideas in isolation from the idea portfolio. Although decision makers in the real world confront the challenge of dealing with multiple ideas at the same time, the focus in this study is on the single idea. This simplification was made in order to simplify the theory building concerning strategic options.

The second limitation concerns the so-called market tests in the constructive research. The constructions presented require testing in a real-life context in order to see how well the theory reflects the reality in business life.

The third limitation arises from the understanding of real options. One could criticize the work for being theoretically limited to such option-valuation models such as Black-Scholes and the binomial model.

## **5.5. Future research**

I hope this dissertation will motivate other researchers to explore the strategic perspective and further develop theories of real and strategic options. Real options are defined in a variety of ways that concern options research and theory building. The terminology therefore requires clarification, and in particular the difference between real and strategic options should be studied and tested under different types of uncertainty.

The research on strategic options should also carefully examine the valuation parameters attached to strategic options, and seek new pricing solutions.

A research stream allowing decision makers to utilize the advances in real options valuation to handle imprecise information is emerging. The projection approach (including, e.g., fuzzy logic and outcome scenarios) has been suggested as a solution to the one-point evaluation problem involving a range of estimates showing the best, most likely and worst outcomes (see e.g., Carlsson & Fullér, 2003; Büyüközkan & Feyzolu, 2003; Mathews et al., 2007; Wang & Hwang, 2007; Collan et al., 2009; Jaimungal & Lawryshyn, 2011). This simple change in logic could strongly enhance the usefulness of real options theory with regard to highly uncertain strategic opportunities.

Normative scenarios combined with options approach were found to have the power to identify future requirements. Extension of this knowledge of required technologies and capabilities to portfolio management would make them even more valuable. A combination of multiple normative scenarios would enable the firm to see the similarities between idea requirements, and to move toward portfolio optimization. Future research should examine this more closely.

Finally, there is still a need to study how firms in dynamic markets can take better advantage of strategic options when they invest in innovation opportunities, and how they could manage the prevalent uncertainty in conditions in which future markets are thin or even non-existent. The research on strategic management should focus more on extreme situations that current management practices and theories do not properly account for.

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## **PART II: PUBLICATIONS**



# PUBLICATION 1

## **FACING THE FUTURE: COMPETITIVE SITUATION IN TELECOMMUNICATIONS IN TERMS OF REAL OPTIONS**

Edelmann Jan, Kyläheiko Kalevi, Laaksonen Petteri and Sandström Jaana (2004)

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## 6

# FACING THE FUTURE: COMPETITIVE SITUATION IN TELECOMMUNICATIONS IN TERMS OF REAL OPTIONS

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## INTRODUCTION

Despite the huge changes in the telecommunications industry since the 1980s, it is widely believed that more changes are yet to come, with profound implications for operators, manufacturers, software and service providers, and users. The telecommunications business requires large assets that can create tremendous sunk costs for the company. In order to be able to avoid these sunk costs, the real options approach suggests for example delaying the investment in order to decrease the uncertainty by obtaining additional information or increasing competencies through learning. As Copeland & Antikarov (2001:12) put it: “A deferral option is an American call option found in most projects where one has the right to delay the start of a project. Its exercise price is the money invested in getting the project started.” Companies can also create joint ventures or other forms of partnerships, such as real options (flexibility options) to expand in response to future technological and market developments (Kogut 1991:19). These examples provide the potential for flexibility through learning and easy funding (Belanger, 2001:2).

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It has been argued that none of the traditional valuation approaches to deal with uncertainty, such as decision-tree analysis, simulations, and sensitivity analysis have the capacity to deal with (radical) uncertainty as effectively and explanatorily as real options. Besides avoiding the sunk costs, the real options thinking is a means of capturing the flexibility of the management to address uncertainties as they are revealed. The traditional discounted cash-flow approaches (e.g. Net Present Value) to value projects (or assets) fail to account for this flexibility. While much of the discussion in telecommunications is focused on the irreversibility of investments, the flexibility that the management can obtain goes beyond deferring, and includes abandon, shutdown temporarily, expand, contract, and switch use as well.

The success of companies is influenced not only by the actors within the firm who are able to react as new information becomes available, but also by the actions of other agents or players outside the firm. They can be e.g. rivals, consumers or politicians deciding on new technologies, on new product types or on deregulation of markets. From this perspective, the strategic success of the company can be viewed as the outcome of an evergoing game. In this paper we will illustrate (in terms of real options) some basic strategic interactions and interdependencies among operators, manufacturers and software providers in the telecommunications industry.

## **DYNAMIC CAPABILITY VIEW OF THE FIRM AND EMERGENCE OF STRATEGIC ACTION SPACE**

Our point of departure in this paper is based on the *dynamic capability view of the firm*. According to it the competitive advantage of firms lies in dynamic capabilities which “are the capacity to sense opportunities, and to reconfigure knowledge assets, competences, and complementary assets so as to achieve sustainable competitive advantage” (Teece 2000, 27). Teece, Pisano and Shuen (1997) emphasize both the *internal* (strengths and weaknesses) and *external* (threats and opportunities) dimensions of this approach by stating that dynamic capability consists of “the firm’s ability to integrate, build and reconfigure internal and external competencies/capabilities to address rapidly changing environments. They reflect firm’s ability to achieve new and innovative forms of competitive advantage given path-dependencies and market positions.”

The dynamic capability concept here refers basically to the capacity to renew existing capabilities and routines and to generate new capabilities in a way that enhances the organization’s strategic responsiveness (Andersen et al 2001, 5). The basic idea is to utilize internal routines and capabilities in order to be able to achieve congruence with the changing, often turbulent the external business environment. This congruence idea (i.e. balancing internal capabilities with external environment)

emphasizes the key role of strategic management in appropriately adapting, integrating and reconfiguring the internal and external organizational skills, resources and functional capabilities to match the requirements of a changing environment. In this view, the firm's competitive advantage lies in the dynamic capabilities rooted in high performance routines operating inside the firm, embedded in the learning processes and conditioned by its history.

However, these internally explained core capabilities are always conditioned by existing and emerging opportunities in the external market and institutional environment. The interplay between *internally generated capabilities* and their replication mechanisms (i.e. learning and innovating) on the one hand and *externally conditioned opportunities and threats* on the other hand (together with good or bad luck as a stochastic factor) determines the ever changing and uncertain strategic action space where the strategic real options are to be found. Figure 6.1 below illustrates this strategically crucial interplay.

In our view, in the future particularly the dynamic capabilities – like the ability to choose the right R & D portfolio, to find a winning standard or mutually useful partnerships – will be major determinants in the success of companies, since strategies have to be based on the ability to create new growth options. On the other hand, the turbulent circumstances of the external market and institutional environment often make it necessary also to use other than growth options. Sometimes deferral, abandonment, or switching options may prove to be efficient strategy options. In fact, we can regard the firms and networks as reserves which generate flexibility to overcome the main problem faced by every firm, namely the fact that there is *no complete set of contingent forward markets* (cf. Sanchez 1993). This brings us to the crux of our paper.

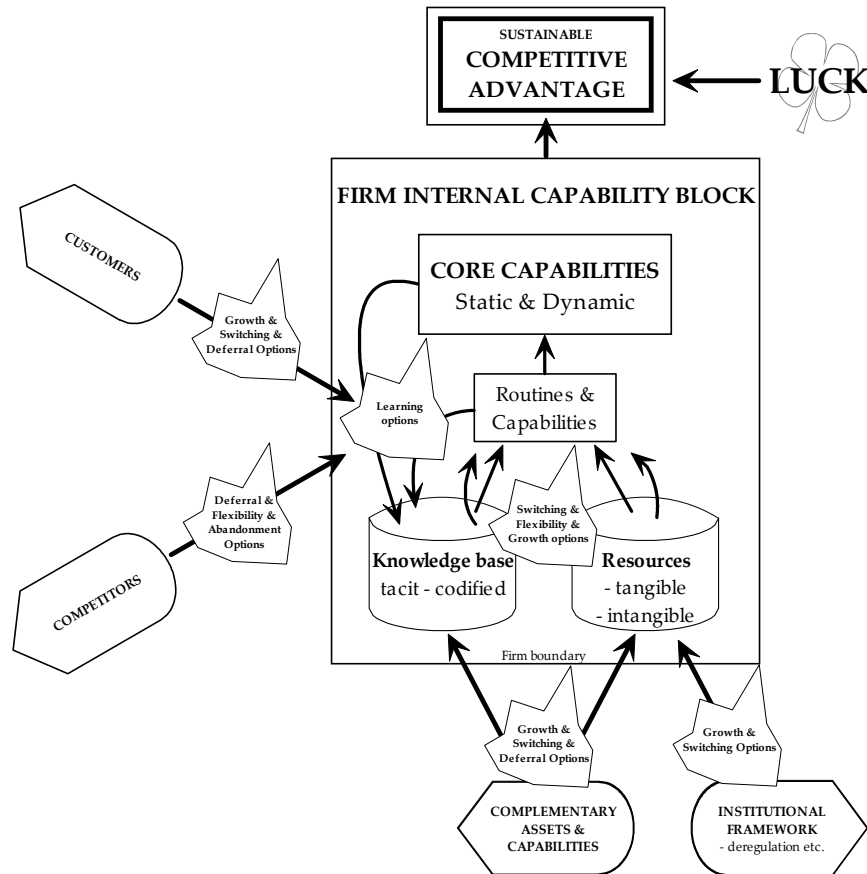


Fig. 6.1. Strategic options as results of interplay between internal capabilities and external market and institutional environment.

In our view, from the real options perspective the dynamic capability view can be reduced to (i) future-related choices between various projects, products, factors of production, partners, and customers in a way which makes it possible to achieve competitive advantage over rivals and to (ii) learning processes which make it possible to sustain the competitive advantage obtained through replication (cf. Blomqvist and Kyläheiko 2000). These choices always dictate the heart of strategic management, and must hence be based on (usually implicit) evaluation of various strategic options. In our view, however, this implicit evaluation needs more explicit methods that are *prospective*, capture the most relevant variables behind the decisions, and result in at least partly quantitative comparisons between the alternatives. We assume that the real options approach as a method can fulfill our expectations.

Just in this area the comparative advantage of the use of the real options approach is at its greatest (for a similar view, see Foss 1998). One cannot cope with prevalent uncertainty and relatively transitory windows of strategic opportunity without

grasping the mechanism creating strategic options thoroughly. In our view, firms and the interfirm networks between them (e.g. strategic alliances) can be interpreted as institutions, which try to generate *strategic flexibility* in the use of the most important, i.e. strategic, options. Interestingly, in this fairly abstract strategic options framework we can directly utilize the basic definition of an option, which is a right to choose whether or not to take some action now or at some future time. Another well known lesson derived from the basic financial options theory also holds true here: *the more volatile the cashflow, the more valuable is the option*. The reason is, of course, that the more volatile the price of the underlying asset is, the greater the potential positive returns (upside potential) are, whereas potential losses (downside risks) are limited to the exercise price of the option, which for example in the R&D context normally covers only the cost of development in all the sequences needed.

## **REAL OPTIONS APPROACH AS A STRATEGY MAKING TOOL**

While real options reasoning has traditionally been seen as an advanced valuation tool in the domain of finance, the strategic management oriented research focuses on the benefits it provides to strategy formulation. To be strategically responsive an organization must commit resources and build its dynamic capabilities within *flexible* structures, thus avoiding over-commitment in fixed assets. Consequently, in assessing the real-option literature we can distinguish two different paradigms: using the real-option-approach in strategic decisions, and using it as a valuation model in unique investment decisions. In this paper we use the real options approach in the strategic context. Briefly, in the strategic context the option theory supports option modeling features in choice mechanism underlying strategy and helps defining strategic options suitable for the strategic action space (e.g. Bowman and Hurry, 1993, Sanchez 1993, Foss, 1998; McGrath, 1997; Amram and Kulatilaka, 1999).

The option theory always copes with uncertainty: the value of the option is the greater, the greater the uncertainty is. In the strategic context uncertainty is mainly related to environmental uncertainty (Bowman and Hurry, 1993:766-767). Dixit and Pindyck (1994:47) distinguish between two forms of uncertainty: technical uncertainty and input cost uncertainty. In addition, McGrath (1997:977) defines a third form of uncertainty, lying between the two forms Dixit and Pindyck (1994:47) identify. It is present when the sources of uncertainty are largely “external” to the firm (i.e. not technical in nature) but can be influenced by strategic actions. This kind of “endogenous” uncertainty cannot be dealt with the traditional Black and Scholes options valuation models but is of great importance in our dynamic capability-based strategic options realm.

When controlling uncertainty and utilizing the opportunities opened by it in terms of the real options theory, the downside risk can be assessed and thus not-accepted alternatives may be avoided. If the downside risk is realized, the sunk costs will rise. In order to avoid the downside risk the investment can be for example delayed (*a deferral option*), or the size of the investment can be decreased (*time-to-build option/staged investment*). If the initial large investment is split, the small investments support learning before large investments (*learning option*). The above option alternatives always include also the option to *abandon* the project. On the other hand, the upsides that are rejected in traditional discounted cash-flow approaches (e.g. NPV) can be taken by identifying *growth options* through learning and innovating during the project. To put it briefly, real options provide flexibility through limiting the downside risk while maintaining access to upside potential at the same time.

Sanchez (1993) stresses the flexibility of strategic decision making. According to him the flexibility concept can be considered from two different aspects: *uncertainty and uniqueness*. The greater the (mainly externally determined) uncertainty, the more flexibility there exists - first, because of a wide range of final outcomes of the strategic process, and second, in making decisions so that the downside risk will be eliminated. Uniqueness is based on firm-specific internal capabilities relevant for strategy decisions.

Belanger (2001:4) analyzes flexibility with the timing of options as follows: “the wait and see attitude embodied in a flexibility approach may reduce the lifetime returns of a strategic direction (denying the firm any benefits of first mover advantages and potentially locking out opportunities in some industries), but is expected to increase the probability of a successful course of action being pursued”. However, in our research subject, the telecommunications business, we often face the opposite case mainly due to strong network externalities in consumption and lock-in tendencies in technologies (because of standards etc.). Hence, it can often make sense to forget the wait and see options and undertake an outright and immediate launch in order to gain first-mover advantages.

Steinbock (2001:96-97) analyzes the importance of first-mover advantages in the Finnish telecom/mobile cluster and draws a conclusion that typical first-mover advantages can explain the success of the Finnish telecom companies during the 3G mobile era. The Finnish firms have managed to exploit the advantages derived from the first mover’s reputation effects, high switching costs, economies of scale associated with marketing mix and brand creation, continuous capability-enhancing learning and asymmetric information due to privately shared information within the culturally united scientific/engineering community. As a result, the Finnish telecom/mobile cluster has grown, expanded, specialized, and diversified amazingly during the last ten years.

## **COMPETITIVE SITUATION IN TELECOMMUNICATIONS INDUSTRY**

The present competitive situation in the telecom market is much more complicated than it has ever been. The question is how the emerging technological change affects in the competitive situation of the telecom industry when the outcome will probably be the Mobile Internet. In this situation technologies and large companies will collide when two huge markets – the Internet and Mobile market – are combined. As noted by Christensen (1997), technologies can be either sustaining or disruptive from the industry's capability point of view. When the two above markets will merge, the technologies sustaining the Mobile market, like EDGE (Enhanced Data rate for GSM Evolution) and UMTS (Universal Mobile Telephone System) will be disruptive from the Internet operators' perspective and similarly the prevailing Internet technologies, for instance W-LAN (Wireless Local Area Network), will be disruptive for the mobile operators (Figure 6.2). Steinbock (2001:97) illustrates this kind of development succinctly as follows: "The rise and expansion of the Finnish [telecom] cluster coincided with the second-generation digital cellular in which Nokia dominated handset sales and Sonera became the pioneer of mobile commerce and services. In the 3G environment, however, the competition would be highly complex, intensive and global"

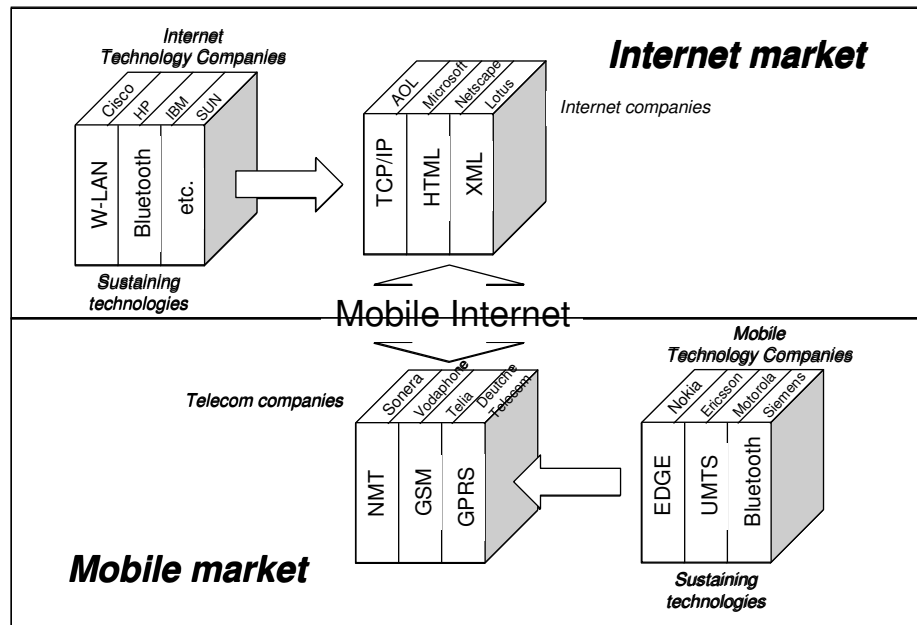


Fig. 6.2. Description of technological change in the Mobile Internet.

Figure 6.2 does not illustrate the whole complexity of the competitive situation in the merged market, because it excludes both the terminal market (PC and Mobile phones) and the operating system (Windows, Linux and Symbian) market. The forces of the user groups (like operator forums) or customers, especially large industrial ones, are also excluded in this context in order not to complicate the picture. If these matters were taken into account, the decision would be very complicated because the decisions would be compromises or agreements between the players rather than independent decisions of a party.

## TECHNOLOGY CHOICES IN TERMS OF REAL OPTIONS IN TELECOMMUNICATIONS

Figure 6.3 below illustrates the main players and interactions within the whole telecom industry. The interdependencies between various players are not described here in detail. However, some more illustrative examples as to the strategic options open for the players in the changing competitive situations will be given later in this paper. It is worth mentioning that the diagonal of the game matrix shows the gray cells where traditional inner industry-based competition rules. Interestingly enough,

the most interesting and valuable strategic options cannot be found there. They lie somewhere else, which will be analyzed later.

	<b>Operators</b> (Vodafone, NTT DoCoMo)	<b>Device</b> <b>Manufacturers</b> (Nokia, Motorola, Ericsson)	<b>Network</b> <b>Manufacturers</b> (Nokia, Ericsson)	<b>Operating Systems</b> Manufacturers (Microsoft, Symbian)
<b>Operators</b>				
Device M.				
Network M.				
Operating Systems M.				

Fig. 6.3. Interaction matrix of main player types of the telecom market (the names of the firms are just illustrative).

All the players in the telecommunications business are becoming more and more dependent from each other. At the moment, it can be roughly said that network and operating system manufacturers earn their money from the operators and the operators from the end customers, i.e. consumers and companies. But the game situation is rapidly changing. To give an example, we can look at the rapid convergence of the mobile and computer (internet) world which opens up new opportunities especially for the end users. So far the mobile usage has been centralized on normal mobile phoning and short message sending (SMS), thus benefiting the operators. In the brave new world, however, the mobile phone users will be able to utilize PDAs (Personal Digital Assistant) - in other words handheld computers - and comparable devices as mobile phones as well. This will change the game set-up dramatically in favor of users. Their bargaining power will be increasing, which will have repercussions over the whole game matrix presented above.

All this can be traced back to the rise of new technologies called GPRS and W-LAN. The handheld computers contain more and more technologies that make it possible to use them in the meaning of a mobile phone; the old circuit-switched network was inefficient and expensive. The recap is that the old definition of the mobile phone is changing.

The external technology-induced threat faced by the telecom operators will be a threat for the network and mobile phone manufacturers as well. They are also losing their bargaining power and therefore the opportunities to exploit their former first

mover advantages. Even the traditional Porterian externally biased strategic framework gives a first clue as to what to do: if the source of main revenue dries up, and in other words, rival techniques corrode the existing ones, new business models, earning logic and/or shielding techniques have to be launched. In terms of strategic options we can conclude that so far the business runs fine from the perspective of an operator as it enables for all the players to operate with the old business models due to old path-dependent capability enhancing technologies. In this situation the bargaining power of an operator is based on the high switching costs and the lock-in phenomenon which hinders the users from exiting. However, the external threat is more current when all the pieces are ready for users to bypass the operator i.e. when new technologies makes it possible to radically lower the switching costs, thus strengthening the bargaining power of the end users. In this new situation the manufacturer's position will also be in danger. It may lose its milking cow (i.e. the operator).

Again we can look at this situation in terms of strategic options. If things go wrong for manufacturers it may happen that their old path-dependent cumulative (dynamic) capabilities are in jeopardy. They may face the rise of competence destroying (disruptive) technologies which can alter the whole bargaining power structure of our game matrix. This means that both the operators and manufacturers have to think about different strategic options to be able to overcome the new situation. Of course, they can wait and see but there are great risks to be overdriven by new rivals. They can also try to bet on the winning horse and form a partnership or strategic alliance with it. The risk associated with this strategy is the danger of getting "held up" by the providers of new technologies. In the new situation the providers of the most important strategic complementary capabilities may take the whole jackpot. Of course, there is always a risk to bet on the wrong horse as well.

Now we will take a more detailed look at how today's operators and manufacturers can be passed by customers. The handheld computers provided in malls, other than Nokias, can be boosted e.g. with the W-LAN function. This means that these handhelds can be used in the limited area as mobile phones with appropriate software. To expand this LAN the areas have to be linked somehow together and this means nodes. We will not get into more technical details here but the most important fact from the game matrix perspective is that wide LANs are possible. The users – today's lead users, really can pass the operator.

The more open the system is, the more possibilities of this kind will be opened up to customers. But can the customers do the things described above? Of course they can. Linux users are a good example. About seven years ago Linux looked like Unix from the average person's point of view. Today's Linux looks more like motored and reliable version of Windows. The boom of Linux will likely happen in the near future.

In turn, it is now reasonable to believe that this all could happen also in mobile phones. This depends on the actions the Internet community.

Due to uncertainties and the speed of the diffusion of new technologies, the capability to invest in all technologies simultaneously is limited, even for the largest operators in the world. The merging industries also lack knowledge in their disruptive technologies. In this situation the device manufacturers, for example Nokia, have an opportunity (i.e. strategic growth option) to continue in the old established GSM path, i.e. to use GSM and extend it with HSCSD and simultaneously take GPRS under development (i.e. to use the strategic deferral or even the learning option). The other strategic alternative for Nokia would be to take the other development path, i.e. the W-LAN path. However, the W-LAN has so far not been typical technology for mobile phones. This in turn means that for Nokia the W-LAN strategic option involves substantial technological uncertainty whereas the GSM path uses established technology. In this kind of environment the strategic use of real options connected to the technology choice can be at its best. Figure 6.4 below illustrates our Nokia-inspired example.

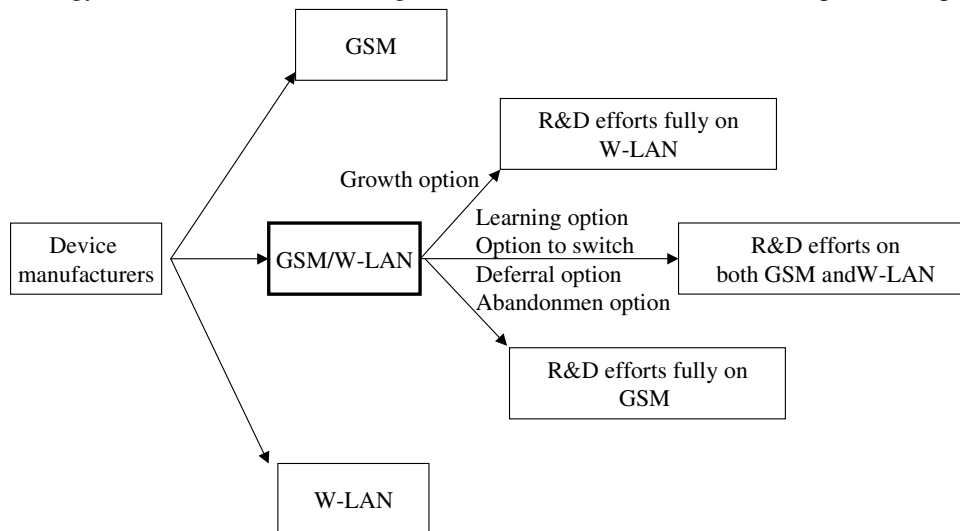


Fig. 6.4. A decision framework for a technology choice of device/network manufacturers.

From Figure 6.4 we can see that a device manufacturer, for example Nokia, actually has three basic choices: 1. to stay in the GSM-based established technology, 2. to invest in the development of W-LAN technology to be used in the devices, and 3. to make a strategic switching decision to change the technology from GSM to W-LAN. The company has the possibility to take a *deferral option* by staying at the GSM path and investing in the development of W-LAN. The opposite case, i.e. trying to take the first mover's advantage by committing to W-LAN technology includes a huge amount of

uncertainty, but also opens up potential for a tremendous upside, if the technology becomes a success among consumers. By taking a deferral option and investing gradually in W-LAN technology the company can learn more about the new technology-related capabilities and gain more information about the reactions of the market. Taking the *switching option* would need much more development efforts as the W-LAN technology has to be ready if it is wanted to be a real substitute for GSM.

Consequently, the size and the risks of the development investment in W-LAN technology determine the readiness of the company to adopt this new technology in its devices. If the W-LAN-related development investment is assumed to be little, the company can take *the option to learn and the option to wait*. On the other hand, if the company invests heavily in the research and development of W-LAN, it takes a switching option which enables it to use either GSM-based technology or W-LAN technology later. The device manufacturer can also *abandon* the new technology, i.e. W-LAN, during the course of the time, and continue the business with GSM-applications only.

The operator faces a different decision situation related to the technology choice (see Fig. 6.5). The crucial decision the operator faces is the decision about the capacity level it intends to operate with. Figure 6.5 illustrates this decision situation in terms of strategic options.

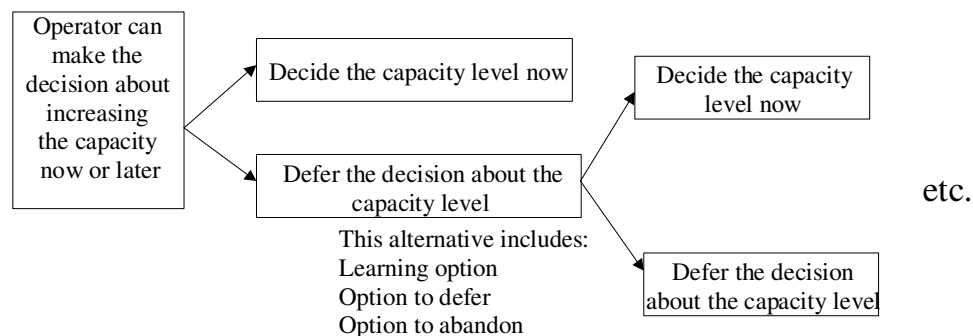


Fig. 6.5 A decision framework for the technology choice of the operator

Figure 6.5 is fairly straightforward. Only one comment is worth explicating. By postponing the decision (deferral option), the operator can gain more information and learn more about the behavior of the customers. The value of this learning option can be calculated.

## DISCUSSION AND CONCLUSIONS

In this paper we have analyzed the possibilities of utilizing the real options approach when trying to shed light on the complicated issues of strategic alternatives in the ICT sector. In our view, the real options are especially valuable for projects, that involve both a high level of uncertainty and opportunities to dispel it, as new information becomes available (Kyläheiko 2001). Within these projects the options to defer and learn, abandon, expand, extend, or switch can all be applied. However, in the telecommunications business there is little time to learn to know the volatile markets or constantly emerging new technologies. Considerable first mover's advantage-related rewards may be gained, but the players also face considerable risks. In such a turbulent business the players need to have flexibility in their strategic decisions for example by making strategic alliances, i.e. using the option to contract. The firms can also use growth options e.g. by acquiring high performance high tech companies with good teams in order to get the needed programming capacity for product development.

One implication especially stressed by Foss (1998) seems to be worth mentioning in this context where uncertainties are high. In such a situation the use of networks seems to be very important because they make it possible to obtain new dynamic technological and organizational capabilities that are not normally easily available in the open markets. "Networks can be viewed as a pool of resources, constituting a greater variety of reserves than can be accommodated within the necessary constraints of a single firm" (citation of Loasby, see Foss 1998, 16).

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# PUBLICATION 2

## **DECISION MAKING PROCESS COMBINED WITH STRATEGIC OPTIONS APPROACH IN INNOVATION PROPOSAL SELECTION**

Edelmann Jan, Koivuniemi Jouni, Laaksonen Petteri and Sissonen Antti (2003)

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# **Decision Making Process Combined with Strategic Options Approach in Innovation Proposal Selection**

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**The decision making in innovation proposal selection has traditionally based on e.g. decision trees, performance metrics, and decision networks. Increased efficiency in innovating processes has helped to generate new ideas and innovations quicker than ever before, which has increased the innovator's selection problems considerably. The decision making should not be seen as a final act, and this view should be installed in the whole innovation proposal selection process, including understanding about how to be prepared for the changing future where flexibility has value. The literature has widely agreed on how inadequate the traditional valuating tools are, and the same time it has proposed the real options approach to be a very advantageous solution for valuating future investments. However, we have seen very few real solutions showing how to really use the strategic options approach in the innovation selection. We approach this issue by presenting one possible way to choose the R&D innovation proposals from a great number of ideas with a tool that is based on the real options approach.**

## **1. Introduction**

The fundamental phase in the innovation process is the evaluation of the generated ideas, but very often it is not appropriately performed (Calantone et al., 1999). Experience suggests that some form of a structured development system with clear decision points and agreed rules on which to base the decisions is needed (Tidd et al., 1997).

The evaluation process begins where the process of generating ideas finishes. The key issue is to decide what are the most prominent ideas that can be developed into actual applications and businesses that are not only profitable for the firm, but also beneficial for the customer.

Managing the innovation process is an act of balancing between the costs of continuing with the evaluation and the danger of eliminating potential fruitful

options (Tidd et al., 1997). There is a trade-off between gathering enough information to support the decision making and actually making swift decisions. How to take into consideration all the critical factors when choosing which supposedly top ideas the firm should direct its scarce resources to?

In an ideal situation the decision maker has immediate access to perfect information about all the ideas, i.e. they are developed all the way into working applications that are tested and used. This would eliminate the risk of dropping off an idea that at first sight seems poor but in the light of perfect information turns out to be excellent.

The limiting factor that makes the ideal situation impossible is the availability of resources for the firm, especially time and money. On the other hand, new ideas are not a rare resource. Tens of ideas can be generated rather quickly; the problem is choosing the ideas which to start with among them.

The selection of R&D projects is not a new topic in the literature, and a number of different kinds of evaluation methodologies have been developed in categories such as: financial, strategic, quality, environment, market, and technological (Linton et al., 2002). A great number of different kinds of idea selection processes have been presented, but there is an absence of the kind of tool described in this paper. We will put forward a preliminary idea on how the strategic options approach could actually be used for choosing ideas from an idea set to be developed further.

We approach the question from the individual innovation point of view rather than from the portfolio management point of view. We form a questionnaire to solve a part of the problem of using the real options approach in the idea selection. We leave the portfolio management examination out of this study, limiting the examination in isolated ideas.

### 1.1 The design process

Koberg and Bagnall (1991) have presented a seven-step process *The Universal Traveler*, which is a cycle that will continue so far that the final products have been developed (acceptance, analysis, definition, ideation, idea-selection, implementation and evaluation). We follow this kind of design process where the idea selection is only one part of the whole process, and for instance the innovation evaluation will be done separately. We consider the project selection as a continuous process where the project should be periodically reviewed and re-evaluated (Twiss, 1986).

In terms of real options, R&D projects are usually carried out through multiple phases where it is always possible to stop continuing the series of subsequent steps. These kinds of option-to-option cases are called compound options. Each step is a source for new information, knowledge, know-how and firmness of the investments' success possibilities, enabling the decision maker to stop at any point. (Brach, 2003)

It is not unusual that dozens of R&D projects are started, and most of them are abandoned in their original form. The problem the firm faces is that it usually has to

have a lot of resources and time to do this. For instance, it took Gillette ten years and \$1050 million to get its razor blade MACH3 from idea to market, including six different innovations and multiple phases (Herath & Park, 1999). "*The innovation is a quest into the unknown*" (Teece, 1995).

### 1.2 Project selection

According to Cooper (1999) the project selection faces basically two kinds of problems: 1) the project ideas are simply bad, 2) there are far more opportunities than resources. What we are interested here, is a situation where the firm has so many project ideas that it cannot decide what to invest. We approach the dilemma with the question: how could the real options approach be used as a (Cooper's) Gate? (See Cooper, 1999)

In this paper we concentrate only on the early phase of the project selection (Cooper, 1997), where the selection based on the real options approach will give trendsetting results that can be used as a start for more specific idea valuation. We hypothesize that the real options approach can be used also throughout the whole selection process. This will be studied in the near future with the innovation session data presented in this study.

The project selection has been under academic discussion since the 1960's, and hundreds of publications under that theme have been published, the approaches being either quantitative or qualitative from "*rigorous operations research methods to social-science-based interactive techniques*" (Henriksen & Traynor, 1999). The discussion around the real options approach started in the 1970's and has increased its popularity steadily, especially in the late 90's (see Collan et al., 2002).

Even though the real options approach is in many sources considered to be a capable tool for selecting investment projects, we still lack real options tools and studies that could solve the managements' problems in idea selection by the real options approach. An excellent theory and philosophy is not enough in this case.

## 2. Idea selection and decision making models

The management has many different kinds of methods to be used in decision making. The decision making in the innovation proposal selection is typically based on for instance: decision trees, performance metrics (such as NPV, ECV, ROI, EVA or the payback period), experience and intuition. The use of R&D project selection methods is, however, rather uncommon in firms, particularly the use of complicated mathematical tools, whereas simpler methods are used more frequently (Higgins & Watts, 1986; Martino, 1995).

The reality shows that the financial tools are the most favored, but not systematically used, in many cases. If there is a strategic decision to be made, experience and intuition gain ground (Zhu, 1999) because of the uncertain and unpredictable future. We have noticed that even when the decision is strategic in nature and the

management “feels” that the decision should be a certain decision, the management wants to get some numbers on the table to support the decision making.

The innovating of new ideas is a straightforward process and it has been shown that very easily tens of new ideas can be generated by brainstorming in a short time (Laaksonen et al., 2001). Koen et al. (2002) have observed that in most cases the problem is not how to generate new ideas - the problem is in selecting which ideas to follow to achieve the most business value for the future health and success of the business.

A great number of different kinds of methods for evaluating and selecting ideas, innovations and projects have been developed. Cooper (1999) has listed some *project selection methods*, such as: economic and financial methods, business strategy, bubble diagrams and portfolio maps, scoring models, and checklists. We can widen the list by different kinds of *decision making methods and models* described by Büyükoçkan and Feyzolu (2003): probabilistic models, options pricing theory (OPT), scoring models and check lists, behavioral approaches, analytical hierarchy process (AHP), fuzzy logic, sensitivity analysis, and scenario analysis. The lists overlap in some parts, and the latter list is more complementary than substitutive.

Noteworthy is the considerable number of the methods. Even though a great number of different kinds of methods have been developed, according to Koen et al. (2002) there is no single process that will guarantee a good selection and a combination formed with an iterative process is more likely needed. They also remind that the financial approaches are often only wild guesses and should be used in later phases.

### 3. The logic behind the real options approach

The real options approach (ROA) has its roots in financial options and mathematical option pricing. The logic was adapted to real life cases and the real options were discovered in the 1970's. On these bases we can divide the approach into two different methods that can be kept separated or treated as one method. The real options approach includes a qualitative (philosophic) approach and a quantitative (mathematic) approach (e.g. Naukkarinen et al., 2001).

#### 3.1 Managerial viewpoint

The logic behind the real options comes from the real life, and the mathematical basis defines the rules through the philosophy of the approach. The real options approach states that if a decision will be made it is not final until the decision maker has fully committed himself to the investment and there are no more options available.

Even though the options pricing is a brilliant idea, the mathematics behind the approach is too complicated for a manager planning to use this approach in every day business. The ability of the different option pricing

models to use different states of input variables is creditably described in Perlitz et al. (1999) and Angelis (2000), which state that the B&S-model and binomial model are not capable of handling multiple options well and the Geske-model is more suitable for this.

The approach is complicated and Byzantine, with many diverging option pricing formulas. The management needs a simple and fast tool that gives a simple result at least for the first. But is this too much to be asked for applications of the real options approach? We do not give a final answer in this paper, but we argue that the approach should be considered from a different perspective than it has been done before.

#### 3.2 Applying the real options approach

In this paper we will concentrate on the question, how the real options approach can be used in idea selection. The question includes a lot of uncertainties about what could be the best approach in the ways of using the ROA.

First of all we have to decide whether we want to approach the product and business model ideas with a qualitative or a quantitative method. The ideal situation from the managerial point of view is to get a simple list presenting the option values, risk values and all economic data. Unfortunately that can be too time-consuming (i.e. Bräutigam et al., 2003) and we are forced to disregard that possibility in the situation where we have hundreds of ideas to evaluate.

The second issue that should be decided on, is which option pricing method to use, because they all have some special characteristics. In this paper we use a combined approach. The differences between the models are quite narrow from the first selection phase point of view.

The managerial mindset is tuned for numbers, and the theory of the option pricing approach is ideal for that, even though the use of the real options approach may require a totally new way of thinking (Day et al., 2000). Our experience shows that calculating the option values, even for one project idea, is not trouble-free: idea selection done on the mathematical basis can be too slow and difficult (see Day et al., 2000). The required numbers can always be installed in the model, and the uncertainty about their accuracy can be decreased by using for instance the fuzzy logic approach (see Carlsson & Fullér, 2001).

The problem concerning the use of ROA from the management's point of view is simple: using the real options approach as commonly proposed in the literature is just too time-consuming. You can run the process from the beginning to the end for a handful of ideas, but not for a hundred ideas. A manager can handle probably five different project ideas well, but an increase in the number can be seen as a decrease in the quality of evaluation. There may be arguments against this, but we approach the issue from the managerial point of view.

The evaluation process should start so that it is possible to cut down the number of ideas that are attached to the options valuation process later. A fundamental question is: does the idea or innovation include real options that are valuable for the firm? However,

consideration of the real options is a very awkward and time-consuming task.

### 3.3 R&D and real options

There exist a lot of studies on how to apply the real options approach in the evaluation of R&D projects. Specific to these studies is that a big part of these studies concern single R&D projects (Schwartz & Moon, 1998; Perlitz et al., 1999) and how the real options approach could affect the evaluation and valuation as compared to other methods. Common to most of the publications is that they do not try to put i.e. projects and innovations in order.

A different approach presented in this area is McGrath's and MacMillan's (2000) strategic technology assessment review (STAR<sup>®</sup>) method. The purpose of the method is to assess uncertain projects and the option valuation. Noteworthy is that the approach is closer to the managerial mindset than seen in the field of real options before. The only problem with this method is that it has too many questions (166 questions in 15 different sectors) to be answered. It is obvious that this kind of evaluation model is suitable for projects that are in final stages in the selection process.

We have also discovered that the projects and cases that are evaluated usually have a market price; illustrations of projects that aim for future markets (lacking the real market price) are rare. We went through 73 publications that included different variations of real-option applications and found that approximately over 50 % of them were interested in an underlying security that has a direct market price. The reason probably lies on the option pricing formulas that require a market price. Another observation was that the most of the papers concentrate on valuing objects individually and there were no intentions of ranking the projects on the basis of their real value.

### 3.4 Value of the real options

To put it simply, investment decision making is about managing two types of risk: technological uncertainty (including technical uncertainty) and market uncertainty (or private and non-private). If the investment target does not include considerable uncertainties or strategic opportunities (as real options), the investment calculations can be made with the capital budgeting tools' accuracy (DCF & IRR). There is no additional advantage in using the real options approach for valuating the investment.

Many, but not all, R&D projects have built-in flexibility. This means that they include options like the option to contract or expand, option to abandon, and option for further development. Added to this, in many cases the project can be designed to contain more flexibility. In terms of real options, the flexibility means value.

The management is most interested in finding out the value of each innovation. With the real options approach

we should find out the variables that are the value components of the innovation. If we are able to get some values for the ideas, we are also able to say something about their importance for the firm.

It has been stated that increase in technological uncertainty will in some cases decrease the option value, and an increase in market uncertainty will usually increase the option value (Perlitz et al., 1999; Boer, 2000). As an example we can say that the greater the variance in possible market value, the greater is the possibility to achieve great wins or losses. If the technological uncertainty is high, the risk can be decreased only by investing time and money. On the other hand, high technological uncertainty will not increase the possibilities to be successful in the current business, but will increase the potential upside.

The option value factors based on the option pricing theory according to Trigeorgis (1997) and Perlitz (1999) are presented in Table 1 (+/- influence on the option value):

**Table 1 Factors affecting the value of real options.**

- |    |   |
|----|---|
| 1) | Volatility of the potential outcomes/value of the underlying asset        |
|    | a. Market uncertainty (+)   |
|    | b. Technological uncertainty -)/(+)                                       |
| 2) | Present/expected value of benefits/cash flows of the underlying asset (+) |
| 3) | Expected investment/implementation cost (-)                               |
| 4) | Time to maturity (+)  |
|    | (time until the opportunity disappears)                                   |
| 5) | Risk-free interest rate / Time value of money (+)                         |
| 6) | Payments lost while waiting to invest (-)                                 |

The values for the options related to the ideas can be calculated on the basis of their factors. We will not go into a detailed level of the option pricing values in this paper, but good sources for this are Faulkner (1996), Trigeorgis (1997), Herath and Park (1999) and Angelis (2000).

## 4. Approaching the issue of multiple ideas

We have arranged GDSS-innovation sessions for companies from ICT and forest industry (more specifically paper industry) and during the sessions the firm representatives have brainstormed approximately 250 ideas related to their business in the field of wireless applications and new business models. After one year, most of the ideas have remained untouched. In other words, the firms have had some difficulties to adopt the ideas in their R&D process or even shorten the idea list systemically. We aim to offer them an alternative tool.

#### *4.1 GDSS innovation session*

The developed full day GDSS session process aims to be a resource for generating new business model ideas originated from the opportunities the wirelessness and mobility open up. The process combines for instance von Hippel's (1988) Lead User process, Hamel's (2000) revolutionary business model approach and the group working with a computerized GDSS-system (see Laaksonen et al., 2001).

The innovation session takes approximately half an hour with a group of ten participants. When the brainstorming part is finished, the lead user group has generated at least 50 different ideas on how wirelessness and mobility can be utilized in their business. The ideas can, for instance, be on the area of process rationalizing, or, in the best case, change the boundaries of the business or significantly reformulate the current business.

#### *4.2 The generated ideas*

Taking a closer look at the innovation sessions we have held it can be seen that most of the ideas are related to the current business. The result of a rapid review is that at least a tenth of the ideas can be considered as new business concept ideas that may include strategic options.

A great portion of the ideas is composed of so called improvement ideas, the effects and costs of which can be estimated quite easily. But are there any new capabilities created while trying to achieve an effective way of working? If the answer is no, the effects can probably be calculated with traditional cost accounting methods.

During the evaluating part of the session days, the firms' lead user representatives have evaluated the ideas to be approximately very profitable and significant for their business. We have kept an eye on the firms that have taken part in the innovation sessions and have noticed that they have been incapable to properly choose from that number the innovations which to start developing further. We claim that the problem the firms encounter is that the profitability and future actions are too hard to be evaluated and justified, with the financial tools and policies that are widely used in the business environment that dominates today's business activity.

#### *4.3 Building a questionnaire for innovation selection*

The first phases of project assessment do not necessarily require cost justification (Lawson & Finkelstein, 2002). Cooper (1999) continues that too early use of financial analysis in the project evaluation can beget damage, and the financial analysis should be limited to known projects. Therefore, the steps before the financial analysis should be qualitative and non-financial considerations, and the use of financial techniques should be avoided until the later phases of the project evaluation.

The real options approach is a twofold method for evaluating investment proposals. The approach is suitable for being used either as a strategic evaluation tool or as a

mathematical valuation tool. In accordance with the literature we follow the quantitative part of the approach keeping in mind the regulations of the options pricing. The next chapter will present a tool for idea selection based on the real options approach and its philosophy.

### **5. Questionnaire for identifying ideas to be handled through the real options approach**

As noted above, the real options approach is very time-consuming. When there are more than five ideas to be evaluated with the real options approach, there arises a need for a tool for cutting down the workload. We believe that an efficient questionnaire could be that kind of a tool.

We have built a short questionnaire (Table 3) that can be used for finding out which innovations can be handled further with the real options tools and which innovations can be left for other methods (see Henriksen & Traynor, 1999). The result after the first round is not final, but a good start for making the decision making process more effective. If the number of ideas to be evaluated with the real options approach will decrease by 90 %, it will be considerably easier to focus on the rest 10 %.

The questionnaire is built on the basis of the real options approach theory and the evaluation through questions follows the mathematical basis of option pricing. The model that is behind the questionnaire will give the ideas a relational value that can be used for putting the ideas in an order. We are able to change the weightings according to our preferences when the values are calculated.

The outcome of the questionnaire is that the ideas are separated in two different groups. The first group is those ideas that very likely include some valuable options. They can be evaluated and valued further with options pricing tools. The other group includes ideas that should be evaluated and valued with traditional financial methods like NPV; the use of real options approach is just waste of time.

Another valuable feature of the questionnaire is that it helps to identify the characteristics and, as mentioned, the relational value of the idea. Despite this fact, the questionnaire has not been designed for valuating the ideas, and a more detailed valuation will be performed later. Then again, the questionnaire does not try to give a direct answer for which ideas are bad and which are not.

#### *5.1 Forming the questionnaire*

The questionnaire should take into account the boundaries of the real options and concentrate on factors that define the boundaries. In Table 1 the factors affecting to the value of real options are presented. These factors are essential for forming a picture of the ideas and their possibilities. The questionnaire will find out the real option variables, such as uncertainty, incomes, costs, and time scale.

Based on the boundaries of the real options we are able

to limit the number of ideas that will be put in the real options approach evaluation process. Adner and Levinthal (2002) have illustrated the difference between the NPV and real options on the basis of irreversibility and uncertainty. They have also illustrated the difference between the real options and path dependent investment. We can say on the basis of the value of one variable or a combination of the values of various variables, whether the real options approach should be used.

The factors behind the option pricing theory are extensive, but we include also some test factors that possibly affect the value of the idea. In Table 2 three test factors are presented.

**Table 2** Factors that may have crucial influence on the value of the idea (continue to Table 1).

7) Competition
8) Managerial flexibility
9) Irreversibility

The mentioned test factors are included in the questions presented in the preliminary idea appraisal form (presented in Table 3). The questionnaire includes twelve questions in nine categories. Each question aims at getting information about the ideas significant in each category. Short explanations are presented in the following:

1) **UNCERTAINTIES**: Uncertainty is a very important real option value component. As mentioned above, the uncertainty can be twofold. The influence of market uncertainty is positive concerning the option value and on the other hand technological uncertainty can decrease the real option value.

2) **IRREVERSIBILITY**: The irreversibility of an investment increases the investor's risks of the sunk costs and fixed costs (Dimpfel & Algesheimer, 2002). Increase in the rate of irreversibility decreases the management's flexibility and thereby "*the greater the irreversibility, the higher the value of the option to defer investment*" (McDonald & Siegel, 1986). As opposed to this, "*the greater the irreversibility of an investment, the lower the value of the option to abandon*" (Myers & Majd, 1990).

3) **MARKET VALUE**: Financially the market value means the cash flows that could be achieved. If the market uncertainty is high but the size of the market is small, the actual possibilities are low.

4) **GROWTH**: The investment may be necessary for further investments, or to achieve a new level in doing business. This category includes also new business models.

5) **FLEXIBILITY**: A new business may increase the firm's ability to shift on markets and give it new operation possibilities.

6) **IMPACT**: Radical change in the business environment may have crucial effects on the market size and the growth possibilities. Even competition may become harder.

7) **TIME**: The investment decision is not a now-or-never decision, and the decision can therefore be postponed as long as the option to be deferred is alive. Additional information will lower the uncertainties and thereby the value of the option to be deferred.

8) **SCALE OF INVESTMENT**: How much money has to be invested to adopt the idea? Is the need large compared to the annual budget?

9) **STAGING**: What are the possibilities to stage the investment in smaller pieces? This will increase the flexibility. There is no obligation to continue if it is noticed later that there are no real business possibilities. Only the invested assets are lost.

The order of the questions is preliminary. In an ideal situation the questionnaire is built so that if one or a combination of answers will be answered in a particular way we can without doubt say that the idea does not include real options. In that case, the real options appraisal can be stopped immediately and the idea can be put in the other basket of ideas that can be evaluated best with some other method.

## 5.2 Implementing the questionnaire

The ranking of ideas by the questionnaire can be done in many ways, but we suggest that a mean value or a weighted mean value is used. The scale can be from 5 to 1 where "Very high" gets the value 5 and "Very low" gets the value 1. The mean value will then vary between 1 and 5 without any weightings. The questionnaire can be filled directly in Excel and the values can be calculated immediately.

The result is that those ideas that will get a low mean value include very few real options or are less attractive from the firm's viewpoint. Another way to use this questionnaire is to select some factors that are especially followed. If the firm wants to avoid technological uncertainty it can weight the value with a negative weighting coefficient having a negative influence on the mean value and idea ranking.

Some options are adversarial and that complicates the process of putting the ideas in order based on the real option values. It depends on which options are important for the firm.

The next step in developing the questionnaire is to test it and make the necessary correlations. The version of the questionnaire presented here is a draft for academic discussion.

**Table 3 Preliminary idea appraisal form. (NB: Layout error in the conference proceedings corrected)**

<b>PRELIMINARY IDEA APPRAISAL FORM</b> (Please check one answer for each question)					
IDEA: _____	Very high	High	Average	Low	Very low
1a) TECHNOLOGICAL UNCERTAINTY How remarkable do you see the risk of failing in <i>technological</i> issues?					
1b) MARKET UNCERTAINTY How remarkable do you see the risk of failing in <i>market</i> issues?					
2) IRREVERSIBILITY Rate the <i>possibility of recovering</i> the invested assets.					
3) MARKET VALUE Rate the <i>business impact</i> of the idea in its final form.					
4) GROWTH What is the <i>significance of this idea</i> for further investments or upgrading?					
5a) FLEXIBILITY1 What is the <i>difference of the business</i> based on the idea and your current business?					
5b) FLEXIBILITY2 What is the rate of the idea to widen your <i>possibilities to operate</i> ?					
6) IMPACT What could be the <i>impact on the current value chain</i> ?					
7a) TIME1 What is the <i>likelihood of postponing the investments</i> to acquire additional information? (rivals, own business, etc)					
7b) TIME2 Likelihood to <i>gain technical and market success</i> during the next three years?					
8) SCALE OF INVESTMENT Rate <i>the size of the investment</i> compared to your company's dimension.					
9) STAGING Rate the <i>possibilities to stage</i> the development process in phases.					

Compare to Henriksen & Traynor (1999)

## 6. Conclusions

Innovation is all about creating a future of which we cannot be at all sure. There is always a risk of placing a stake in the wrong place at the wrong time. We have seen that investments in innovations are very often found to be just waste of time and money. To capture the uncertainty even partly, it is logical to try to find out the prominent investment proposals. The decision maker should try to decrease the likelihood of total investment loss and build up flexibility for the dynamic world.

The resources of firms are always limited, and a firm can focus on a limited number of projects only. If the firm's environment is very innovative, the number of ideas can rise very high, leading to a situation where the firm has difficulties in choosing which ideas it will develop further. The problem the firm faces is which ideas are the best to be further developed and finally put in practice.

It is proposed that the traditional investment appraisal methods are unable to capture the value of future investments and the real options approach is widely suggested to be a method that takes into account the value of an uncertain future.

The selection method literature has suggested that the options approach could be a capable selection tool. Most of the literature concentrates on single R&D projects and their option value compared to the values produced by other methods. The real option applications do not offer much help for idea selection.

We approached the gap and problem from the managerial point of view. The real options theory can be a very challenging method for a manager, and probably also too complicated and time-consuming. There is a need for a tool that takes the real option value into account, but will not make the use of the tool too difficult. Even though very many articles about R&D project valuation with real options approach have been

published, a simple tool for management in that area has not been presented yet.

We ended up by building a *preliminary idea selection questionnaire*. The questionnaire includes twelve questions, the purpose of which is to give the ideas a relative real option value. Based on this value, the ideas can put in an order.

On the basis of the questionnaire, the ideas will get values indicating that idea should be evaluated with other tools or that the idea does not include real options. The objective of the questionnaire is to cut off all those ideas out of the selection process that can be evaluated better with other methods, are not justified from the firm's point of view, or include some very valuable options for the firm.

The real options approach is an attractive theory and philosophy. The further studies will show what will be the development with workable applications based on the approach.

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# PUBLICATION 3

## **A STRATEGIC INVESTMENT CASE IN WOOD PROCUREMENT IN FINNISH PAPER INDUSTRY: REAL OPTIONS PERSPECTIVE**

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## A STRATEGIC INVESTMENT CASE IN WOOD PROCUREMENT IN FINNISH PAPER INDUSTRY: REAL OPTIONS PERSPECTIVE

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### ABSTRACT

The real options approach (ROA) is considered very advantageous in strategic IT investments evaluation. However, few papers show how the ROA reflects the reality. In this paper it is presented an investment case where a Finnish paper industry company carried out an innovative and strategic IT system investment in wood procurement during the years 1988-1996. The case is approached from the real options approach perspective to clarify how these kinds of innovative investment ideas could be illustrated and managed with it.

**Keywords:** Real options approach, information technology, strategic investment

### INTRODUCTION

Innovation activity and its significance to firms increase in emphasis when they act in the free-market. Innovations are a natural part of firms' means to survive in an environment where competition gnaws at the profits. Whilst firms aim to achieve competitive advantage and growth through innovations they may encounter problems in their diverse investment possibilities. However, innovative activity is seen mandatory in a competitive environment (Baumol, 2002) and actions for innovations and ideas about how to run the business differentially vary. The source of innovation, for instance, can be a new business model, product, service or process or an incremental improvement (Cooper, 1999; Hamel, 2000; see appropriate typology in Garcia & Calantone, 2002). Intrinsically, the whole innovation process means great uncertainty. Investments in innovations are very often found to be just a waste of time and money due to failure during the innovation process or at launch, or in never becoming profitable (Cooper & Kleinschmidt, 1995; Griffin & Page, 1996; Cooper, 1999). Therefore, the evaluation of innovative ideas is vital so that scarce resources can be allocated to the right places.

It is proposed that traditional investment appraisal methods are unable to capture the value of future investments, and the real options approach (ROA) is widely suggested to be a method for assessing future possibilities (Amram & Kulatilaka, 1999; McGrath & MacMillan, 2000; Adner & Levinthal, 2004). However, even the ROA has been suggested

to be the future investment evaluation method over many decades there are few practical solutions or examples and for instance Kemna (1993) stated that the process of adapting option pricing theory (OPT) to the practice in strategic decision-making is far from smooth. There are only few real life examples how to use the ROA (see e.g. Benaroch & Kauffman, 1999). The problem seems to be that the real options theory is not that 'real' than it is claimed. In this paper, the evaluation process is approached from the perspective of the management where a real life case is used as a data to show how the ROA reflects reality. On the other hand, this paper aims to clear up how the decision-making around an innovative idea can change with the real options approach.

An innovative operation process idea that is used as an example in this paper is a real case investment in the Finnish paper industry. The case firm had an idea to utilize the newest but immature technologies in their manually operated wood supply process in the 1980's. Advancement in computing technologies and mobile telephony gave the firm possibility to reshape operations in a way that was totally new in the whole industry. A Finnish paper industry company carried out an innovative and strategic IT system investment in wood supply during the years 1988-1996 which later proved to have a significant effect on their business. The project was started at the time when mobility meant analogous, expensive, and slow connections. The development of overlying mobile networks and new IT technology gave the firm a possibility to create totally new operation models in wood procurement. The challenge was that there were no off-the-shelf solutions.

#### *Literature Review*

Strategic IT investments is one of the areas where the real options approach is considered a very advantageous and usable tool to support decision-making (Zhu, 1999; Balasubramanian et al., 2000; Benaroch & Kauffman, 2000). In recent years, the amount of literature in the area of strategic options has increased significantly. However, there is still a lack of studies which show the applicability of ROA in the decision-making process concerning strategic IT investments.

Strategic IT system investments are often made under great uncertainty; the investor faces market and technology risks at the same time. One of the greatest challenges in firms is managing new innovative IT investments that are strategic by nature because the decision-makers have no data about how a particular investment can become a success. The investor faces the dilemma of where to invest and not to invest. Very often the selection of investment proposals is based more on the gut feeling than on formal comparison which takes future options into account. The decision-making concerning strategic future investments is difficult to rationalize on the basis of accurate information because it is not available. A common situation is that the decision-making is based on qualitative information and strong intuition only (Kyläheiko et al., 2002). The case firm faced a situation where they had a great idea that was seen a great possibility or a strategic opportunity. The traditional budgeting and pricing methods that were used did not offer capable tools for properly binding the possibilities and flexibility into calculations.

The ROA is one way to ensure maximizing the shareholder and company value. Through this thinking the business opens up so that opportunities can be seen and evaluated more naturally than with the widely used capital budgeting methods such as the Discounted Cash Flow (DCF) (e.g. Zhu, 1999) which ignore the inborn flexibility the management carries out all the time (Campbell, 2001). A real option pricing model is a

language by means of which the possibilities the firm has can be described. On the other hand, the ROA is purely a real world option valuating system to calculate values for alternative courses of action. In our view, the modeling part of the approach can be its valuable part (see for instance Leslie & Michaels, 1997) where the world can be opened up as a map of opportunities.

Myers (1984) suggested that the ROA could be a helpful tool between the financial and corporate strategy. Dai et al. (2000) have argued that option pricing methods help the management in evaluating properly the opportunities that IT investments create, and they also state that these methods are suitable for assessing the value of different types of IT projects, including infrastructure projects, software prototyping, decision support systems, and technology standard-based projects.

The ROA aims to help the management to take into account the multiplicity of the future in contrast with the traditional investment evaluating systems. The management is offered a possibility to see if an investment contains some exceptional possibilities. When this is the case the ROA is in its place. We can generalize that the investment project should be sizeable enough, strategic by nature and it should not consist of an up-front, irrecoverable cost (Brabazon, 1999).

However, so far the ROA has not been as simple and streamlined as most of the known decision-making and evaluating methods. We may value real options with the Black-Scholes or the binomial model, facing the problem that the option value may be based too heavily on uncertain estimates decreasing the quality of the calculations (e.g. Lander & Shenoy, 1999). According to this, the dilemma of the estimates about cash flows and volatilities shall be solved before the method can be absorbed into the firm's strategy process. On the other hand, the present literature concentrates mainly on the theory of real options and not on the implementation of the real options approach. We focus on the question of how to use the ROA in managing an innovative and strategic technology investment where the investment case is used as an investment frame.

## **METHODOLOGY**

This paper is based on a review of existing literature and a case study of an investment in a wood supply system. The case and the literature are used to develop theoretical arguments concerning the investment decision-making in relation to the ROA. The case method was used because it is a good method to capture a longitudinal phenomenon.

The research data of this study is composed of qualitative data including thematic interviews, annual reports, and personnel magazines. The research topic in this study is the management of an investment project. The case is unique and it is handled as an individual case.

The conducted interviews reflect how the system investment was carried out according to individual memories. To get as complete picture of the investment as possible, a small series of interviews from different angles were carried out. The interviewees were selected on the basis of the knowledge about their part during the investment process. The persons who were nearest to the operational level were interviewed first and the managerial level later. These interviews reflect the interviewees' view of the chain of events and not necessarily the actual events. The interviewees had common working background and possessed individual as well organizational memories. The final picture of the investment case was formed on the basis of the interviews and other sources (e.g. annual reports and

other research studies of our research institution). The number of interviews was small (four interviewees in three interviews) because some of the key persons have passed away. Nevertheless, an adequate level of information was achieved.

The investment case is explained and analyzed through the real options application framework. This study clarifies the applicability of the ROA in the decision-making process concerning strategic innovative IT investments under uncertainty in this specific case. It also explains whether the decision-makers acted according to the presented real options framework or whether they followed only the traditional investment rules. It is shown how the real options theory explains this strategic investment case, and what kinds of real options the decision-makers had.

### **THE CASE OF AN INNOVATIVE WOOD PROCUREMENT SYSTEM**

In the past the case firm, as the whole industry, worked quite similarly with wood supplies so that firms' wood departments were responsible for acquiring the needed lumber which was acquired from the firm's own forests or from the market. Transports were mainly managed so that the forest workers cut down trees which were then stacked on the roadsides. Later these roadside stocks were collected by trucks which were managed by the firm's forest department. The case firm's lumber acquisition areas required a lot of staff to handle transports in each area, and the trucks had their own operating area where they collected stocks to be transported to the mill.

In the case firm in the 1970's, the amount of roadside stocks was huge in comparison with the annual consumption and the amount of lumber to be consumed in the next nine months was stored on the roadsides. This met high bounded equity, and the quality-based losses were high because of deterioration (the quality of wood decreases over time). The wood consumption was also problematic: all the lumber was not utilized most effectively and the amount of waste lumber was high. The organization which was responsible for wood procurement was large because the controls were carried out manually, and the number of areas and their sub-organizations where the lumber was acquired were high.

The management saw a threat that if the ratio of roadside stock stays high when the overall wood consumption rate increases the funding of the business would become problematic. Thus, this and above mentioned reasons together motivated the firm to innovate new ways of managing the wood procurement differently than before. The proportion of roadside stocks was due to decrease drastically.

#### *The future vision*

The management had a vision about changing the way of doing wood supplies dramatically. They envisioned a computer based data system that would store and process all relevant information, that communications between the trucks and the control center would be made wirelessly, that trucks would have micro-computers and digitalized maps, and that the location of the trucks and the lumber lots would be known on the basis of their co-ordinates which would make the optimization of the routes possible (see more details in Hiltunen, 2001).

The idea about the future's wood procurement system was simple enough to be understood but extremely difficult to implement with the technology that was available at the time. This idea started a consequential change process in the organization, and it was

officially named as a strategic investment. Next, we narrate the phases of the investment project shortly.

#### *The 1970's – Visioning and planning*

The firm has a long tradition in the wood consumption optimization. The modeling of the business with different kinds of models was the firm's common operating mode. The development process of wood procurement optimization started already in the early 70's, but soon it was realized that the computing technology was too immature.

The firm and its personnel from the top to the lower management level were interested in managing and optimizing wood consumption. The motivation for this was that wood (pulp) is the main raw material in the paper industry and it is of great importance for the firm's cost structure. The firm investigated different possibilities from time to time to optimize wood consumption and related costs. In the middle of the 1970's, the firm had a large project where the objective was to optimize the use and transports of lumber.

The importance of managing lumber transports and consumption increased when the management wanted to find a procedure for getting wood in the right place at the right time. Trucks had sometimes difficulties in finding lumber stacks, but as well the firm used too high quality wood for purposes where lower quality wood would have been more economic. However, the planning produced a thick report that can be seen as a start for further development in wood procurement.

#### *The 1980's – Computers and global positioning system*

The management of the case firm's forest unit realized in the early 1980's that they might be able to change their wood supply process significantly. The vision was that lumber transports could be managed remotely and the transports and usage of wood could be optimized efficiently with computers. To develop this kind of system required the firm to develop and possess totally new competences and technologies. The optimization of wood<sup>1</sup> usage was set as the primary target, and the optimization of transports as the secondary target.

At first, the firm concentrated on optimizing lumber transportations by decreasing unnecessary transporters by optimizing transport routes. On the other hand, the optimization had direct influence on the bounded equity (when fewer vehicles were needed and the number of roadside stocks decreased). Investments in the new technology in the wood procurement system enabled greater productivity through lower costs and expenses, higher quality with better performance and greater reliability, better timelines (deliveries on time), and greater flexibility.

#### *The 1990's - Implementation*

When the project started there were no guarantees that it would be carried out successfully because there was high uncertainty concerning internal and external issues. The management of the forest unit, however, had strong faith in their vision. They believed that they would be able to solve the problems. The firm had an internal IT department which was built up of experts in information technologies and paper technologies. The innovation

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<sup>1</sup> Raw material components for different purposes and for different places to get an optimized result.

needed modern technology and competences which the firm acquired outside or developed itself successfully mobilizing capable experts and the newest technological possibilities.

The technology itself was an important trigger in speeding the project. The global positioning system (GPS) was tested already at the beginning of the 1980's which made tracking the trucks possible. Before bigger investments were made, the firm made more tests and pilots with the IT department which was later hived off as an independent firm.

The new way of managing wood procurement meant that a combination of different, not all available, immature, and unreliable technologies should be designed. The major technologies that were supposed to work together were:

- 1) Mobile communication technology
- 2) Mobile data transferring
- 3) Truck routing system
- 4) Microcomputers in the trucks
- 5) Digital maps
- 6) Centralized data system
- 7) Global positioning system (GPS).

When the project was officially started in 1988 only a few technologies were sufficiently developed to be used. There were no wireless data connections to the trucks, no operative route optimization, and no digital maps. One of the main reasons for starting the project was that the management was behind the project: the CEO of the firm was keeping track of the project and did actually take part in some tests. The project covered the whole firm in those days.

The technology was not the only problem; the organization itself was a source of uncertainty, even though it was believed that there would not be problems with the users (employees and subcontractors). Therefore, this aspect was left unexamined. When it finally came the time to train users to use the new systems it turned out that it took more time than was expected and more resistance was encountered than expected beforehand.

The management was offered calculations about the profitability of the investment but the numbers behind the calculations were subtle estimates. Nevertheless, the investment looked profitable. According to the interviews, the profitable calculations had an effect on the decisions of the management, but were not the only reason – the management believed that the investment would be lucrative.

The main idea of the investment was to change the current way of procuring wood. The main problem was that the technologies were not available and there was a need for considerable technological development. Later, the firm got e.g. a cd-rom writer for copying maps on disks; there were only few writers available in the whole of Europe at the end of the 1980's. Next, a closer look at the investment case through the ROA is taken and it is explained what the ROA could have given for the decision makers.

## **REAL OPTIONS PERSPECTIVE**

The real options approach would have been helpful at the time the case investment was planned. Thinking about the options and their option value would have helped the management in decision making as well actively help in detecting other possibilities for the future business. The use of ROA would have showed decision makers more precisely what kind of opportunities the firm could have than the methods that were used (for instance intuition and NPV).

A simplified real options frame (or application) that is presented in Figure 1 shows how an innovative idea would have been evaluated. At first, when an innovative idea is composed, the opportunities and threats related to it have to be identified. These opportunities and threats can be appraised so that the strategic option potential can be detected. The real options related to the investment are detected while the idea or investment proposal is evaluated. After all, the decision maker is able to form a frame which illustrates the options. The frame functions as a decision tree to help in deciding whether strike any options now or later by making investments that give the firm rights to the underlying securities.

The Figure 1 show how the ROA could have been used in the case. When the opportunity and threats were detected (1), the decision maker should have evaluated them (2), for instance, through an appraisal form (see Edelman et al., 2003) or some option pricing model such as Black-Scholes, Binomial model, or Geske model (see Perlitz et al., 1999). The questions in the appraisal form would have challenged the decision makers to think uncertainties related to investment and the factors impacting on the investment's feasibility, but also showing the option value of great technological uncertainty. An idea appraisal form could have helped the management to identify their real options, optionality and opportunities telling how much strategic value the idea contains from the firm's point of view. Based on the single values the firm would have been able to concentrate on the essential questions. The traditional budgeting methods did not help in evaluating the different possibilities related to the investment and the decision making based on them was more 'now-or-never'. Concurrently with the appraisal process the real options would have been detected (3). The technological uncertainties in this investment case were high so would have also been the real option value. Then, based on the real options the project contained, it could have been formed a decision making framework. Staging the investment in smaller steps would have helped the management to understand their possibilities to succeed (4). Finally, the decision maker would have been able to make decisions about the future steps based on the created opportunity map (5).

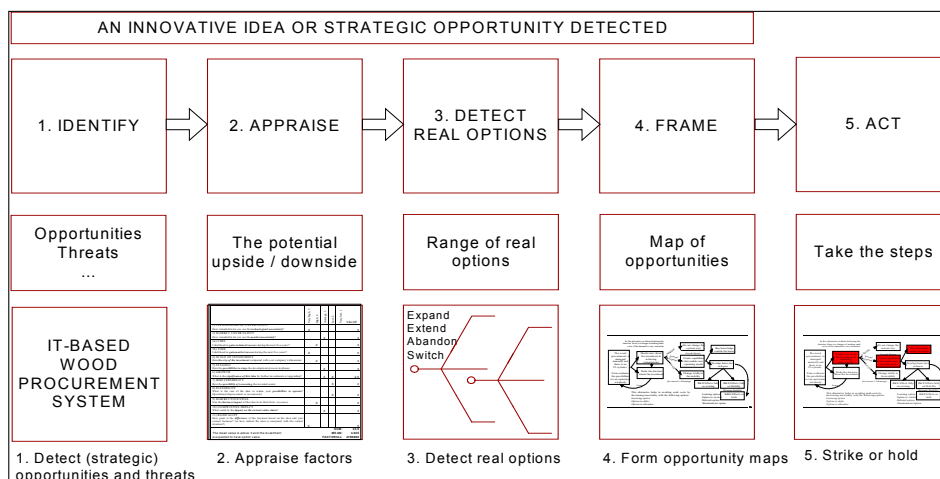


Figure 1 - First steps in the evaluation process

There are significant advantages in using the ROA. The purpose of the above frame is to show some of that the ROA could have offered the management when it was making decisions about investing in the IT-based wood procurement system. The traditional investment perspective would have widened and the investment could have been approached in a way that fits better to the reality. The value of real options was not discussed in this paper but the assumption is that the value of real options shows which steps are lucrative and which are not which would have been useful in decision making.

Another important aspect compared with other evaluation methods is that, the ROA gives the management possibility to take the natural flexibility into account, for instance, by deferring the investment making small tests to learn before making further investments.

The project that was officially started in 1988 was actually started much earlier. The case company did some tests and studies before the project was officially started to learn how the wood supply operations could be managed in the future. Later, when the project was started, the firm tested parts of the supply system which gave the firm knowledge about the feasibility to continue. They possessed and took advantage of the option to stage, the option to defer, and the option to extend just to mention a few. The firm was taking small steps while trying to achieve the vision.

## CONCLUSIONS AND DISCUSSIONS

The aim of this paper was to approach a strategic IT investment case from the real options approach point of view to clear up how these kinds of investments can be managed and illustrated with the ROA. The present literature concentrates mainly on the theory of the real options approach and its applicability in reality is less discussed.

One way to approach a firm's innovative ideas and their options is the way we show in this paper. Outlining the complexity of the world and its possible paths may create a valuable framework for decision making.

In our view, the problem of the modern view of real options is in the perspective it has been considered and how it has been used. Most of the literature keeps the eye only on counting the value of the real option derived directly from the financial options. The investments, especially strategic innovative IT investments, cannot be valued accurately because of their contingent characteristics.

The investment case of Finnish paper industry was described in this paper and the case was analyzed with a real options application framework. It was noticed a lot of elements that are a part of the real options approach: the investment was staged in smaller pieces for instance to achieve more knowledge concerning technological uncertainties. It was found out also some references to that the real options approach and its logic could be a part of managerial mind set, even though the investment case is just an implication for that. The future studies should profoundly analyze whether the philosophy of the real options approach actually is an implicit part of the decision-making process.

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# PUBLICATION 4

## **MANAGING R&D WITH NORMATIVE SCENARIOS**

Edelmann Jan, Bergman Jukka and Jantunen Ari (2005)

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## Managing R&D by normative scenarios

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**Abstract:** This study introduces a model of how to manage research and development work based on normative scenarios enabling the analysis of complex ideas and the recognition of new opportunities under high uncertainty. To visualise the concept of normative scenario, a case study is presented where the management of an organisation had an idea of radically changing wood procurement in the Finnish paper industry. A model for a normative scenario is presented on the basis of the case and the factors derived from it. The case is retrospectively analysed to show how normative scenarios could help firms to sense and seize innovative ideas that are strategic in nature. With the normative scenario process, strategic decision makers can find guidelines for critical timing questions by combining scenario techniques, real options thinking and the dynamic capability approach.

**Keywords:** decision making; dynamic capability view; future-oriented investments; innovation management; normative scenario planning; R&D management; real options; strategic planning.

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## 1 Introduction

Managing future-orientated innovations is a complicated task for the persons involved in research and development. From the decision-making point of view, Baumol (2002) claims that innovation makes the sequential fortuitous actions predictable and routine. Therefore, the Knightian uncertainty (Knight, 1921) remains, meaning that the uncertainty increases the more, the further in the future the innovation exists.

The potential significance of a new idea is difficult to recognise when the innovation is in its early stages. The history of the development of technological change contains a lot of descriptions about ideas that have been first imaginary and seemed unfeasible, but have later turned into successes, i.e. innovations as Cumming (1998) defines them. On the other hand, many ideas that have thought to be successful have failed in the technical development phase or at launch.

Accordingly, many companies have difficulties in evaluating the possibilities and the sustainability of ideas for their present and future business strategy (Grant, 2003; Miller and Morris, 1999). When evaluating initial ideas, the complexity of ideas and the uncertainty of their future development can make the process problematic. There is a risk of abandoning a good idea only because it is too difficult to be evaluated and developed further.

The complexity of evaluating initial ideas has been empirically discovered. Laaksonen (2001) asked a small number of managers to evaluate innovative ideas according to their importance for the company's business, strategic effects, the best implementation practices, possible returns and justifications for implementation. The assessment of the ideas seemed to be extremely difficult without time-consuming discussions, clarifications, and further development of the ideas. A question arose: how to evaluate ideas that are sometimes difficult even to understand? The management can identify opportunities and threats, but their impacts and emergence is uncertain. The more the ideas concern strategic issues, the more difficult they seem to be to manage. Despite the fact that a number of management methods has been developed to manage strategic investments (Martino, 1995; Porter et al., 1991), simple and flexible methods are still needed.

The evaluation and management of strategic future-orientated ideas (or investments) is a problematic task to tackle with traditional economic tools and procedures which support more or less simpler ideas. For example, according to the traditional cash-flow analysis highly uncertain projects seem unprofitable even if they contain strategic value. Often numerical methods are incapable of taking into account all the possibilities, uncertainties and flexibility that noticeably exist (e.g. Campbell, 2001).

Decision making based on intuition and judgement could be the most appropriate ‘tools’ for the decision making in strategic business goals. Remarkably, this information can usually be attained only by long-term experience. Therefore, the sense-making capabilities of the management need to be supported and the context of the decision making facilitated with methods that make the decision-making more reliable and enable younger decision makers to take part in the process with less experience and knowledge.

In this paper, a *normative scenario approach* is presented which makes intuition and judgement observable and shows decision makers the path to the desired future situation before it can be achieved. The aim of this paper is to clarify how the sense-making process in an innovation can be supported by normative scenarios. This study presents a case of a *mobilised and optimised wood procurement system* through which it is shown how to combine the dynamic capability view, the scenario technique and the real options approach in decision making as a way to manage R&D.

## 2 Combining scenario and strategic approaches: theoretical background

### 2.1 Real options approach

The real options approach is a way for the management to identify and take into account the diversity of the uncertain future, which cannot be done with traditional investment evaluating systems. The management is offered a possibility to see if an investment contains some exceptional possibilities or flexibility.

Future expectations are a natural part of the real options approach where the future is seen as a wide space having positive, neutral and negative outcomes. The further we look, the more uncertain the accuracy of decisions will be. With the approach, the management can manage the uncertainty related to strategic investment proposals, i.e. an innovative idea, possessing rights but not obligations to proceed. The uncertainties (technological, market and organisational) the firm faces are the source of strategic options of the firm for competitive advantage. (Please note that, term real option refers to flexibility in decision making and strategic options to the strategic future possibilities the firm is able to create for itself by its dynamic capabilities.)

The real options approach offers flexibility restricting the downside risk while preserving access to the upsides (Bowman and Hurry, 1993; McGrath and MacMillan, 2000; Sanchez, 1993). Referring to the real options approach which dates back to the 1970s (Black and Scholes, 1973; Merton, 1973; Myers, 1977), greater uncertainty means the possibility of greater gains or losses; the greater the uncertainty, the higher the real option value. On the other hand, the ability to delay and wait for additional information before making an irreversible decision has value (Herath and Park, 2001; McDonald and Siegel, 1986) and if the investment is likely to create losses, the opportunity to delay the decision of keeping the option alive has value (Dixit and Pindyck, 1995).

If the traditional investment appraisal methods are claimed to be unable to capture the value of future investments, the real options approach is widely suggested to be a method for assessing future possibilities of highly uncertain, strategic and sizeable projects. (Adner and Levinthal, 2004; Amram and Kulatilaka, 1999; Brabazon, 1999; McGrath and MacMillan, 2000). However, few practical real life solutions or operationalisations which show the applicability of the real options approach have been published over recent decades (Benaroch and Kauffman, 1999; Copeland and Tufano, 2004; van Putten and

MacMillan, 2004). The problem seems to be that the real options theory is not as 'real' as it is claimed because most applications the literature has presented concentrate in managing parametric uncertainty while the uncertainty the firm managers face is parametric *and* radical (i.e. structural and procedural) in nature in many cases (Kyläheiko et al., 2002).

## *2.2 Developing an organisation's capabilities*

According to the dynamic capability view of the firm (Teece et al., 1997), firms can achieve sustainable competitive advantage with dynamic capabilities consisting of the firm's ability to build, integrate and reconfigure resources and capabilities in the context of changing environments. The ability to recognise new opportunities, together with the ability to renew the firm's knowledge base, routines and processes prepare the firm for changes in the operating environment. Building new technological capabilities and organising effectively to exploit capabilities is a very challenging task. Capability building involves testing and selecting new knowledge combinations and developing or modifying a set of interrelated knowledge systems, skills, procedures and routines. Technological learning is a path-dependent activity in which knowledge accumulation and incremental improvements are needed to result in a workable combination.

Due to the path-dependent features of capability-building and because of critical timing factors in the market caused by conditions of increasing returns (e.g. first-mover advantages) and competition, managers have to begin the development of capabilities before they know exactly how valuable these capabilities will be. When the firm adopts the options approach in strategic decision-making, it can convert one big resource-investment choice into a series of minor decisions. Decision makers can then take advantage of deferral, abandonment and growth options by evaluating the capability-development process and the changes in the operating environment continuously. If market conditions change unpredictably after the starting moment of the capability building process, the firm can adjust its investment decision in accordance with new knowledge. This creates flexibility in strategic decision making and limits the downside risk while retaining upside potential for new opportunities. Viewing the firm's strategy as a series of sequentially exercised options makes strategic management an iterative, milestone-orientated process (McGrath, 1997). This enhances learning, permits strategic redirection, and conserves the firm's scarce resources in capability development.

From the dynamic capability viewpoint, to achieve sustainable competitive advantage in the changing world, the firm needs the ability to perceive and interpret signals from the incoming information stream and to respond correctly (Langlois, 1997). Scenario making supports the development and utilisation of capabilities by directing attention to essential indicators of changes in the operating environment.

## *2.3 Scenario method*

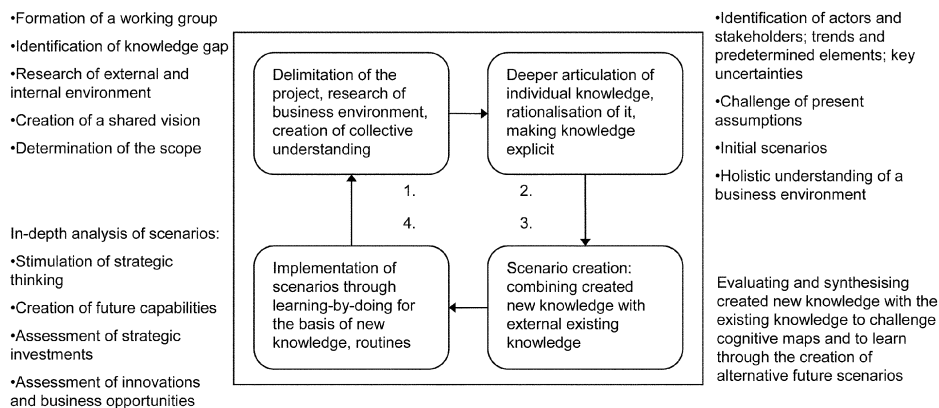
Creating new knowledge presumes that individuals recognise useful data and information, and are then able to transform it, through some process, into knowledge that brings future value for the organisation (Senge, 1990). The fundamental idea behind scenario planning is to provide a structured way to create dynamic interaction between the environment and the organisation to cover a broad range of future possibilities to confront the future

uncertainties and expand people's thinking (Ellis and Shpielberg, 2003; Schoemaker, 1993; Wack, 1985a,b; Weick and Quinn, 1999).

The use of scenario planning reflects the proactive orientation of the organisation (Godet, 2000). Scenarios explore the simultaneous impact of various uncertainties by changing multiple variables at a time, and describe very complex models that cannot be formally modelled (Coates, 2000; Schoemaker, 1997). Scenario planning makes it possible to assess the competitive landscape and strategic segments of the organisation in a new light and renew organisational capabilities towards the future needs under a created future strategic vision (Godet, 2000; Schoemaker, 1997; Teece et al., 1997). Scenario planning can be a catalyst for extracting value from capabilities by channelling them towards new opportunities.

The scenario process is an ongoing process which can be utilised periodically or when needed. It has a certain and common structure involving a varying number of steps (e.g. Masini and Vasquez, 2003; Schwartz, 1996). According to Phelps et al. (2001) the scenario process can be conceptualised into four stages presented in Figure 1 and explained later in detail in a normative scenario process.

**Figure 1** The scenario process and knowledge creation (Bergman et al., 2004)



### 3 The normative scenario as a method

The normative scenario approach is a method for building a picture of the future based on internal and external factors influencing the issue, R&D process in this case. A normative scenario combines the dynamic capability view of the firm with two qualitative approaches: the scenario technique and real options approach for the decision-making process. This combination of complementary approaches introduces a new perspective on strategic management and decision making.

By creating alternative normative scenarios, the management of the organisation is able to realise the future environment through a visualised framework which helps management to evaluate and develop innovations. The use of normative scenarios, firstly, helps firms function internally efficiently to avoid wasting scarce resources by not investing

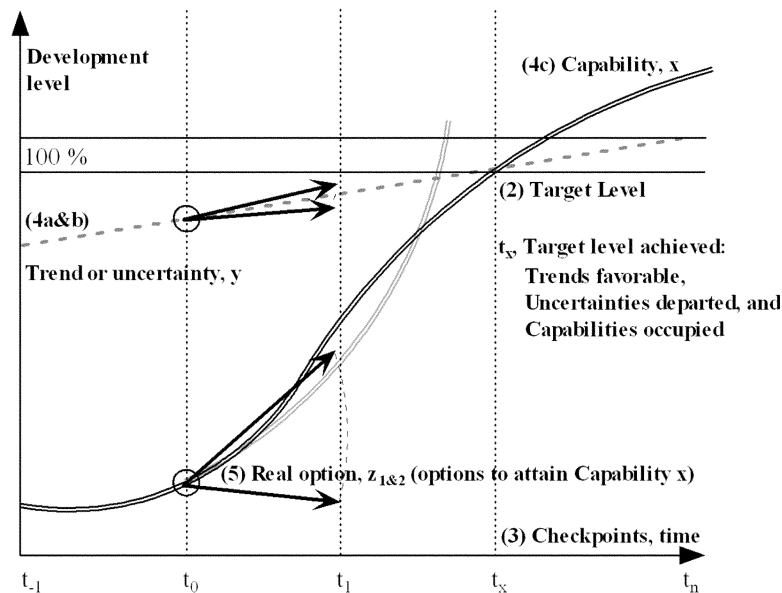
too early too much. Secondly, it helps dynamically sense and seize available and needed capabilities and competencies for the future requirements. Thirdly, it supports the agility and flexibility of the firm to respond to external shifts. Fourthly, it helps decision makers to understand the relationship between different factors and their impact on the business environment and its opportunities. Finally, it helps management to monitor the development and attractiveness of strategic possibilities.

### 3.1 The construct of normative scenarios

By creating normative scenarios, the paths from the future to the present can be determined, based on the created future-orientated knowledge and the expertise of the participants in the process (*backcasting*). For every scenario path, several ‘checkpoints’ are determined where the development of the scenario can be controlled and the investments assessed. Weak signals, uncertainties and real options are recognised during the normative scenario process to help the management to sense and seize the opportunities and the value of new ideas as well as the required capabilities. During the normative scenario process, the driving forces are identified, and using the strategic option thinking investments in an innovation can be assessed through managerial sense making.

Once the management has a vision about an investment or project, they are able to create a normative scenario and an illustration of that (Figure 2). It means that they are able to define a favourable scenario of the business environment where the project can be carried out.

**Figure 2** The normative scenario viewed at  $t_0$  – a basic model



The first step in the process of normative scenario creation is to clarify the technology and business environment and identify the predetermined elements, (1a) *main forces* that will affect the future development of the investments, (1b) the *trends*, and (1c) the *main uncertainties*. The second step is to create future scenarios based on the knowledge of the preceding phase which are presented as (2) *target levels for the investment*. Thirdly, the (3) *checkpoints* of these predetermined elements are identified. Fourthly, the graphs of (4a) *trends*, (4b) *uncertainties* and (4c) *capabilities* are drawn. Finally, their (5) *real options* are identified and located in the checkpoints.

Checkpoints (3) emerge from events that might trigger discontinuities in the business environment. At the checkpoints, the factor values have changed, and the illustration is redrawn and the checkpoints are re-evaluated. The early warning signals based on the knowledge and expertise of the management can be identified and transformed into a tangible form at each time point that has been set on t-lines. They make it possible to sense the realisation of scenarios (Schwartz, 1996).

The shape and angle of the graphs (4) illustrate the development of the monitored factor (uncertainty, trend or capability) against the target level (2). When the graph reaches the target level, the adequate level of the project is achieved. The shape and angle of the graph can change according to, for instance, technological development (including its implementation), increased knowledge, and market changes. The real options (5) illustrate a firm's possibilities to achieve, e.g. a certain capability.

#### **4 The case of a mobilised and optimised wood procurement system viewed through a normative scenario**

During the years 1988–1996, a Finnish paper company conducted a strategic investment concerning the wood procurement system but the planning of the investment had already started in the early 1970s. The investment was initiated because the firm wanted to make wood procurement more cost-effective. The whole industry worked quite similarly: the procurement system required a large number of personnel and operating capital, quality-based losses were common, transport was managed manually, and there were enormous roadside stocks.

The management had a vision about the new wood supply system. They envisioned that a computer based data system would store and process all relevant information, communications between the trucks and the control centre would be wireless, the trucks would have micro-computers and digitalised maps, and the location of the trucks and the lumber lots would be known on the basis of their coordinates which would make the optimisation of the routes possible. (More details in Hiltunen, 2001)

The management was offered calculations about the profitability of the investment but the numbers behind the calculations were subtle estimates. Nevertheless, the investment looked profitable. According to the interviews, the profitable calculations had an effect on the decisions of the management, but were not the only reason. The management believed, based more on reasoning than facts, that the investment would be profitable.

The idea about the future wood procurement system was simple enough to understand but extremely difficult to implement with the technology that was available at the time.

The idea that was officially named a strategic investment started a consequential change process in the organisation.

When the project officially started in 1988, only a few technologies were sufficiently developed to be utilised. There were no wireless data connections to the trucks, no operative route optimisation, and no digital maps. The main problem was the lack of appropriate technologies and the radical development of technologies was not to be expected. They faced the problems of ‘the first mover’, but later the firm got e.g. a cd-rom writer for copying maps on disks, among the first in the whole of Europe at the end of the 1980s.

The technology was not the only problem; the organisation itself was a source of uncertainty, even though it was believed that there would not be problems with the users (employees and subcontractors). Therefore, this aspect was left unexamined. When it finally came time to train users to operate the new systems, it took more time than was expected and more resistance was encountered than anticipated. This problem was solved by adding resources in training activities.

Next, the investment case will be presented through the normative scenario approach and the advantages of the approach will be explained. The research data of this study was composed of thematic interviews and annual reports. The interviews which explain the procedure of the system investment, were based on the individual memories of the chain of events, and not necessarily the actual events.

#### *4.1 Creating a normative scenario*

From the normative scenario process point of view, the participants of the investment project formed a management team of the scenario process to provide background knowledge for the R&D project and the scenario process representing different views. This chapter follows the scenario creation process as shown in Figure 1.

##### *4.1.1 Scenarios*

- *Preparation of a scenario process: background analysis and delimitation of the focus.* An industry analysis revealed a lack of knowledge and strategies to make a change in the industry. The organisations enjoyed a relatively benign environment, and the emerging changes were confusing them rather than opening up new opportunities. The management team set the goals for the scenario process around a loose but shared vision: ‘A new cost-effective intelligent wood procurement system’. The main focus was to assess the future development of the forest industry and, especially, in IC technology development during the next ten years by providing alternative future scenarios, and to recognise the capabilities needed in the future for the development of a new procurement system.
- *Knowledge base construction.* The management team had intensive sessions to create alternative scenarios. Firstly, the management team explored the competitive landscape of the industry and discovered the driving forces that would affect the development of the wood procurement system. The driving forces, guiding the capability development, can be divided in the eight most critical and important groups of key uncertainties and trends (Table 1A), to provide a set of groups that are internally related and separate from other groups. Next, their significance and

impacts on the system were examined. Based on the management team's own expertise and other experts' opinions, the created common understanding around these main forces revealed that several technologies have a critical position in the development of the new system. As a conclusion, these alternative initiative scenarios were selected by identifying the most important forces in capability development relating to the development of the system to facilitate and support the discussion and evaluation of the investment in the scenario process. Then, by setting the limits for the main forces the final scenarios can be created.

- *The scenario creation.* The final alternative scenarios are created through the evaluation and combination of knowledge gathered during the preceding phases on a heuristic basis (Masini and Vasquez, 2003; Schoemaker, 1991, 1997). This phase provided three alternative scenarios concerning the development of the wood procurement system during the next ten years. Each scenario captures alternative developments in the driving forces recognised in the second phase. The goal was to identify the logic of the technology and the overall business development and then organise the possible outcomes of the scenarios around this logic. This phase provides alternative scenarios of the future related to the issue considered (demonstrated in Table 1B). The scenario creation process would have made it possible for the management to reveal blind spots in the decision making challenging the present assumptions and to simplify the complex reality by showing the most critical issues and evaluation points of the investment.
- *The implementation of scenarios.* Each scenario has its specific framework (limits, drivers, stakeholders etc.), which determine the most valuable and essential capabilities for the companies. Knowing the future development (scenarios), the management team would have been able to recognise the most important forces and decide to what extent to develop existing capabilities or to acquire new ones. In this sense, the key uncertainties and trends are dependent on the emerging scenarios. The evaluation of importance of the recognised key uncertainties and trends are performed on the basis of several qualitative characteristics based on the prior knowledge of the management team (Prahalad and Hamel, 1990; Schoemaker, 1992; von Krogh and Roos, 1995), i.e. slow evolution through collective learning and knowledge sharing, path dependence of the development, imperfectly imitable characteristics, complements to existing capabilities, cost-benefit calculations and rareness among rivals. The evaluation provides a comprehensive understanding of the present technological development and their possible future development paths, and reveals the most important uncertainties and trends in each scenario concerning the wood procurement system development (shown in Table 1). If the firm focuses its attention on the most important uncertainties and trends and develops its capabilities to confront the requirements in the selected future, it may sustain its future competitive advantage in the form of a new wood procurement system.

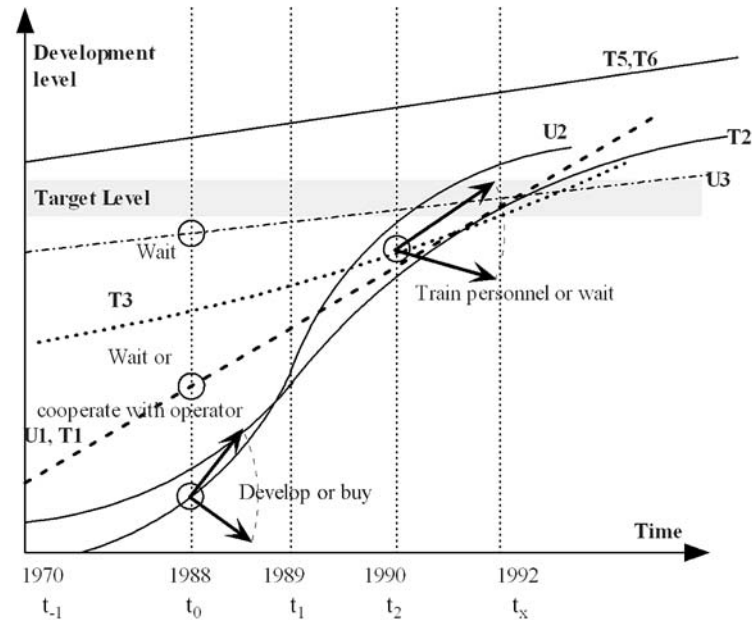
**Table 1** The importance of key uncertainties and trends in each scenario in the development of the wood procurement system (++ very important, – unimportant)

<i>A. Key uncertainties and trends</i>	<i>B. Scenarios</i>		
	<i>Scenario 1 Future wood procurement</i>	<i>Scenario 2 Evolutionary development</i>	<i>Scenario 3 Nothing changes</i>
1 Mobile communication technologies (U1,T1)	+	–	–
2 Truck route optimisation capabilities (U2)	+	–	+
3 Truck tracking technologies (T2)	++	+	+
4 Digital maps in the trucks (U3)	++	–	–
5 Centralised data system (U4)	+	+	–
6 Resistance of people (T3)	–	–	–
7 Demand for wood (T4)	+	+	–
8 Supply of wood (T5)	+	+	–

#### 4.1.2 Normative scenario illustration

Next, a normative scenario illustration is formed of the selected scenario. The trends and uncertainties (Table 1) which were defined during the scenario creation process are drawn based on the historical information and estimations about future events (Figure 3). The case firm knew the development stage of mobile communication technologies in 1988 ( $t_0$ ) and the required development stage for the planned system. The development of mobile network technologies needed to reach network coverage that would cover the operated forest areas where the route information needed to be sent. The checkpoints (i.e. triggers) of the development were defined with the local mobile operator: the networks were planned to be ready as soon as possible (at  $t_2$ , 1990), since the communication networks were essential to the project. The period between the checkpoints may vary and change, but it is important to make assumptions about the coming possible events (e.g. the communication networks will cover the first test areas at  $t_1$ , 1989 when that actually happened at  $t_2$ ) to be able to see if the scenario is about to become realised and what kinds of options are needed to reach the target level (at  $t_x$ , 1992).

The checkpoints are important for the detection, creation and striking of real options, for instance, if the communication network does not cover the test area, further investments in other network technologies are made or the investment is postponed. The scenario checkpoints give information for the evaluation of the sequential decision making and help decide whether the options should be exercised now or later. Referring to the case, if the technological uncertainty of tracking technologies had remained, the option to defer (to do nothing) would have been taken. In practice, this means that the tracking technologies can stay in an untouched area until some weak signal indicates action; for example, the manufacturer's positive news prompted the making of investments in GPS testing devices.

**Figure 3** A normative scenario of the case at  $t_0$ 

When the very first illustration is ready (Figure 3), decision makers start to monitor the development of trends and uncertainties during the technological capability development process. At the same time, they assess their options and the value of them aiming to take advantage of the most valuable options (e.g. at  $t_2$  it is more valuable to take the option to train the personnel (T3) than to wait).

The dynamic capabilities the case firm needed were the ability to reconfigure and renew their information technology and wood procurement resources, e.g. the infrastructure, and capabilities. The IT department of the firm needed to get wireless data communication technologies in the trucks and optimise the routes with computers and digitalised maps on cd-roms.

Although the firm worked in a close relationship with some high-tech companies, the technological development was slower than expected. Flexibility options (Bowman and Hurry, 1993), i.e. alternative technologies would have helped the firm to change the underlying technology to another technology when needed. However, this would have raised the costs of the option portfolio.

The normative scenario will become confirmed when all the necessary technologies, competencies, capabilities and resources achieve an adequate level of development – the target level. The firm has to identify continuously how they are able to renew their knowledge base with a bundle of high technologies and new capability combinations such as route optimisation and mobile communication technologies to reach the normative target level.

The factors of the normative scenario should be reviewed as an ongoing process and (e.g. when new information is received, or/and every three months) discussed as to whether it is time to wait until the trends (i.e. factors that are exogenous and cannot be

affected), become more favourable and closer to the target level to invest more or to strike some alternative options. In contrast to trends, factors such as the organisational uncertainty can be decreased by training the personnel to use the new systems, and partly the technological uncertainty by working more closely with the local mobile operator.

To take advantage of options the firm possesses or may possess, the main uncertainties and shadow options have to be recognised as was done when the scenarios were created. The firm's staging option concerning the communication system enabled them to test the system's functionality with the technology supplier and the network operator in the capital area where the networks worked. However, new uncertainties and options appear occasionally, and the most crucial one should be identified and taken into consideration. Identified options, their features and possible consequences are installed in the checkpoints of the normative scenario. Additionally, to be able to make rational decisions, the management also had to make estimates about the costs, potential benefits and timing questions of the options at each checkpoint.

## **5 Discussion and conclusions**

It has been widely noticed that when decision-making concerns technological issues, innovation is perceived to be rather complicated. One reason for this is that innovations are about creating solutions for a future of which we cannot be sure. We have found that new methods and tools are required to support decision making with data that are very uncertain. Inspired by this, we have developed a managerial method that integrates two qualitative methods – the scenario technique and the real option approach – and the dynamic capability view to manage uncertainty during the strategic investment process.

The normative scenario process is used for managing investment decision making in the field of R&D. From the dynamic capability view of the firm, the combination of scenario method and the real options approach provides more information about the possibilities of long-term investments than traditional methods of analysis. The use of these approaches combined as a normative scenario process helps the firm to assess the uncertainty and possibilities related to the innovative and strategic ideas and investments.

By using the combination of the presented approaches in the evaluation of innovative ideas, the changes in the firm's internal and external operating environment can be assessed with *a visualised framework*. The future requirements of investments can be identified with the normative scenario method, and it can be used to monitor their development and attractiveness and the strategic possibilities the firm has. The investment decision-making process will become more reliable for the reason that most of the factors can be examined dynamically.

This study demonstrated the usability of the normative scenario approach as an effective way of establishing a structured process to support the management of R&D. The process was perceived to be helpful, as it provided explicit assumptions of the changing environment in a narrative and illustrative form. The normative scenario process makes collective learning and strategic thinking possible resulting in long-term strategic visions of the emerging future.

We approached the issue of strategic investment from the managerial point of view. The normative scenario approach can be a very challenging but rewarding method for

managing uncertain projects. Based on the normative scenarios, the project ideas can be opened so that the uncertainties, necessary capabilities, strategic options and other factors can be illustrated in a way that visualises the external and internal world for decision making.

The limitations of the approach are that it is rather time consuming (from weeks to months) and human driven (biased by individuals), and that plenty of human resources and skills are needed. The approach is useful when the amount of historical and future-orientated data is adequate for building scenarios, defining target levels and identifying the real options. The presented approach is aimed for long-term and high risk projects that cannot be handled using traditional methods. To validate the relevance of this paper to the field of innovation management further studies and more empirical evidence are needed. There is a particular need for studying the method from the decision-making theory point of view.

To sum up, the main advantage of the normative scenario approach is that the complexity of decision making can be decreased by *visualising* the objectives and their elements, due to the fact that our minds have great trouble in understanding problems and traps that cannot be imagined (Bazerman, 2002; Dörner, 1997). Once the first normative scenario illustration is formed and begins to be updated regularly, the limitations are transformed into advantages.

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# **PUBLICATION 5**

## **ADOPTION OF ELECTRONIC INVOICING IN FINNISH SMES: TWO COMPLEMENTARY PERSPECTIVES**

Edelmann Jan and Sintonen Sanna (2006)

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## **Adoption of electronic invoicing in Finnish SMEs: two complementary perspectives**

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**Abstract:** Electronic invoicing is one of the latest innovations in the field of electronic business solutions, and the Finnish Information Technology (IT) industry has expected all the Finnish SMEs to adopt it widely. However, the adoption of electronic invoicing seems to be in the slow lane. This study was carried out to find out the reasons for the slow adoption rate of electronic invoicing by SMEs and stop the conjecturing about the reasons. The behaviour of current and potential users was studied in a survey conducted in South Karelia in the spring of 2005. The main advantage that e-invoicing offers is its potential in decreasing the clerical work and costs of the invoicing process, but it is also seen as a source of new business opportunity. To find out the reasons for the slow adoption rate, the survey results were first analysed statistically, and then the analysis was extended by the Strategic Options Approach (SOA) for a closer view.

**Keywords:** adoption; diffusion; electronic invoicing; e-invoicing; innovation; decision making; real options; Strategic Options Approach (SOA).

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## **1 Introduction**

In the digital era, firms and other organisations have planned to increase the efficiency of their business processes by investing in different Information Technologies (ITs) in order to improve organisational performance and achieve a competitive advantage. However, financial management processes especially in small and medium-sized companies are not always in the greatest interest of managers, even though the benefits gained through the adoption of such technological innovations can be relatively significant. One of the latest innovations presented in the field of electronic business solutions is electronic invoicing, which has been predicted to be the next significant business process change in firms using ITs.

Organisations send over 200 million invoices a year to each other in Finland. Most of these invoices are sent by using paper and the number of electronic invoices is low: only ca. 4% (7 million) e-invoices per year, when 66% of the invoices are still sent by using paper (the remaining 30% are EDI invoices) (Finland Post Corporation and IRO Research, 2004). The cost of a traditional invoice is estimated to be 15–90% higher than the cost of electronic invoicing (Nordea, 2006; The Finnish Ministry of Finance, 2001). Firms that send and especially receive large amounts of invoices can make significant (absolute) savings, and smaller firms (relatively) also can make significant savings by reducing the time-consuming manual processing tasks. Other advantages the electronic invoicing creates are the opportunities that may arise from using e-invoices. Strategic options can be created for instance by reorchestrating the firm's processes and mechanisms or by developing growth options by redirecting resources to new business areas.

In Finland the first electronic invoice was sent in October 1999, and electronic invoicing was approved by a EU directive as a legitimate European invoicing method in 2003. The Finnish IT experts' expectations for the penetration of e-invoicing have ever remained high since the first e-invoice. For example in 2001 it was assumed that the penetration rate of e-invoicing would reach 50% in 2005 (Mäkelä, 2001), and in 2004 it was expected that 65% of companies and 42% of consumers will be invoiced electronically in 2007 (Finland Post Corporation and IRO Research, 2004). While the large companies have adopted electronic invoicing systems, the adoption of e-invoicing among SMEs has been much slower than the Finnish IT industry and its experts have anticipated. The discussion on electronic invoicing has concentrated mainly on large companies while the perspective of SMEs has remained marginal even though 90% of the firms in Finland and in Europe are SMEs. This study was carried out especially to find out the reasons for the slow adoption rate of SMEs and stop conjecturing about the reasons.

The adoption of e-invoicing by the current and potential users was studied in a survey conducted in 932 SMEs in South Karelia, Finland, March–April 2005. The results of the survey explain some major reasons that beset the diffusion of e-invoicing. However, to

This paper is organised as follows. Firstly, the innovation in question: electronic invoicing is briefly described. Secondly, a look at the innovation adoption is taken, and thirdly, decision making regarding investments in ITs under uncertainty and the Strategic Options Approach (SOA) are discussed. Finally, the research hypotheses are created and statistically analysed regarding the adoption of electronic invoicing and a further analysis of the data is conducted according to the SOA. This paper presents some of the very first research results regarding the adoption of electronic invoicing.

Electronic invoicing is a reliable and cost-efficient method for handling and processing invoicing of the sales of goods and services and other charges, appropriate for both large and small organisations. The advantage of an electronic invoice compared to an EDI invoice is that in e-invoicing systems the whole invoice is transferred and the invoice maintains its form from the sender to the receiver and there is no need for point-to-point systems. In business-to-business transactions the invoice information is transferred from the invoicing system of the sender directly to the recipient's financial administration IT system to be accepted (Figure 1). Private consumers and companies can also receive e-invoices from their banks on the internet. An e-invoice can be presented on the computer screen in the layout of a printed invoice or in a string of data. This facilitates the approval and archiving procedures of invoicing as well as effective financial IT systems (Elma Oyj, 2006; Nikunen, 2002).

The diagram illustrates the E-Invoice Process Flow, showing the interaction between a Company, an Operator, a Bank, and a Customer, all connected to their respective Financial IT Systems.

**Entities and Systems:**

- COMPANY SENDS E-INVOICE**: The company's action, connected to the **FINANCIAL IT SYSTEM**.
- OPERATOR**: The central entity that manages the process, connected to the **FINANCIAL IT SYSTEM**.
- BANK**: The financial institution, connected to the **FINANCIAL IT SYSTEM**.
- CUSTOMER COLLECTS E-INVOICE**: The customer's action, connected to the **FINANCIAL IT SYSTEM**.

**Process Flow:**

- The **COMPANY SENDS E-INVOICE** (via the **FINANCIAL IT SYSTEM**) to the **OPERATOR**.
- The **OPERATOR** sends the **E-INVOICE SENDING** signal to the **BANK**.
- The **BANK** sends the **E-INVOICE RECEIVING** signal to the **OPERATOR**.
- The **OPERATOR** sends the **E-INVOICE** to the **CUSTOMER COLLECTS E-INVOICE** (via the **FINANCIAL IT SYSTEM**).

**Standards and Transmission:**

- Contracts Standards**: Indicated by dashed lines connecting the **FINANCIAL IT SYSTEM** to the **OPERATOR** and **BANK**.
- Transmission**: Indicated by a dashed line connecting the **FINANCIAL IT SYSTEM** to the **BANK**.

The primary benefits of electronic business solutions, such as e-invoicing, involve dramatical reduction of 'clerical' transaction costs. Also, fewer errors will result through automating offline business procedures; a large number of papers are daily lost on, incorrectly filed and consequently searched for (Liu and Stork, 2000). Even though the benefits of using 'virtual world' technologies are known, the adoption of this technological innovation has not happened on a large scale.

The use of e-invoicing is twofold: organisations and relatively large companies, which send and receive a large number of invoices, seemingly benefit from and use e-invoicing more than the small companies. However, the smaller organisations and other institutions have started to realise that invoicing is an important, resource – and especially time-consuming part of their order and delivery process. It can be assumed that e-invoicing increases the effectiveness of the whole business process because of its broad connection to the operational functions and processes of the firm.

In Section 3, we will go through how the innovation adoption takes place.

### **3 Innovation adoption**

The diffusion of innovation has been defined by Rogers (1995) as a process by which innovation is communicated through certain channels over time among the members of a social system. The process of innovation diffusion is considered to revolve around four key elements:

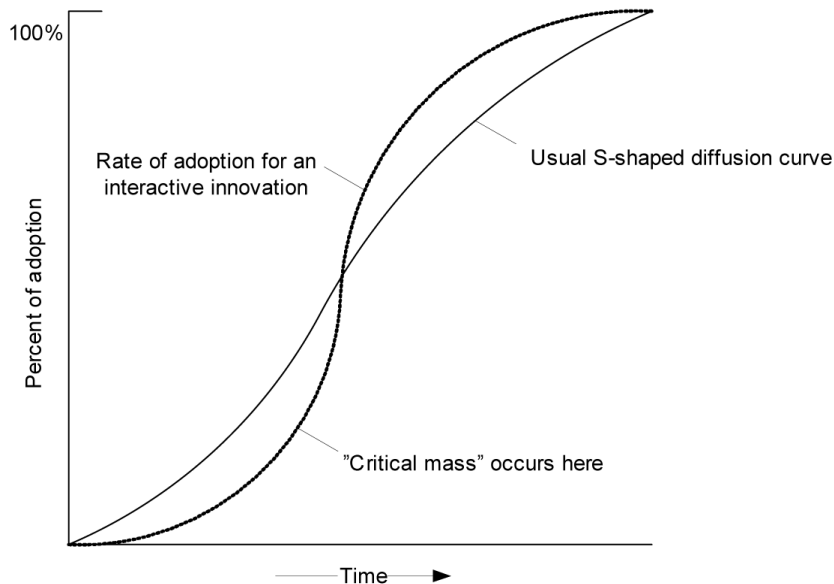
- 1 an idea or innovation
- 2 communication channels to spread knowledge of the innovation
- 3 time during which diffusion takes place and
- 4 a social system of potential adopters in which this occurs and where a set of interrelated units have engaged in joint problem-solving to accomplish a common goal.

The pattern of diffusion is often represented by the S-curve model (Figure 2), with different timings of adoption, ranging from innovators to laggards, defining the steepness of the curve. Rogers (1995) has defined innovation adoption as a decision to make complete use of an innovation as the best course of action available, and correspondingly, rejection as a decision not to adopt an innovation.

Network externalities have a significant effect on the adoption of interactive ITs, such as telecommunications and e-invoicing. A critical mass of adopters needs to be achieved before further rate of adoption becomes self-sustaining. An interactive innovation is of little use to an adopting individual unless other individuals or organisations with whom the adopter wishes to communicate also adopt (Rogers, 1995). This means that the critical mass of individuals must adopt an interactive communication technology before it is of use to the average individual in the system. Thus, each additional adopter increases the utility of interactive communications for all the adopters. Until a critical mass occurs at a relatively early stage in the diffusion process, the rate of adoption is slow, and when the critical mass is achieved, the rate of adoption accelerates (Rogers, 1995). It has been stated that an innovation needs a critical mass of 5–20% of users to be adopted on a larger scale (AtKisson, 1991; Rogers, 1995; Valente, 1995). In organisational innovation

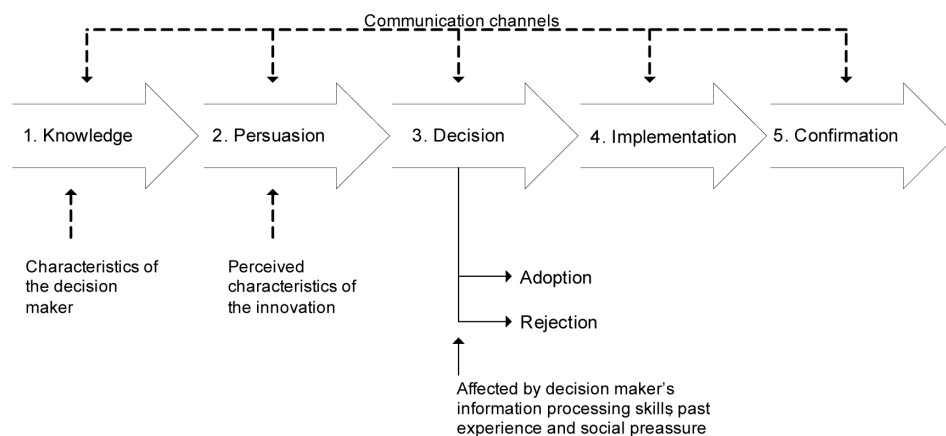
adoption, positive network externalities exist when the intrinsic utility of an innovation increases as a firm's suppliers, customers, competitors or other organisations also use the innovation (Frambach and Schillewaert, 2002).

**Figure 2** Critical mass and the diffusion curve (Mahler and Rogers, 1999)



The basic assumption of the adoption process is that it goes from awareness to full implementation, and every step of the method involves gathering, processing and incorporating of new experiences and information (Figure 3).

**Figure 3** Stages in the innovation adoption decision process (modified from Rogers, 1995)



Before an innovation can be adopted, the potential adopter must have knowledge (1), namely, be aware of existence and exploitability of the innovation (Zaltman et al., 1984). The awareness of an innovation can stimulate a need to adopt it, or a particular need in

the organisation can evolve a search process with the result that awareness of potential innovations will be increased. This is related to the information that the organisation has regarding its external environment. A potential adopter passes through the persuasion stage (2) to the decision making (3) on whether to adopt or reject an innovation, and then to further stages (4 and 5) strengthening the decision. The extent and time of leaving behind certain stages in the adoption process depends on the information available and on the information processing characteristics of the potential adopter (Frambach, 1993). The adoption decision itself is dependent on the decision maker's information processing capabilities (Gauvin and Sinha, 1993), past experience and social pressure. Knowledge and know-how regarding the innovation is gathered after the awareness, and is considered to be an important adoption process for the innovation (Attewell, 1992; Fichman and Keremer, 1997). Further, knowledge and know-how serve the organisation only at the beginning of the concrete implementation.

In addition to information and knowledge, innovation adoption is affected by other multiple factors. The innovativeness of an organisation was found to be dependent on organisational structure (Hull and Hage, 1982; Kim, 1980; Subramanian and Nilakanta, 1996), managerial influence and attitudes (Kimberly and Evanisko, 1981; Zmud, 1989) and environmental effects (Damanpour and Gopalakrishnan, 1998; Miller and Friesen, 1982). Considering the timing of adoption, innovation characteristics are among the major determinants (Beatty et al., 2001; Karahanna et al., 1999; Plouffe et al., 2001). A new innovation that needs investments is often considered as risky. The choice of electronic business solutions depends on many criteria, such as relative network power, integration level of solutions, product characteristics and supply chain relationships (Sheth and Ram, 1987). In the case of electronic invoicing, there are numerous uncertainties that entrepreneurs face. The knowledge of IT-investments and the process changes they bring along may not be fully understood. The network itself is critical, as the innovation is useless unless the parties of the network also adopt it. An IT innovation may be considered difficult if the know-how is minimal. Many innovations require a long period (many years) from the time they become available to the time they are widely adopted and completely utilised. A common problem in the market is how to speed up the diffusion rate of an interactive IT innovation. The more users there are, the more one can take advantage of these network innovations and externalities; and the better it sells, the more it is developed further.

#### **4 IT investment decision making under high uncertainty**

SMEs face great challenges in managing investments in new innovative technologies or innovations. The investor may face a high market and technology risk at the same time without accurate knowledge about contingent events, and the decision is made under a great uncertainty (Balasubramanian et al., 2000; Scarso, 1996; Slater et al., 1998).

Narrower the free resources are, the smaller the business is, and the question of where to invest and where not to invest becomes more crucial. The entrepreneurial decision-making as regards to strategic future options is very often based on intuition and 'seeing things'; when the decision maker lacks information and is free of bureaucracy, economic reasoning and formal comparison are less vital (Penrose, 1959; Rosenberg, 1994; Schumpeter, 1934).

Process investments in IT may drastically change the firm's operating environment. The challenge the decision maker faces is that all the possible implications of a new method of operating are difficult to evaluate. There are either, no or a very few cases that it can be compared to, and the data that could support the decision is uncertain. Later the investment may create possibilities that were not detected earlier simply because the human mind has more trouble in understanding complicated and contingent issues that cannot be visualised and imagined clearly (Dörner, 1997).

Strategic investments in IT, for example, a new technology platform investment, have been described as 'spawning projects' (Brabazon, 1999; Kasanen, 1986), the value of which lies in growth opportunities or options. An IT investment, which is often a modular investment or a platform investment, is a basis for extension investments, or a learning investment to obtain information on how to decrease uncertainty that would not otherwise disappear. The investment may also increase the firm's flexibility or ensure the firm against uncertainty.

To visualise the business opportunities and the options that the firm has, one has to understand the strategic perspective and opportunities that can be identified through the innovative IT investments. The key question is to identify the opportunities and their possible value for the firm. The following section concentrates on explaining how investment under uncertainty can be evaluated.

## **5 The strategic options approach**

The conventional evaluation methods are incapable of capturing the value of future opportunities in uncertain and innovative investments. They very often prove innovative investments are unprofitable because they neglect the value of opportunities related to the investments (Dixit and Pindyck, 1995; Scarso, 1996).

Contrary to this, the use of real options<sup>1</sup> has been suggested to be a capable method for evaluating uncertain IT investments, even though the usefulness of the approach in practice is not evident. It has been stated that the (real) option pricing methods may help the management in evaluating the opportunities that IT investments create (Benaroch and Kauffman, 1999; Zhu, 1999).

The real option is a subconcept of the SOA, concentrating on real option valuation whilst the SOA has a broader perspective. The term real option refers to valuating flexibility in decision-making and strategic options to the valuable strategic opportunities available for the firm (Edelmann et al., 2005). The SOA covers both concepts. On the one hand, the SOA is a strategic analytic 'philosophy', and on the other hand it is purely a real-world option valuating system to define mathematical values for alternative course of action.

The most well-known real option valuation approaches in use are the Black and Scholes option pricing formula, the Binomial option pricing formula and the Geske model (Perlitz et al., 1999; Zhu, 1999). The approach arises from the idea that financial option thinking can be transferred with certain assumptions on real assets (Benaroch and Kauffman, 1999) (Table 1).

The SOA is a method for the management to identify and take into account the diversity of the future in contrast to the traditional investment evaluating systems. The advantage that the SOA offers is powerfulness in complex investment decision making situations where means to reduce the complexity of decision making is required.

The logic behind the SOA is to solve how an investment project can provide access to upside opportunities while avoiding costs and downside risks without losing its flexibility. In total, the options approach is a language to be described and to evaluate the possibilities the firm has (Belanger, 2001; Dias and Ryals, 2002; McGrath and MacMillan, 2000).

**Table 1** Attributes affecting the value of real options based on the option theories

1	Volatility of the potential outcomes/value of the underlying asset
	a) Market uncertainty (+)
	b) Technological uncertainty ( $\pm$ )
2	Present/expected value of benefits/cash flows of the underlying asset (+)
3	Expected investment/implementation cost (–)
4	Time to maturity (+) (time until the opportunity disappears)
5	Risk-free interest rate/time value of money (+)
6	Payments lost while waiting to invest (–)

*Note:*  $\pm$  refer to the effect on the option value.

*Source:* Perlitz et al. (1999) and Trigeorgis (1997).

Options are entrenched in real assets, for example, in the form of option to expand, option to abandon or option to defer the decision (Dias and Ryals, 2002). With the strategic options, the investment decision and decision-making problem is approached in stages, giving the management a chance to try things and wait when the alternative seems too uncertain. The small steps taken can give the firm an advantage against competitors by making it more prepared for the future. It is a step to tackle uncertainty that is related to the investment proposals where greater uncertainty means a possibility of greater wins or losses.

The real option theory, based on the Black–Scholes model, says that the greater the uncertainty is, the more the real option value increases (Leslie and Michaels, 1997; Perlitz et al., 1999). On the other hand, the ability to delay and wait for further information before making an irreversible decision has value (Herath and Park, 2001), and if the investment could, in any likelihood result in a loss, the opportunity to delay the decision of keeping the option alive has value (Dixit and Pindyck, 1995). When there is high uncertainty and flexibility to respond to uncertainty, strategic options are important.

The traditional real option valuation can be extended to include value attributes, which aim to take market dynamism into account. The framework follows the traditional real option valuation formula, but the focus is on the analysis and not on certain option values. Each attribute aims at getting information about the strategic option value of the innovation. The framework is presented in Section 7.2.

The management should not think that they can or should use the real option valuation everywhere. Very often the real options value is high when the Net Present Value (NPV) is closer to zero. If the NPV is high, the additional flexibility that the thinking option offers has a relatively low additional effect on the value, and conversely, if the NPV shows a very negative value for the project, no amount of optionality can

rescue the project (Copeland and Antikarov, 2001). If the decision is clear and the NPV shows without any bias that the investment should be made, the use of the ROA may be a waste of time. Thus, it has to be well thought out whether the investment has any option value. It can be generalised that to have option value, the investment project should be sizeable enough, strategic by nature, and it should not consist of an up-front, irrecoverable cost (Brabazon, 1999).

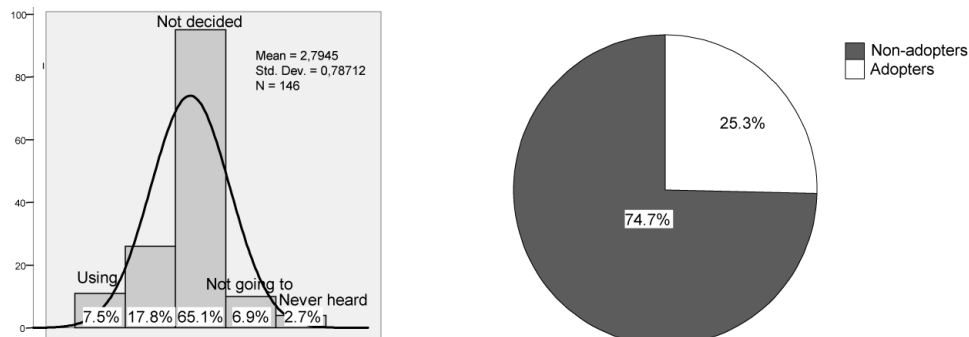
The SOA is important in investment decision making. With this thinking the shadow options (i.e. unrecognised opportunities) (Bowman and Hurry, 1993) can be described so that the strategic opportunities can be seen and evaluated more naturally than with the widely used capital budgeting methods, (Zhu, 1999; e.g. Phelan, 1997) or pure real option valuation. The focus is on taking into account the inborn flexibility the management shows all the time (Campbell, 2001). The approach may change the decisions made by the management dramatically, fitting in the intuition of the management better than, for instance, the NPV. It can be argued that the SOA is near the normal behaviour of experienced managers.

An investment in e-invoicing can be seen as an every-day investment that can be evaluated by using cashflow-based evaluation methods. However, the case seems to be very different: the innovation seems to include uncertainties that hinder its adoption by SMEs. The following sections present first the statistical analysis of the research hypotheses, and then the data are further analysed on the basis of the SOA.

## 6 Survey on the adoption of electronic invoicing

The aim of this study was to empirically examine the non-adoption of a technological innovation, namely e-invoicing. This section concentrates on analysing the survey on the adoption of e-invoicing. The data were collected by a mail survey during March and April 2005. All the companies were contacted over phone before the questionnaire was sent to them. The survey was sent to 932 companies, and the response rate was 15.7%. The data included 146 companies in South Karelia, which were named by 10 large companies and the local municipalities as the ones sending most invoices to them. Of the studied companies, 25.3% (37) had adopted e-invoicing, of which 7.5% (11) had fully adopted it and 17.8% (26) were testing their first e-invoices. E-invoicing had not been adopted by 65.1% (95), and 6.8% (10) reported having rejected it (see Figure 4).

**Figure 4** Adoption of e-invoicing in South Karelia (SMEs)



### 6.1 Research hypotheses

The empirical analysis of the adoption of e-invoicing consists of testing the following hypotheses: *The demands of the environment* reflect Rogers's social system and environmental influence where the value network has a common goal to become 'electronic' in their invoicing process even though the incentives of each player vary. The network in which the company operates may even require the adoption of some innovations. In the case of invoicing, the positive network externalities should facilitate the adoption.

*H1: The market demand has a positive influence on the adoption decision.*

*Perceived uncertainty*, which is derived from the lack of tacit (Forsgren, 2002) and codified knowledge, has a significant negative influence on the decision of adopting (Nooteboom, 1989). The uncertainty is related to the network externalities, as there might be scenarios where the investment will not be worthwhile, and the unpredictability of the diffusion of e-invoicing among companies raises the perceived uncertainty. Uncertainty is also expected to increase, if the innovation is considered to be complex and if no expertise exists in the company for IT issues. The higher the companies perceive the uncertainty around the innovation, the more unlikely the adoption will be.

*H2: Perceived uncertainty impedes the adoption decision.*

After awareness of innovations' existence, *knowledge and know-how* are the premises of adoption. Learning or communicating the technical knowledge required to use a complex innovation successfully places far greater demands on potential users and on supply side organisations than the signalling of the existence of innovation (Attewell, 1992). Without knowledge or know-how about e-invoicing, one cannot adopt it. On the other hand, an increase in knowledge decreases perceived uncertainty and risks.

*H3: Higher level of knowledge (a) and know-how (b) have a positive influence on the adoption decision.*

### 6.2 Measurement

A factorial analysis was conducted in order to clarify the measurement constructs required for testing the hypotheses. All the items were measured on a five-point Likert scale ranging from totally disagree to totally agree. The exploratory factorial analysis provided four factors (Table 2). After the factorial analysis, the reliability of the constructs was evaluated with Cronbach's alpha, ascertaining that the measures were eligible enough for continuing the analysis.

### 6.3 Testing the hypotheses

An Analysis of Variance (ANOVA) was used as the method for testing the hypotheses. The independent variable indicated the probability of the adoption of e-invoicing. The companies were asked to evaluate the time it would take for them to adopt e-invoicing. The group comparison and the mean values for the dependent instruments are shown in Figure 5 (a)–(d).

**Table 2** Factor analysis of measures

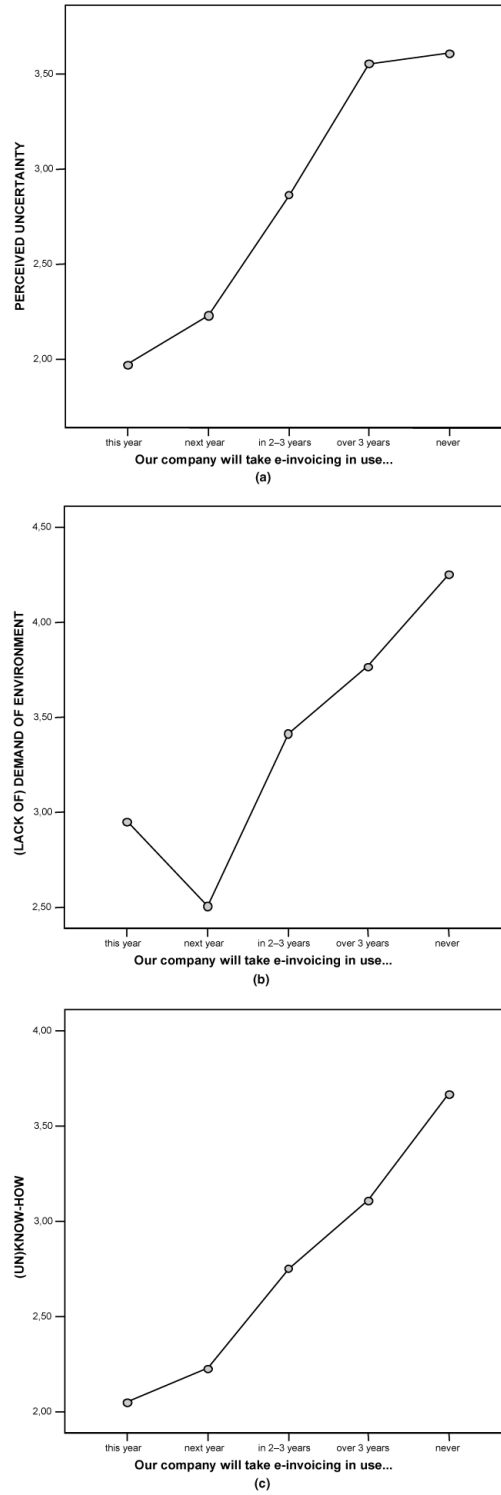
	<i>Factor loadings</i>			
Perceived uncertainty 1	0.721			
Perceived uncertainty 2	0.715			
Perceived uncertainty 3	0.710			
Perceived uncertainty 4	0.694			
Perceived uncertainty 5	0.656			
Perceived uncertainty 6	0.635			
Perceived uncertainty 7	0.617			
Demand of the environment 1		0.881		
Demand of the environment 2		0.873		
Demand of the environment 3		0.694		
Demand of the environment 4		0.570		
Knowledge 1			0.769	
Knowledge 2			0.763	
Knowledge 3			0.677	
Know-how 1				0.783
Know-how 2				0.524
Reliabilities (Cronbach's alpha)	0.868	0.810	0.700	0.632
Mean scores	2.758	3.298	2.863	2.679

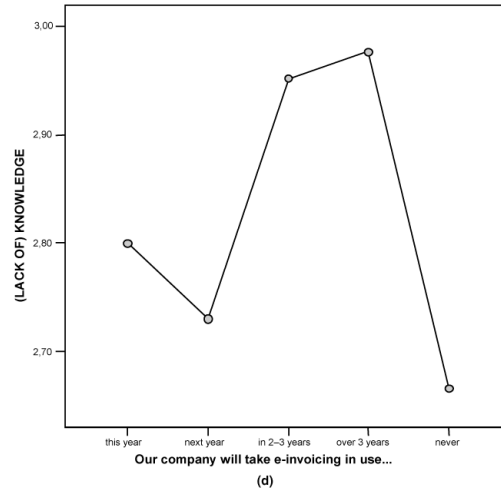
On the basis of the ANOVA results, the hypotheses (Table 3) about the demand of the environment (H1) and perceived uncertainty (H2) can be accepted. The third hypothesis evaluating the importance of knowledge (H3a) had to be rejected, as no significant group differences were found. The last hypothesis (H3b) concerning know-how was accepted.

#### 6.4 Findings

The major findings of the analysis were as follows: firstly, lack of *demand* from the environment was perceived to be the most important reason for companies not adopting e-invoicing. The higher the level of demand is, the quicker the adoption takes place. Secondly, the higher the perceived *uncertainty*, the further the decision of e-invoicing being deferred. Finally, the companies' *knowledge and know-how* level were not perceived to be high enough, and the lack of know-how extends the expected time of adoption. We could not show that the lack of knowledge had a significant influence on the time of adoption (possibly due to an error caused by the small amount of data). However, the most important reasons were the lack of environmental demand and the perceived uncertainty (including seven different variables). In addition to the presentation of hypotheses, the study aims to clarify the major reasons for non-adoption. The companies, which were not using or planning to use e-invoicing, were asked to evaluate some factors that were related to the adoption of e-invoicing. Table 4 partly supports the findings of the ANOVA analysis with the evaluation of propositions presented in the questionnaire, including the information that the non-adopter SMEs were not fully convinced about the benefits of e-invoicing.

**Figure 5** Means of measurement items ( $N = 97-99$ )



**Figure 5** Means of measurement items ( $N = 97-99$ ) (continued)**Table 3** Results of ANOVA analysis

Hypothesis	F-value	p-Value
H1: Demand of the environment	6.874	0.000
H2: Perceived uncertainty	12.345	0.000
H3a: Knowledge	0.320	0.864
H3b: Know-how	5.123	0.001

**Table 4** Reasons to avoid e-invoicing (non-adopters)

	Agree	Neutr	Disagree
Our suppliers have not demanded it	65.1	18.9	16
Our customers have not demanded it	63.2	13.2	23.6
We are not convinced of the benefits of e-invoicing	48.6	19.6	31.8
We do not have enough information about e-invoicing	38.3	32.7	29
Our competitors do not use e-invoicing either	28.8	42.3	28.8
We do not want to change our invoicing routines	28.3	20.8	50.9
We do not believe that the e-invoicing connections are operating well	25.5	32.1	42.5
E-invoicing is too expensive	24.5	36.8	38.7
We do not have a suitable person to take care of the implementation	22.6	22.6	54.7
Integrating e-invoicing into our systems is difficult	22.1	29.8	48.1
We have not found a suitable operator	20.4	33	46.6
It takes too long to start to use e-invoicing	18.9	38.7	42.5
We are concerned about the security issues	17	29.2	53.8
We are waiting for the actions of our competitors	15.2	32.4	52.4
The risks are too high	14.2	32.1	53.8
We are afraid to become too dependent on the operator	14.2	36.8	49.1
E-invoicing is technologically too complicated	13.1	35.5	51.4

## **7 Strategic option analysis of the adoption of e-invoicing**

The following analysis has two phases: firstly, the recognition of real options is presented, and secondly, the strategic option value is examined.

### *7.1 Recognition of real options*

The first step in the process of strategic options value realisation is the recognition of real options (Barnett, 2005), including creation of active real option. E-invoicing by itself can be viewed as a strategic option (see Edelmann et al., 2005) but here we will have a broader perspective on firms' real options. It is possible to identify some options that the firm has in all situations, such as deferral and abandonment options, meaning that the investment can always be deferred in order to learn, or the investment can be abandoned to avoid further ex post costs. The option to contract, expand, extend and switch are options where the investment project can be scaled, switched or stepped up. Latimore (2000) divides options simply into growth options and flexibility options, which are explained as follows.

#### *7.1.1 Growth options*

The investments in e-invoicing may create avenues for new business opportunities in new market areas or by new business models. When the investment in e-invoicing can be scaled up if new, favourable market information emerges, the firm is in possession of a growth option. A good example of a growth option is the possibility for business where the transaction of money is very small and would otherwise be unprofitable. Often a growth option is built by creating platforms: the investment in e-invoicing can perform as a platform, which enables further investments (because of new favourable possibilities) but does not oblige them. However, most of the SMEs' investments in e-invoicing do not open any special growth options.

#### *7.1.2 Flexibility options*

A new business may increase the firm's capability to shift on the markets and give it new operation opportunities and capabilities to change the course of its plans in the future. The adoption of electronic invoicing gives the firm a few exceptional flexibility options, but in most cases firms possess normal dividing, deferring, abandonment or switching options. The options related to e-invoicing are dependent on the integration level: the higher it is, the more options there are.

An option to divide the investment in smaller doses increases the firm's possibilities to avoid sunk costs. There is no obligation to continue to further divide if it is noticed that the investment in e-invoicing may turn to be unprofitable, and only the invested assets are lost. The dividing option the firms usually have is the learning option, which enables them to gain information about e-invoicing and reconsider the investment after that.

In most cases firms have the right to withhold the investment by having a deferral option (a timing option): the market demand does not seem to be a compulsion for action. SMEs possess the deferral option, enabling them to accumulate knowledge in order to reduce uncertainty and avoid committing themselves in irreversible investments

(Brabazon, 1999). However, additional information combined with prior information does not completely eliminate the uncertainty (Herath and Park, 2001).

If there is an opportunity to shut down the project, the firm holds an abandonment option, which makes it possible to prevent any further losses. In most cases this is the most common option to have.

When the firm has the ability to switch on the inputs to an investment or the outputs from an investment, it has particularly valuable switching options in a situation where competitor actions and market demand are difficult to forecast. In the case of e-invoicing there are some outputs that could be switched to something else: increase in the firm's capabilities can be used in other e-business projects.

## *7.2 Strategic option value examination*

Next, the strategic value of the innovation is examined on the basis of the following attributes:

- 1 uncertainty
- 2 market value
- 3 scale of investment
- 4 irreversibility
- 5 time and
- 6 impact.

The framework follows the traditional real option valuation formula extended by value attributes, the goal of which is taking into account the market dynamism. Each attribute aims at getting information about the strategic option value of the innovation.

### *7.2.1 Uncertainty*

Uncertainty is the most significant real option value component. One classification says that investment decision making is about managing two types of uncertainty: technological uncertainty and market uncertainty (Ansoff, 1965); whereas another classification defines uncertainty as for instance, endogenous or exogenous. The influence of market uncertainty is positive concerning the option value, and contrary to that, technological uncertainty decreases the real option value in most cases. Kyläheiko et al. (2002) show that the concept of uncertainty needs to be broken into smaller elements where parametric, structural and procedural uncertainties are identified.

The market uncertainty is perceived as high because, suppliers and customers have not shown their interest clearly. The market demand is expected to be high but there is no knowledge about the accurate time of the emergence of the need. The technological uncertainty is perceived as low, even while the overall costs, required competencies and resources are unknown. A major part of the uncertainty is radical: the probability of events and their consequences are unknown.

### *7.2.2 Market value*

The market value means the cash flows that the company can achieve. In this case the market value of the e-invoicing option is derived from possible savings or/and further options to create the market value. It is learnt that there may be benefits in using

e-invoicing, even for the smallest firms, while there is no more need for time-consuming manual invoice processing (The Finnish Ministry of Finance, 2001). However, there is uncertainty as regards to whether the benefits do exceed the costs. The value can be increased through options, which either increase the integration level of the firm's financial systems or increase the future business opportunities.

### *7.2.3 Scale of investment*

How much is to be invested on assets in order to adopt the innovation? Is the need large enough compared to the firm's annual investment budget or free resources? The smaller the firm is, the less free financial assets it has, the more critical would be the investment decision.

The scale of investment required in the case of e-invoicing can be quite large: the greater the integration level of the financial system, the higher the costs. Providing e-invoicing on the internet, as Finnish banks do, may decrease firms' start-up costs and also decreases the possibilities for strategic options, such as extension options, by committing firms to the banks' systems and limit integration possibilities.

### *7.2.4 Irreversibility*

The irreversibility of an investment increases with the investor's risks of the sunk costs and fixed costs (Dimpfel and Algesheimer, 2002). An increase in the rate of irreversibility decreases the management's flexibility, and thereby the greater the irreversibility, the higher the value of the option to defer the investment (McDonald and Siegel, 1986). As opposed to this, the greater the irreversibility of an investment, the lower the value of the option to abandon (Myers and Majd, 1990). An irreversible investment where the investment cannot be returned should be withheld as long as possible and reasonable (Dixit and Pindyck, 1994) or be divided into stages (Amram and Kulatilaka, 1999). The irreversibility level of investments in e-invoicing is considered high. There are a few possibilities to recover the investments. The in-built capabilities are seen to be the only reversible investments to be used in other IT projects.

### *7.2.5 Time*

The investment decision is not a now-or-never decision, and the decision can therefore be postponed as long as the option to defer is alive. Additional information will reduce the uncertainties and thereby the value of the deferring option. The opportunities e-invoicing offers are alive as long as the situation remains unchanged. In order to avoid e-invoicing, half of the respondents mentioned that their competitors are not using e-invoicing. This may be a reason for them to wait (because the option does not die), but it may decrease the value of growth potential.

### *7.2.6 Impact*

The adoption of an innovation may have a crucial effect on the market size and the growth potential while competition may become tougher. In this case, the diffusion of e-invoicing may have a direct impact on the firm's effectiveness and offer new comers with some temporary competitive advantage.

## 8 Conclusions

This paper has presented its findings concerning e-invoicing and its adoption in Finnish small and medium-sized enterprises. The reason why this study was initiated was that there have been many conjectures and fallacies about e-invoicing, and we wanted to know the actual reasons for the slow diffusion.

The results of the survey presented in this paper show that there are some clear reasons, which explain part of the slow diffusion. The perceived uncertainty concerning e-invoicing in SMEs is relatively high. Secondly, the supply chain has not demanded its players to use it. Thirdly, there is lack of know-how, that is, how to do it in practice. We also shed some light on further research results. Especially e-invoicing seems to require a personal contact with companies. Information read somewhere does not seem to help the adoption decision. Instead, face-to-face contact in trade fairs and with sales persons support the adoption decision.

The quantitative study was extended by the SOA in order to gather more information about the adoption decision. The option analysis revealed that the SMEs have many different strategic options. Some options are inherent in most of the cases, whereas other options have to be created intentionally. For some firms, e-invoicing offers better opportunities for achieving competitive advantage by adopting a more effective business process. Once the investments to be made in a more effective financial business process (and platform) are decided, the possibilities for reorganising the whole financial system and recognising the further options will be enhanced. However, most small enterprises do not possess the required capabilities and resources for carrying out the change rapidly, so phasing the investment in smaller steps is required. The firms possess a natural phasing option, if they are able to phase the investment.

A common characteristic of SMEs is that the search costs of information are relatively high for them. It is valuable for them to wait and see what happens. As 90% of the companies are small enterprises, it is difficult to get the diffusion process of an innovation started and to reach the critical mass. The strategic options could explain the results of the quantitative analysis. Related to this, the parties whose interest is to promote the diffusion process should consider the decision making of SMEs, not only according to the survey but also on the basis of the strategic options possessed by SMEs.

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## Note

- <sup>1</sup>A real option is a right but not an obligation to take action at a predetermined cost called the exercise price for a predetermined period of time (Copeland and Antikarov, 2001).

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