Lappeenranta
University of Technology

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IDENTIFICATION OF CHARACTERISTICS FOR SUCCESSFUL UNIVERSITY-COMPANY PARTNERSHIP DEVELOPMENT

Thesis for the degree of Doctor of Science (Technology) to be presented with due permission for public examination and criticism in the Auditorium 1383 at Lappeenranta University of Technology, Lappeenranta, Finland on the 5th of June, 2015, at noon.

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ABSTRACT

Vesa Karvonen

Identification of characteristics for successful university-company partnership development

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The importance of university-company collaboration has increased during the last decades. The drivers for that are, on the one hand, changes in business logic of companies and on the other hand the decreased state funding of universities. Many companies emphasize joint research with universities as an enabling input to their development processes, which aim at creating new innovations, products and wealth. These factors have changed universities' operations and they have adopted several practices of dynamic business organizations, such as strategic planning, monitoring and controlling methods of internal processes etc.

The objective of this thesis is to combine different characteristics of successful university-company partnership and its development. The development process starts with identifying potential partners in the university's interest group, which requires understanding the role of different partners in the innovation system. Next, in order to find a common development basis, matching the policy and strategy between partners is needed. The third phase is to combine the academic and industrial objectives of a joint project, which is a typical form of university-company collaboration.

The optimum is a win-win situation where both partners, universities and companies, can get added value. For the companies added value typically means access to new research results before their competitors. For the universities added value offers a possibility to carry on high level scientific work. The research output in the form of published scientific articles is evaluated by the international science community. Because the university-company partnership is often executed by joint projects, the different forms of this kind of projects is discussed in this study. The most challenging form of collaboration is a semi-open project model, which is not based on bilateral activities between universities and companies but on a consortium of several universities, research institutes and companies.

The universities and companies are core actors in the innovation system. Thus the discussion of their roles and relations to public operators like publicly funded financiers is important. In the Finnish innovation system there are at least the following doers executing strategies and policies: EU, Academy of Finland and TEKES. In addition to these, Strategic Centres for Science, Technology and

Innovation which are owned jointly by companies, universities and research organizations have a very important role in their fields of business. They transfer research results into commercial actions to generate wealth.

The thesis comprises two parts. The first part consists of an overview of the study including introduction, literature review, research design, synthesis of findings and conclusions. The second part introduces four original research publications.

Keywords: public research organization, university-company collaboration, university-company partnership, research collaboration, interest group management, value chain, value creation, Triple Helix model, Strategic Centre for Science Technology and Innovation, SHOK, Finland

ACKNOWLEDGEMENTS

Dear Reader

After I finished my first doctoral dissertation in 2002 I had luckily forgotten the pain, misery, stress and huge workload which are typical elements in this kind of academic operation. When I started this second research mission I thought that this will be a *stairway to heaven*[1] but soon it changed into *highway to hell*[2]. But *oops, I did it again*[3] and I did it *my way*[4]. It is again my turn trying to *shake your foundations*[5].

I really appreciate professional backup from my supervising Professors Tuomo Kässi and Vesa Harmaakorpi. Thanks to their flexibility and encouraging attitude during this process it was possible to execute it in relatively short time. The constructive feedback from my reviewers, Professor Saku Mäkinen and docent, CEO Ari Ahonen, helped me a lot in focusing and justifying the text into more accurate and compact form.

I really was a *fortunate son*[6] because during this process I had a privilege to collaborate with superb co-writers: Matti Karvonen, Andrzej Kraslawski and Eeva Jernström. Your expertise kept the articles in line and I learned so much from you. Thanks to Sinikka Talonpoika for assistance in translating my rally English to understandable form.

I am grateful for the financial support I received from the Suomen Kulttuurirahasto Etelä-Karjalan rahasto. Without the grant this project would still be in progress...

Without the full support from my family this mission would never have been finished. Maximum thanks to my wife Susanna, who is always *wonderful tonight*[7] and the rest of the time she is my *pride and joy*[8]. Thanks to my *rock ´n´ roll children*[9] Veera and Veeti. And of course thanks to my highly respected mother and father. And thanks to my friends for encouragement and positive ass kicking.

And finally thanks to various breweries for stimulation and inspiration.

I will close all speculative discussions concerning my third thesis, because *this will be the last time*[10]. *Schools out forever*[11].

Born to lose, live to win[12].

Lappeenranta, May 2015

Vesa Karvonen

References:
1. Led Zeppelin, 2. AC/DC, 3. Children of Bodom, 4. Sid Vicious, 5. AC/DC, 6. CCR. 7. Eric Clapton, 8. Stevie Ray Vaughan, 9. DIO, 10. Rolling Stones, 11. Alice Cooper, 12. Lemmy Kilmister

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LIST OF ABBREVIATIONS

CLEEN	SHOK, focus on energy and environment
CST	Centre for Separation Technology (institute hosted by LUT)
DIGILE	SHOK, focus on information technology
EU	The European Union
FIBIC	SHOK, focus on bioeconomy
FIMECC	SHOK, focus on metals and machineries
IPR	Intellectual property rights
LUT	Lappeenranta University of Technology
NIS	National innovation system
PPI	Pulp and paper industry
PRO	Public research organization
RYM	SHOK, focus on built environment
SALWE	SHOK, focus on health
SHOK	Abbreviation from Finnish words for Strategic Centres for Science, Technology and Innovation
SRA	Strategic Research Agenda, normally in use in SHOKs
Tekes	National Agency for Technology and Innovations
TH	Triple Helix model

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LIST OF PUBLICATIONS

This thesis has two main parts, an overview (Part 1) and four publications (Part 2). The publications comprising the second part are listed below, summarizing the contribution of the author of this thesis and the acceptance procedure for each paper.

PUBLICATION I

Karvonen, V., Karvonen, M., Kraslawski, A. (2014) Mapping the activities between a public research organization and interest groups: Case study LUT CST in Finland, *European Planning Studies.*

This article can be found at:
http://www.tandfonline.com/doi/abs/10.1080/09654313.2014.938222

The author drew up the research plan with the co-authors, and conducted the research. The paper was written in collaboration with the co-authors and the author had the main responsibility of the process.

PUBLICATION II

Karvonen, V., Jernström, E., Kraslawski, A. (2015) Types of connections between plant location selection and the long term corporate level value creation and methods of their identification. Case study; pulp and paper industry, *International Journal of Industrial and Systems Engineering,* Vol. 19 (3), pp. 277-293.

The author drew up the research plan with the co-authors, and conducted the research. The paper was written in collaboration with the co-authors. It is accepted for publication and is in press.

PUBLICATION III

Karvonen, V., Karvonen, M., Kraslawski, A. (2012) A tuned value chain model for university based public research organisation. Case LUT CST, *Journal of Technology Management & Innovation*, Vol. 7 (4), p. 164-175.

The author drew up the research plan with the co-authors, and conducted the research. The paper was written in collaboration with the co-authors. The author had the main responsibility for the whole process including revising the paper over the journal review process.

PUBLICATION IV

Karvonen, V., Karvonen, M., Kässi, T. Public research organization navigating in the cluster based national innovation system. Submitted for publication in *Innovation: Management, Policy & Practice,* August 29th 2014.

The author drew up the research plan with the co-authors. The literature review and data collection were performed jointly with the co-authors. The paper was written in collaboration with the co-authors, and the author had the main responsibility for revising the paper over the journal review process.

1 INTRODUCTION

The basic tasks of universities are research, education and societal impact. Due to common economics, the resources to fulfill this mission have decreased, and this has led universities to new situation. The huge improvements in telecommunications and data processing enable easy networking in research globally. This increases the demand for achieving more world-class scientific results. This dilemma is introduced in subchapter 1.1 below. The motivation for this research and the research gaps are explained. The first two subchapters are followed by presenting the solution to the found gap. Next, the research question and objectives are presented and finally the structure of the thesis is explained.

1.1 The changing role of universities

Since the 1980's there has been increasing pressure on academics to collaborate with industry partners and to commercialize the results of their research. A ('paradigm') change in the university system from research universities into entrepreneurial universities has been observed (Rothaermel et al., 2007). Some authors (Siegel et al., 2004) have seen this as a natural evolution of a university system that emphasizes economic development in addition to the more traditional mandates of education and research. Many universities have built more or less full-range support mechanisms for entrepreneurship, such as technology transfer offices and incubators or science parks that spawn new firms. Engaging increasingly in interactions with industry, the core of the university system has expanded to include activities outside basic research with the goal of transforming inventions into innovations. This is an area where we have seen an increasing amount of academic entrepreneurship activities, such as contract research, consulting, patenting, licensing, and spin-off firm creation (Klofsten and Jones-Evans, 2000; Perkmann et al., 2013). In many countries university reforms have been carried out in order to support commercialization and technology transfer in general.

Universities have to argue for their economic role and demonstrate their societal impact to an increasing extent in order to obtain public funding even for basic research. Universities can contribute to economic development both by interaction with existing industry and by other types of commercialization of knowledge, such as university licensing or the establishment of new firms.

Increased societal interaction can enhance the public image of universities, which in turn can lead to accountability for funding. The change in the mission opens the possibility for many universities to get a broader funding base through other nongovernmental sources (Rasmussen et al., 2006).

New expectations and a changed funding structure are two major changes in the academic world. There are still diverse views of the implications of this change, as some scholars suggests that a more entrepreneurial university strives for more applied and problem-solving research and thus interrupts or even threatens academic freedom (Powell and Owen-Smith, 1998). More frequent concerns include worries about shorter time horizons in research and tensions related to impartiality and conflicts of interests (Etzkowitz, 1998), as many institutes need to operate in a manner similar to private companies (Etzkowitz, 2003). The third mission of universities as regional engines of innovation and economic growth has increased the importance of partnership management and a focused strategic direction in both academic and economic development of goals (Etzkowitz et al., 2000; Etzkowitz and Klofsten, 2005). Regardless of the ongoing discussion about the future of universities' basic missions and open public science, it seems that it is possible to manage both academic and value adding pursuits. For instance, Gulbrandsen and Smeby (2005) argue the relationships can be complementary and mutually beneficial. They found a significant relationship between industry funding and research performance, as faculties with industry funding conduct more applied research, collaborate more with external researchers both in academia and industry, and report more scientific publications and entrepreneurial results. However, for example in different project (open, closed) types, there is need for institutional policies to ensure that the public sector mission is not compromised.

It is widely recognized that technological innovation plays a central role in the long-run economic growth of a social system and its emerging technologies. The Triple Helix model includes three elements; government, company and academy (see Chapter 2.1). Leydesdorff and Etzkowitz, (1996) suggest that in a knowledge-based society the boundaries between the public and private sector, science and technology, university and industry are fading increasingly, giving rise to a system of overlapping interactions which did not exist previously. In practice the model is seen, for example, in situation where universities perform tasks that were formerly assigned to firms and vice versa. While the academic work is being redirected towards commercial applications, industry-university collaboration is becoming a critical issue, and wider industrial and political interests are integrated into the planning and organization of university research. The Triple Helix thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies, and therefore academic researchers have to take account of the impacts that the scientific outputs of their work have on industry. At the same time researchers working in industry need to be updated on the evolutionary developments of science (Leydesdorff and Etzkowitz, 2000; Ughetto, 2007). Naturally, the Triple Helix model does not exclude focusing on two of the three dynamics, for example, in studies of university-industry relations. However, one can expect more interesting results by studying the interactions among the three sub-dynamics. At the very least, the third dynamic of the Triple Helix model should be identified as another variable while discussing the said sub-dynamic interaction. (Leydesdorff and Etzkowitz, 2000).

1.2 Motivation

The motivation for this study originated at the personal level. I have worked in several organizations and positions, all linked to the university-company interface. I have worked for the public financier organizations (e.g. Tekes on the national level, Employment and Economic Development Centre on regional level and Finnish delegate in COST domain on the EU level). I have also experience of the fund applicant role (e.g. Saimaa University of Applied Science and Lappeenranta University of Technology (LUT).)

When I was the director of Centre for Separation Technology (CST) hosted by LUT I wanted to understand my daily work better and tried to find scientific backup for it. During the first trials I found that there is a huge amount of information concerning university-company relationships and joint project development in different innovation systems, but this was not exactly what I was looking for. As a consequence, an academic interest started to rise.

1.3 Research gaps

There is a lot of literature concerning university-company relations (see Chapter 2.3). In most cases the articles are structured on the bilateral basis where the missing links are the policy level and presence of public financiers. There are not many papers focusing on research units dealing with several industries simultaneously. Many case studies are located in huge economies and/or areas which differ a lot from the situation in Finland.

The university-company relations are always in close interaction with national innovation system. On the national level there have been lots of changes in it during the last two decades in Finland. One reason for that is the membership in the European Union which offers opportunities on the policy and public research funding issues.

Most of the relevant subthemes linked to university-company relationship is well documented and discussed in many research papers. The simultaneous aspects like joint value creation, interest group management and joint project development are reported too in the literature. Despite that there are not many papers discussion about the holistic and systematic combination of those issues. This led to the question of whether it is possible to localize the globally best practices into our national scale, spiced by the innovation system and public funding possibilities available in Finland.

1.4 The research questions and objectives

The main research question of this study is: What are the characteristics of successful university-company partnership development and how to identify them? This is a big subject, and therefore it has been divided into sub questions shown in Table 1.

Table 1 Research questions

Research question	Objectives	Method	Publication
What are the elements of common interest in joint project development in the university-company relationship?	To define the core interest groups and their role in university-level fund raising.	Literature study flavored by insights of the authors.	I
Technology push or holistic understanding of industrial needs?	To define the interactions between long-term value creation and process plant site location.	Literature study flavored by insights of the authors.	II
How to define the different forms of added value in university-company joint projects?	To define the interactions between value chains between university and company.	Literature and case study questionnaire.	III
What is the position of public research organization in a cluster-based innovation system?	Understanding the importance of semi-open joint project development.	Literature, open domain sources and interviews	IV

The objective of this study is to deepen the understanding of interactions in the university-company partnership. University-company relations occur on many levels simultaneously, which makes it a challenge to the research approach. This challenge has been met by dividing the holistic research question into the sub questions presented in Table 1.

The goal of this study is to combine following elements and their interactions into one procedure: 1) definition of interest groups and their role in the innovation system, 2) to find the common interest of the actors based on the policy and strategy, 3) identify the forms of expected added value from the joint operations and 4) to emphasize the special characteristics of semi-open joint project model. In this study the approach by Triple Helix model (see Chapter 2.1) is essential. The focus of this study is in the university-company relation and the governmental aspects are mostly present through policy and public research funding options.

All the objectives presented in Table 1 include a state-of-art definition explaining how are the university-company relations in the elected research frames are organized today and what are the benefits and misfits in them. The final objective is to find solutions which can be later implemented into the university-company partnership to improve its performance.

The Centre for Separation Technology (CST) is used as the case (see Chapter 4.1). The focus of this research institute is on chemical engineering, but details like yield, chemical analysis, process engineering etc. are not included in this thesis. The managerial operations of the research unit are present, but more attention is paid to the interactions and characteristics which are behind the everyday management than the managing itself. In this study there are also links to some global drivers, like global warming, energy efficiency and lack of pure water, but these issues are only as examples of the operation environment of today.

The case selection causes always some limitations related to the available scale of the data but in the LUT CST has versatile enough connections to different industries and research organizations to develop the procedure mentioned above. The most of the findings of this thesis are however easy exploitable and implement generally.

1.5 Overview and organization of the thesis

All the chapters have inputs and outputs which will iteratively lead to the conclusions of this thesis. The structure of the study and the key contributions of each chapter are shown in Figure 1.

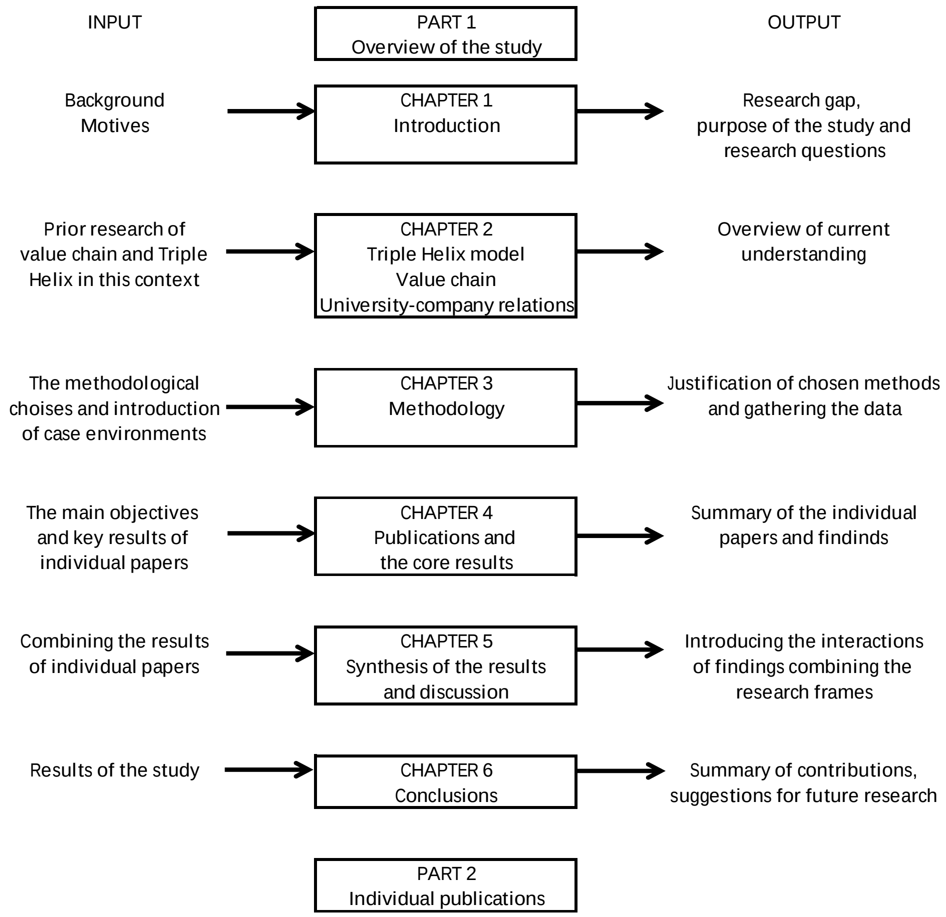

Figure 1 Outline of the study

As shown in Figure 1 this thesis is divided into two main parts. Part I provides an overview of the study and Part II comprises four individual publications addressing the research questions introduced above. The first part begins with an introduction to the study. Chapter 1 describes the background, the identified research gaps, the purpose of the study, the research questions, and the theoretical and contextual background of the study.

Chapter 2 examines the theoretical frame based on relevant literature where the focus is on the Triple Helix model, value creation and value chain, and university-company relations. Chapter 3 discusses the methodological choices, research methods, and empirical data employed in the study. Chapter 4 summarizes the key results of the individual publications included in Part II. In Chapter 5 the most important findings from publications are discussed in relation to the research questions. Also credibility assessment and suggestions for further research are located in this chapter. Finally, Chapter 6 presents the conclusions of the study.

2. LITERATURE REVIEW

This chapter introduces the theoretical frames used in this study. The Triple Helix model is interesting because it illustrates the situation in Finland today very well. To understand the added value creation, the value chain model is still important as well as the literature related to the interface of university-company relations.

2.1 Triple Helix model

The double and triple helix have a remarkable role in the history of science. Linus Pauling and Robert B. Corey (Pauling and Corey, 1953) introduced in 1953 that the DNA of different organisms is formed by three chains which are organized as spirals. Some months later, James Watson and Francis Crick introduced their double spiral model (Crick and Watson, 1953), which later proved to be the right model in biology, but the model of Pauling and Corey is still valid in modeling different kinds of transition processes on the cell level.

The Triple Helix model was used to define institutional structure and its evolution for the first time in a technological workshop in 1994. Then Henry Etzkowitz ja Loet Leydesdorff used the model to explain the relations, interactions and their changes between university, industry and government (Leydesdorff and Van den Besselaar 1994; Etzkowitz and Leydesdorff 1995).

It is widely recognized that technological innovation plays a central role in the long-run economic growth of a social system and that of emerging technologies. The Triple Helix model, theorized by Leydesdorff and Etzkowitz (1996), suggests that in a knowledge-based society the boundaries between the public and private sector, science and technology, university and industry are fading increasingly, giving rise to a system of overlapping interactions which did not previously exist. In practice the model is seen for example when universities perform tasks that were formerly assigned to firms and vice versa. While the academic work is being redirected towards commercial applications, industry-university collaboration is becoming a critical issue; and wider industrial and political interests are integrated into the planning and organization of university research. The Triple Helix thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies. Therefore academic researchers have to take account of the impacts of the scientific outputs of their work on the industry, and at the same time researchers working in the industry need to be updated on the evolutionary developments of science (Leydesdorff and Etzkowitz, 2000). The original Triple Helix model is shown in Figure 2.

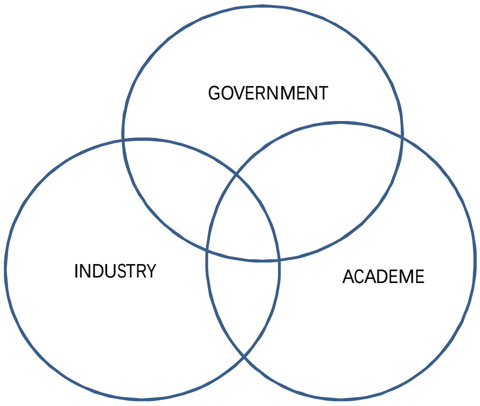

Figure 2 The Triple Helix model (Etzkowitz and Leydesdorff, 2000)

Figure 2 shows the coexistent nature of government, academe and industry. Depending on the case there are different kinds of interactions between those factors. The government level links to enabling regulation and usually also to the availability of public funding to boost the innovation system. It is important that the collaboration between industry and academe is executing governmental objectives like wealth generation, creating new jobs, etc.

There are definitions and approaches for different kind of innovation environments. Marshall (1916) emphasized agglomeration economies and production clusters behind that phenomenon. Porter (1990, 1998) developed the cluster theory to the famous “diamond model” and then Krugman (1991, 1998) introduced the “new economic geography” term. Companies collaborate with public, semi-public and private institutions which lead to different kind of partnerships on selected geographical area (Cooke, 1998; Cooke and Morgan, 1998).

The Triple Helix is flexible and it can be used in various levels depending on the selected innovation environment. Examples of the various level innovation environments are area (Mayer et al., 2014), national (Etzkowitz and Leydesdorff, 2000; Freeman, 1987; Lunvall, 1992; Nelson, 1993), regional (Cooke et al., 1997; Storper, 1997; Braczyk et a., 1998; Harmaakorpi and Melkas, 2005; Uotila and

Ahlqvist, 2008) and cluster or sectoral levels (Breschi and Malerba, 1997; Malerba, 2002; Cooke, 2010) as a frame to identify expertise, knowledge and R&D potential.

The convergence of national science and technology policies in Finland has been studied by Lemola, 2002 and the role of the regional development officers in executing the policy by Sotarauta, 2010.

The original model presented in Figure 2 has been developed later. Patent markets can be considered as an example in terms of three coordination mechanism because of the "social contract" implicit in the patent system. As shown In Figure 3, patents are considered as positioned in terms of the three coordination mechanism of 1) wealth generation on the market by industry, 2) legislative control by government, and 3) novelty production by academia (Leydesdorff, 2012). Whereas patents are output indicators of science and technology, they function as input into economy, as others can learn from them and improve upon them. Their main function, however, is to provide legal protection for intellectual property. Patents can be presented as events in a knowledge-based economy which can be positioned in the three-dimensional space of industry, government and academia (Leydesdorff, 2012; Mowery et al., 2001; Nelson, 2001).

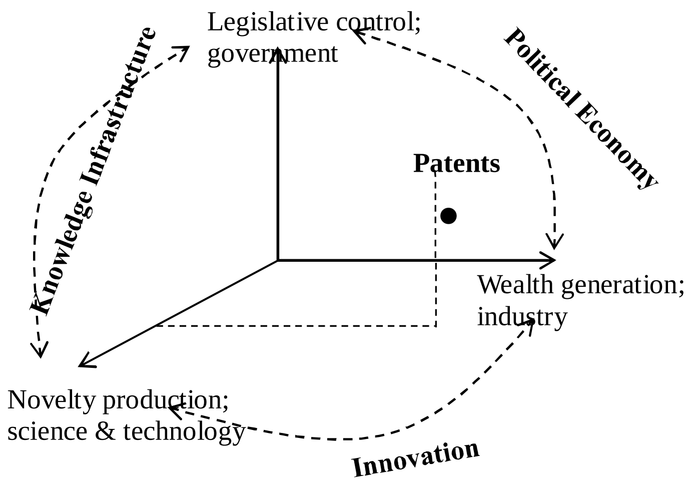

Figure 3 Patents as events in the three-dimensional space of Triple Helix interactions (Leydesdorff, 2012)

Figure 3 illustrates the connection between academe (named in this figure science and technology) and industry. Academe should create a scientific basis which can be utilized by industry to produce novel products and processes. One way to meter the success in that is the number of patents, especially the university-company joint patents. The existing industry is not the only potential utilize of innovations. The increasing entrepreneurship is important as well (Kim and Yang, 2012).

Naturally, the Triple Helix model does not exclude focusing on two of the three dynamics, for example, in studies of university-industry relations. However, one can expect more interesting results by studying the interactions among the three sub-dynamics, or the third dynamics should at least be declared as another source of variation (Leydesdorff and Etzkowitz, 2000). The original Triple Helix model has recently developed with novel features (Arnkil et al., 2010; Carayannis and Campbell, 2009; Carayannis and Campbell, 2010).

2.2 Added value creation and value chain

Michael Porter introduced the value chain model in 1985. The classic Porter value chain approach is suitable for many industrial processes and manufacturers. Porter himself has reported of case studies carried out in different industries concerning his strategy and value chain, as well as many researchers inspired by him. The value chain model can also be used for service companies because the basic elements are similar to industry. In the context of this study, the most interesting value chain applications are linked to public research organizations and process industry.

The classic Porter model shows the value chain in the original format, Figure 4.

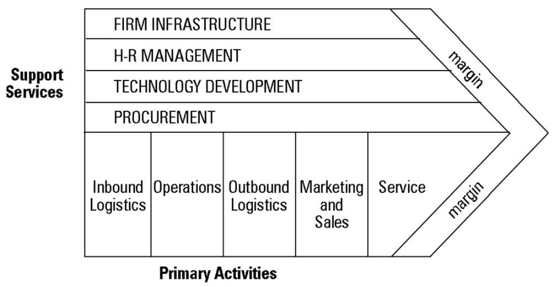

Figure 4 The value chain (Porter, 1985)

As can be seen in Figure 4, Porter divides the elements of the value chain into two categories; support services and primary activities. The support services include firm infrastructure, human resources management, technology development and procurement. They are all important factors and enable services. In most cases they are also centralized even in big companies. The primary activities are directly related to production and products. This set covers inbound logistics, operations, outbound logistics, marketing, and sales and service. The aim of support services and primary activities is to create a margin to the company and wealth to the owners.

There are papers focusing on topics like the value creation in knowledge-based companies (Woiceshyn and Frankenberg, 2008), the relation between profitability and working capital in the value chain framework (Viskari et al., 2011), and cost and cost structure management through the value chain (Anderson, 2006; Prajogo et al., 2008).

The interactions between public research organizations and value creation have been discussed in several articles. From direct technology push we have moved through a knowledge era (Landry et al., 2006) to innovation methodology (Hansen and Birkinshaw, 2007). The importance of implementation of value strategy through the value chain has been studied (Walters and Lancaster, 2000) as well as the market aspects of the same thing (Grunert et al., 2005). Mathematical models have been created to define the value chain (Roper, et al., 2008), and performance management in value chains has been studied by Kannegiesser et al. (2008).

Value creation in the process industry is different from that of many other industries. The reason for this is capital and energy intensiveness and difficulties to change the main product during the expected life span of the production plant. In this study, the pulp and paper industry (PPI) has been selected as an example because the dependence on renewable raw materials gives an extra challenge to this business.

In the pulp and paper industry, environmental issues including water are always present. The long-term scenarios until 2030 (Szabó et al., 2009) present a framework for these issues in general, as well as the situation in the USA (Heath et al., 2010). Energy issues also have a connection to sludge and waste water treatment (Stoica et al., 2009). There is also a case study related to this issue from Sweden (Thollander and Ottosson, 2008), and an example covering the greening strategies of the Nordic PPI (Luukkanen, 2003). A novel angle in a biorefinery energy overview is available in Moshkelani et al. (2013).

The environmental impact of forestry and the forest industry has a remarkable role in ensuring the long-term raw material flow. The added value in forestry operations in Norway (Michelsen et al.,

2008) sheds light on the production chain; an environmental life cycle assessment case from Sweden (González-García et al., 2011) has also been documented. The sustainability of forestry has become more important during the last decades. This issue has been studied by Vehkamaki and Backman (2011). Studies have been conducted on ideas of environmental regulations in PPI investment (Harrison, 2002). Case studies from the USA cover the impacts of climate change policies (Ruth et al., 2000).

The management of the supply chain is emphasized when dealing with renewable raw materials. The green values in it are presented in general in Srivastava (2007), the special challenges of the North-European paper industry in Koskinen and Hilmola (2008), and the supply chain planning models to PPI in Carlsson et al. (2009). The renewability of raw material and sustainability are discussed in Pulkki (2001), and a wider scope in a bio-economy frame in Van Dam et al. (2005). The supply chain challenges and strategies on a global level have been studied as well (Koskinen, 2009). There are also other viewpoints in supply chain managing, such as flexibility in the supply chain using coordination (Arshinder, 2012), option and capacity reservation contracts (Gomez-Padilla and Mishina, 2013), and the use of multi-objective optimization (Karimi-Nasab et al., 2013).

There is a study of corporate social responsibility and sustainable competitive advantage (Li and Toppinen, 2011) as well as of the social acceptability of the PPI (Mikkilä, 2006). The customer relationship strategies in the global paper industry frame have been reported by Alajoutsijärvi et al. (2001), and the typology of the strategic moves of Finnish paper industry by Rusko (2011). Service is an essential element of the value chain. The service orientation in the PPI has also been studied (Davidsson et al., 2009).

Technology itself is one of the core elements in plant design process. The role can be enabling (Van Horne et al., 2006) and it converges technological environments (Karvonen and Kässi, 2011). Technology has utilizing role in processing renewable raw material (Narodoslawsky et al., 2008), and biorenewables also offer opportunities towards next generation process systems (Marquardt et al., 2010).

The investment costs of novel PPI production plants are huge. Depending on the production capacity, the costs vary from 300 M€ up to over 1,000 M€. The strategic decision making (Braglia and Gabbrielli, 2012; Athawale et al., 2012; Lee and Wilhelm, 2010) starts the green field investment project where the site location selection (Anand et al., 2012; MacCarthy and Atthiawong, 2003;

Smith and Clinton, 2009; Xie et al., 2010) plays important role. There is an optimization methodology for the identification of uncertain process integration investments (Svensson et al., 2009) and the influence of the cyclicality of capital-intensive industries (Berends and Romme, 2001). The available operating time is important for the profitability of a plant. Garg et al. (2013) have studied this by applying the Weibull fuzzy probability distribution on the unit operation used in the paper industry. Case studies from the USA cover capital vintage (Davidsdottir and Ruth, 2004) and dynamics of material and energy use (Ruth and Harrington, 1997). Many case studies are located in China, where there are many novel investments in new capacity; plantation-based wood pulp industry (Barr and Cossalter, 2004) and an analysis of supply-demand and medium term projections (He and Barr, 2004).

2.3 University-company collaboration

There are lots of research papers about the nature of public research organizations (PRO) and their relations with industry. The research covers many angles from ethical dilemmas of university-company collaboration (Kenney, 1987) to university research collaboration (Starbuck, 2001) in general, a case studies from Germany and Brazil (Rohrbeck and Arnold, 2006; Löbler et al., 2012) in a selected industry, and technology transfer (Lee, 1996).

Also the importance of technology development in research organization plays a remarkable role (Mina, et al., 2009) in this area. A profile of public laboratories (Joly and Mangematin, 1996) offers good background, as well as a paper concentrating on a public research organization and knowledge infrastructure (Dalpé and Ippersiel, 1999). Many institutes operate like private companies (Etzkowitz, 2003; Marion et al., 2012; Rothaermel et al., 2007; Shane, 2004; Van Looy et al., 2004) or business units, but there are some differences.

There are research papers covering the role strain (Boardman and Bozeman, 2007), effective university-industry interaction (Barnes, et al, 2002; Perkman and Walsh, 2007), the market approach (Mindruta, 2008), and research collaboration of university research centers (Boardman and Corley, 2008; Orlikowski and Barley, 2001). The development of university-industry collaboration has been an area of interest for research (Santoro and Betts, 2002), as well as the processes and performance in this relation (Johnson and Johnston, 2004).

The innovation approach is studied a lot in this environment. The links between the customer relationships of PROs and technological innovation (Nordberg, et al., 2003), the importance of boundary crossing (Kaufman and Tödtling, 2001), and the impact to a regional innovation system (Fritsch and Schwirten, 1999) have been subjects of research.

Many investigations of the impact of PROs at the national level in Finland has been executed as university research funding and publication performance (Auranen and Nieminen, 2010) and the internationalization of Finnish PROs (Loikkanen et al., 2010), as well as the role of PROs in the change of the national innovation system (Hyytinen et al., 2009).

The research impact has been studied (Lähteenmäki-Smith et al., 2006; Gardner et al., 2010) as well as transaction costs related to academic research (Landry and Amara, 1998). The university-company relationship is not only a managerial issue, there are also other things to consider (Permann and Walsh, 2009; Tartani and Breshi, 2012).

Because the interest of this study is closely linked to chemical engineering (and any other capital-intensive industry where the operations are similar), the following papers are interesting (Kannegiesser, 2008; Rönnberg Sjödin and Eriksson, 2010; Rönnberg Sjödin et al., 2011; Rönnberg Sjödin, 2013; Scott-Young and Samson, 2008). Because knowledge is close to service in many ways, also comparison to the service profit chain offers an interesting approach (Heskett et al., 1997).

2.4 Introduction of the national innovation system

The national innovation system has changed a lot in Finland in recent years. One of the drivers has been the new balance between the supply and demand side innovation policies. The new policy in Finland includes a broad-base and systemic approach to boost the national productivity improvement. These should lead to pioneering and forerunner character as a part of the innovation policy (Veugelers et al. 2009; Sotarauta 2012). New strategic emphasis is given to universities as sources of national economic competitiveness in knowledge-based innovation business. From the perspective of competitiveness, universities are not approached merely as providers of basic research and skilled academic workforce, but increasingly as major players in the global and European “innovation business” with their own “product portfolios” and engaged stakeholder networks. The academically-oriented research in Finland has been moved to universities and the remaining duties have been re-organized into 4-5 public research organizations (Veugelers et al.

2009). There are also new instruments to boost the initiatives launched by the Prime Minister`s office like national Bioeconomy and Cleantech strategies from spring 2014.

The ongoing university reform is the most important change in the system for several decades in Finland. Its most important objectives are to improve the research quality, and the societal impact, and to support the internationalization of universities. The most important qualitative change in the funding of research is in the redefinition of 'strategic research' via Strategic Centres of Science. The policy shift can be seen to imply a redefinition of strategy to mean research that has the approval and/or collaboration of specified target groups in the industry.

The change described above has also meant a new, expanded role for universities with regard to their 'third mission' - the societal impact. However, in many universities no additional funding is provided for the various forms of collaboration that are invoked in the name of the third mission, resulting in a situation where many universities face functional overload (Clark, 1998; Jakob et al., 2003). The dilemma is that the expectations concerning the output of Universities have increased, but at the same time the financial resources have decreased. The reductions of governmental financing in basic research coupled with academic "third mission" activities in universities have been the major factors behind the changing role of universities in the management of interest groups. This has forced all universities to redefine their research focus. The universities are looking for particular strategic niches where they could have enough critical mass to make world class research.

2.4.1 The semi-open innovation model

This subchapter introduces the different contents of semi-open innovation. On the top level there is the semi-open innovation model which combines typical characteristics from the open innovation and closed innovation models. This combination offers a platform for semi-open innovations. In practice this means cases which are based on classic basic or curiosity research and on the path to the market will be influenced by customer needs, industrial R&D and applied research until they are ready to be commercialized. The actual operative tool for the above-mentioned issues is the semi-open project model where ideas from the academy are refined to the form of a research plan in close collaboration with the industry.

The semi-open model is typical for Strategic Centres for Science. Semi-open research in university and company joint research projects combines university researchers, large companies and small companies together to solve short-term and long-term issues. In this context, the semi-open innovation model has adopted elements from both company level R&D and classic basic research. The typical R&D elements in "closed innovation" are the close market orientation and the importance of intellectual property rights (IPR) management at the same time. In the open domain scientific approach, the quality of academic research is the driver, even though in many cases it is difficult to see a direct utilization path. In the semi-open model the goal is to create an ideal match between scientific ambition, market orientation and the ownership of research results. To operate with these elements successfully in the Triple Helix environment, the management of the PRO is crucial. Simultaneous collaboration and competition are always present as well.

The decision to set up the Strategic Centres for Science, Technology and Innovation (the abbreviation in Finnish is SHOK) was made by the Science and Technology Policy Council chaired by the Prime Minister of Finland in 2006. The centers are intended to constitute national choices to assist in appropriate direction of limited resources. The promotion of even closer cooperation between business life and the world of research has been set as an objective. At the core of the objective is generating top-level expertise on a global scale and the critical mass required by it in strategically selected fields. The centers focus on producing new information and its efficient utilization globally. Their activities aim at increasing the global appeal of Finland and, consequently, increasing the volume of international cooperation and funding (SHOK, 2013; Ministry of Education, 2006).

Before launching the national guidelines, the regional level strengths linked to knowledge, expertise and R&D potential in Finland had determined during 2002-2003. This operation was conducted by Tekes and regional authorities called Employment and Economic Development Centres in form of regional technology strategies (e.g. Saurio et al., 2003).

The Strategic Centres develop and apply new methods for cooperation, co-creation and interaction. International cooperation also plays a key role in the operation of the Centres. In the Strategic Centres, companies and research units work in close cooperation, carrying out research that has been jointly defined in the strategic research agenda of each Centre. The research aims to meet the needs of the Finnish industry and society within a five-to-ten-year period (Tekes, 2013 a). One remarkable document to start this kind of development is the final report of Finland in the Global Economy project (Brunila and Vihriälä, 2004) and the role of the Strategic Centres as national innovation policy instruments (Nikulainen and Tahvavainen, 2009). The Strategic Centres have been evaluated by an international expert team recently (SHOK evaluation, 2013).

Strategic Centres for Science have relatively large programs (duration 4 years, total budget from MEUR 20 to MEUR 35). Programs are generated and developed by the shareholders of Strategic Centres for Science companies and universities together. Each Centre consists of a coordinating function, a non-profit limited company, jointly owned by the shareholders, and a virtual research organization network. The company's shareholders include relevant companies, universities and research institutions. The Centres provide a permanent cooperation and interaction forum for companies and research organizations. Technology, service providers and end-users cooperate in the research programs, which promote the demand and user-orientation of innovation processes. The Centres will also act as gateways to international cooperation and as avenues for training and recruitment.

In the research programs of the Strategic Centres, it is possible to generate sufficient critical mass and combine versatile competences to achieve world-class expertise and global breakthroughs. They facilitate long-term strategic research and contribute to speeding up the innovation process.

In addition to the shareholders of the Centres, which include relevant companies, universities and research institutes, public funding organizations have made a commitment to providing funding for the centers in the long term. Within each Strategic Centre, some € 40-60 million is invested in research annually (Tekes, 2013 b). The original idea of Strategic Centres was that the industrial or business partners define the questions and then research partners will find answers to them. This requires of course clear understanding of the roles of the consortium participants.

At the SHOK program level, the financing system is the following: about 40 % of the total costs are paid by the participating companies, 10 % by the universities and research organizations, and the rest in financed by Tekes (Tekes, 2011). Also the funding role of the Academy of Finland has increased during the last years.

The following centers are active today. CLEEN Ltd. is a cluster for energy and environment (CLEEN, 2008). The focus of FIBIC is on sustainable bio-based economy (FIBIC, 2010). FIBIC was the first SHOK, to operate in 2007 (in the beginning the name of the company name was ForestCluster). FIMECC

Ltd. (Finnish Metals and Engineering Competence Cluster) is an open innovation R&D company increasing and deepening the cooperation between companies, universities and research institutes in R&D (FIMECC, 2012). RYM Oy is a Strategic Centre for Science, Technology and Innovation of the built environment (RYM, 2009). The focus of SalWe is in health and well-being (SalWE, 2013), and DIGILE operates in the field of ICT (DIGILE, 2013). This company changed its name during 2013. When this Centre was established it was called TIVIT (Tieto ja viestintäteknologia, which is ICT in Finnish).

Figure 5 shows the positioning of the SHOKs in the Finnish innovation system. This example is of FIMECC but the principles are the same with the other SHOKs.

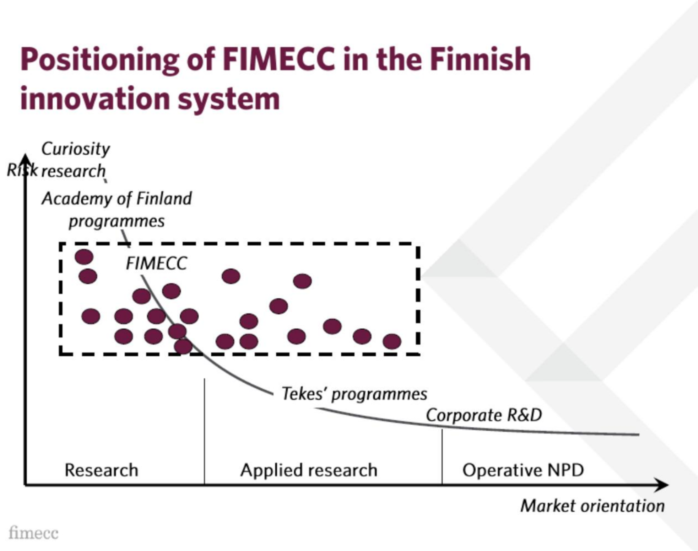

Figure 5 Positioning a SHOK in the Finnish innovation system, case FIMECC (FIMECC SRA dated October 6th, 2012).

Figure 5 shows that the strategic aim of SHOKs is to combine curiosity research with industrial needs. The SHOKs are innovation platforms in their field where the academia and industry can develop joint research programs together. The presence of industry fastens the path of novel scientific findings to be used as input in industrial R&D.

The expected benefits to boost a pure Triple Helix-based innovation model on the cluster level are increasing the need for radical innovations. The challenge is to encourage cross-cluster or cross-industry collaboration as well, because the industrial convergence has already changed the traditional industrial borders and the standard industrial classification.

3 RESEARCH DESIGN

3.1 Research approach

The research approach of this study is shown in Figure 6.

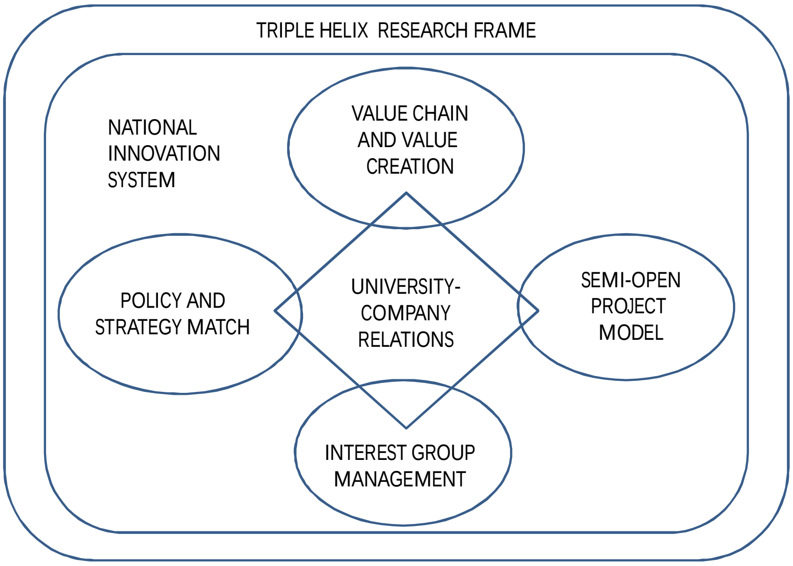

Figure 6 The research approach of this study.

Figure 6 illustrates the research approach of this study. The Triple Helix is the major research frame of the study. It is localized to the national innovation system (NIS) in Finland. The university-company relation which can achieve deeper partnership status, is in the focus of this study. On the practical level, the joint project development, is the common and typical maneuver of that. It is studied from different viewpoints like policy and strategy match, value chain and value creation, interest group management and the importance of a semi-open project type. The difference between policy and strategy in this context is the following. Policy refers to the regulation level, like the EU and Finland which offer big frames, initiatives and programs to be executed though different kinds of public financing instruments. Strategy is linked in this study to independent companies and their needs.

3.2 Methodological choices of the study

The choice of the research approach is depending on the nature of the research. Most of research is executed between two opposite research philosophies; positivism and hermeneutic science. Positivism is based on the ideas of August Comte (1798-1857) and the "father" of hermeneutics is Friedrich Schleiermacher (1768-1834). The continuum in research traditions is shown in the Figure 7.

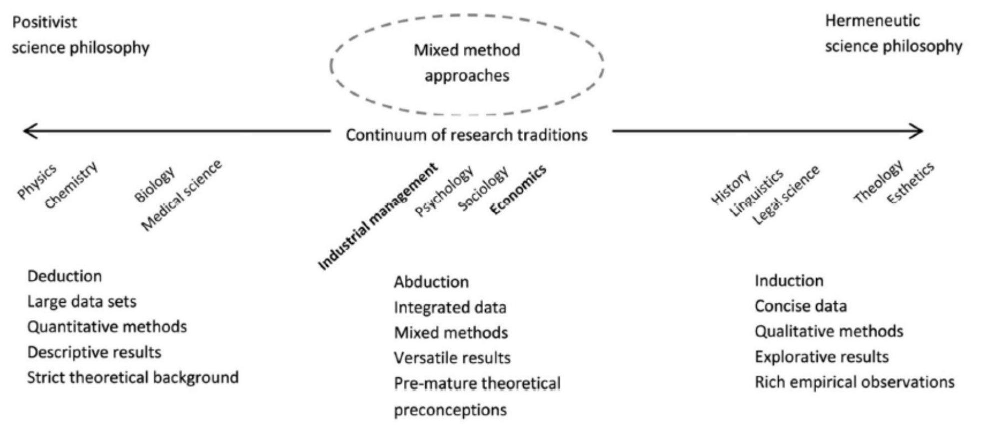

Figure 7 Research approaches in the continuum of research traditions (adapted from Hirsjärvi et al., 2008; Kasanen et al., 1993; Olkkonen, 1993; Model, 2010)

This study links to the industrial engineering and management research tradition where both quantitative and qualitative methods can be used. The suitable research methods under quantitative and qualitative research are shown in Table 2.

Table 2 Examples of quantitative and qualitative research (adapted from Eriksson and Kovalainen, 2008; Myers, 2013)

Quantitative research: focus on numbers	**Qualitative research: focus on text**
Surveys	Action research
Laboratory experiments	Case study research
Simulation	Ethnography
Mathematical modelling	Grounded theory
Statistical analysis	Discourse analysis
Econometrics	Narrative

The objective of this study is to understand the operations and actions of existing research institutions. As an outcome, novel development ideas are expected to be refined to tools for improving performance at the organization level.

The background described above was the reason why action research was selected as the main methodology in this study. The term action research has been introduced by Lewin (1946). Action research aims at understanding real world actions in a chosen research frame. According to Denscombe (2010), the purpose of the action research strategy is to solve a particular problem and to produce guidelines for best practice. Figure 8 illustrates the issue.

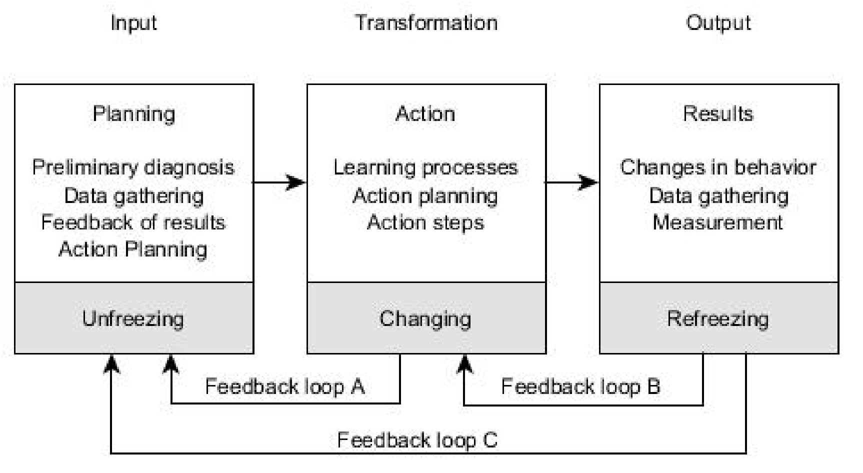

Figure 8 Systems model of the action-research process (Lewin, 1958)

Figure 8 summarizes the steps and processes involved in planned change through action research. Action research is depicted as a cyclical process of change.

1. The cycle begins with a series of planning actions initiated by the client and the change agent working together. The principal elements of this stage include a preliminary diagnosis, data gathering, feedback of results, and joint action planning. In the language of systems theory, this is the input phase, in which the client system becomes aware of problems as yet unidentified, realizes it may need outside help to effect changes, and shares the process of problem diagnosis with the consultant.
2. The second stage of action research is the action, or transformation, phase. This stage includes actions related to learning processes (perhaps in the form of role analysis) and to planning and executing behavioral changes in the client organization. As shown in Figure 8, feedback at this stage would move via Feedback Loop A and would have the effect of altering previous planning to bring the learning activities of the client system into better alignment with the change objectives. Action-planning activity carried out jointly by the consultant and members of the client system is included in this stage. Following a workshop or learning sessions, these action steps are carried out on the job as part of the transformation stage.
3. The third stage of action research is the output or results phase. This stage includes actual changes in behavior (if any) resulting from corrective action steps taken after the second stage. Data are again gathered from the client system so that progress can be determined and necessary adjustments in learning activities made. Minor adjustments of this nature can be made in learning activities via Feedback Loop B.

Action research is problem-centered, client-centered, and action-oriented. It involves the client system in a diagnostic, active-learning, problem-finding and problem-solving process. The concepts and methods of action research have been studied by Argyris et al. (1985), the system level approach aiming at whole system change by Burns (2007), and the role of participative inquiry and practice by Reason and Bradbury (2007).

Linked to the action research methodology case studies are also used in this study. One case, LUT CST, was studied in several research contexts (value creation, Triple Helix and interest group management).

Thomas (2011) gives following definition of case study: "Case studies are analyses of persons, events, decisions, periods, projects, policies, institutions, or other systems that are studied holistically by one or more method. The case that is the *subject* of the inquiry will be an instance of a class of phenomena that provides an analytical frame — an *object* — within which the study is conducted and which the case illuminates and explicates."

There is lots of literature available concerning case study design, and methods and the implementation of the results (Yin, 2009; Stake, 1995; Baxter and Jack, 2008). There is always a scientific risk present if the results of a single case with relatively limited data are generalized. In this study this risk is noted and also the conclusions are tightly focused on the case environment.

According to Saunders et al. (2009), one of the criteria for action research is that it is about the resolution of issues together with those that experience them directly. Action research may involve practitioners so that they collaborate with the researcher, and the researcher may also be a practitioner him/herself. A third characteristic is the process of action research, which is iterative. This action process is depicted in Figure 9.

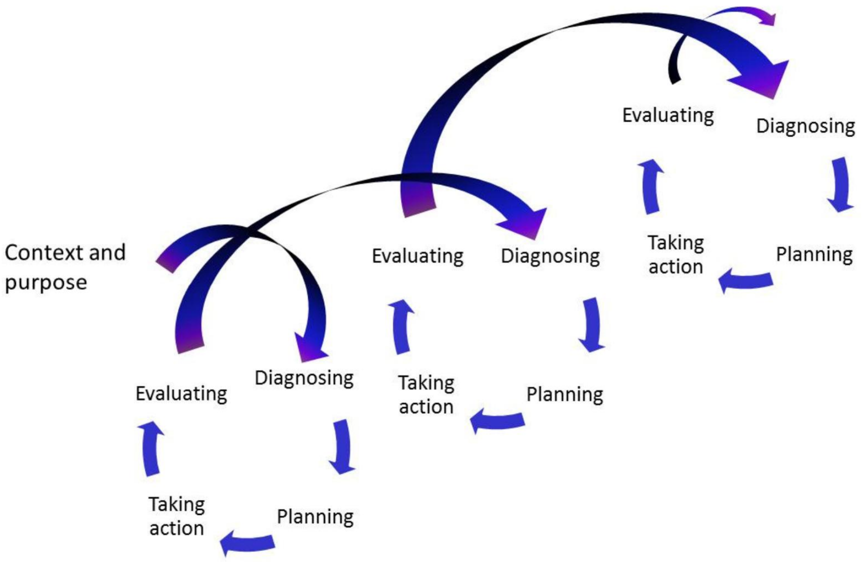

Figure 9 The action research spiral (Saunders et al. 2009).

The Figure 9 shows the nature of action research as a continuous process. After the diagnosis comes the planning of performance improvement. Plans are implemented and later evaluated before the next research spiral starts.

Qualitative analysis was executed during this research project as well. It was based on data collection, which is discussed in the following subchapter.

3.3 Data collection

The formats of the data collection used in this study are shown in Table 3.

Table 3 The data formats per publication in this study.

Publication	Used data formats
1	Empiric data related to the LUT CST and interest groups
2	Mostly based on literature study
3	CST member enquiry
4	Open domain sources and selected interviews and
	Scopus database

The CST member enquiry is shown in appendix 1 of publication 1. The research approach in publication 2 was to combine value chain and basic elements linked to chemical engineering plant location selection. In this case the study was based on the literature. In publication 3 the author was familiar with the research object from many viewpoints according to the “spirit” of action research, because of previous jobs. The data for publication 4 was collected from several open domain sources concerning ownership, strategy and the contents of strategic research agendas. This material was added by the Scopus database and selected interviews of decisions makers representing different actors in the national innovation system in Finland.

3.4 Quality of the research

The quality of academic research can be evaluated with various criteria. The common criteria are reliability, validity and generalizability (Miles and Huberman, 1994; Patton, 2001). The general guidelines presented by the authors are of course valid in this study as well, but actually they fit quantitative research better.

To the quality of qualitative research the term “trustworthiness” introduced by Lincoln and Cuba (1990) is essential. This term includes definitions for credibility, transferability, dependability and confirmability. Applicability can be also added to the list (Wagner et al., 2010). This criteria set with their definitions is presented in Table 4 (Storbacka, 2011).

For the chosen research method, action research, there are specific tools for quality evaluation, introduced by e.g. Zuber-Skerritt and Fletcher (2007), Feldman (2007), Reason (2006) and Boog et al. (2008). In action research the researcher has the observer´s role. This means that the researcher is relatively close to or in some cases in the research target or object. This is a very challenging situation; it is difficult on the individual level to retain one´s objectivity. During this study the role of the team of authors was valuable in every publication. The mixture of insiders and outsiders helped a lot in “staying in line” and keeping the right role.

The case study design is the key for the quality of research. This theme has been studied among others by Benbasat et al. (1987), Simon et al. (1996), Darke et al. (1998), Lincoln and Guba (1990) and Yin (2009). In this research, the nature of action research has been the guideline. The quality matters are mostly related to the case studies and the research approaches in them. In the analysis and conclusions, generalization of the results has not been used.

Table 4 Trustworthiness of the research (adopted from Storbacka, 2011)

Criteria	Method of addressing trustworthiness
Credibility (Internal validity, authenticity) The extent to which the interpretations of empirical data reflect the reality as perceived by the informants.	• *Prolonged engagement*: The researcher was engaged in a research project lasting 31 months that focused on customer value assessment with the three pilot firms included in the study, involving continuous interaction and several meetings with senior managers of the pilot firms. • *Persistent observation*: Interviews were conducted with 62 managers in total over a time-span of 4.5 years; that is, the duration of this study. • *Peer debriefing*: Joint analyses with the second author and larger research group, expert-led workshop focusing on designing the study and interpreting the early findings, eight presentations on emergent findings to academic conferences for feedback from other researchers, four publications have gone through a double-blind review process for academic journals, and received feedback and comments from reviewers and editors over the review process. • *Triangulation*: The study employs interview data from different persons, from different firms, and from different industries, and multiple forms of secondary data, including process frameworks, strategic plans, documented business cases, white papers, project diaries, and training material. • *Member checking*: Manuscripts of all publications sent to all participants for verification. Interviewed managers gave written feedback on the results of each individual publication. Emergent findings presented to managers at several project steering group meetings. **Result:** Emerging findings were constantly revised based on empirical observations and comments from the participants over the research process.
Transferability (External validity, fittingness) The extent to which the findings can be applied to other contexts.	• Ten globally operating firms from ten different industries, which provide a wide range of offerings from products with life-cycle services to highly customized and service-intensive customer solutions, participated in the research process. • Use of theoretical sampling. **Result:** Given the extensive data from ten globally operating firms that serve customers in a wide range of industries, it can be assumed that the findings are highly transferable/generalizable across several industries in business markets.
Dependability (Reliability, auditability) The extent to which the study and its findings can be replicated.	• Research design and implementation process is clearly outlined. • Sampling protocol is explained in detail. • Formalized steps of collecting, organizing, coding, and interpreting empirical data are applied. **Result:** The overall research process is clearly explicated, and the path from empirical data to interpretations is described in detail (i.e., how, why, and when).
Confirmability (Objectivity) The extent to which interpretations stem from empirical observations and the data, and can be confirmed by others.	• Use of triangulation. • Use of direct interview quotations to demonstrate interpretations. • Within and cross-case analyses of emergent findings. • Member checks through written feedback from interviewed managers and verbal feedback from project steering group meetings. • **Result:** interpretations were altered, expanded, and refined.
Applicability (Utilization, action orientation) The extent to which the findings are relevant for and can be employed to benefit the participants.	• Emergent research findings were discussed in several project steering group meetings with practical recommendations. • Manuscripts with emergent findings were sent to all the participants, and results were found useful. • Companies in the pilot set have reported adopting some of the best practices identified during the study. **Result:** participants benefited from the findings and conclusions of the research.

4 PUBLICATIONS AND REVIEW OF THE RESULTS

This chapter starts with the introduction of the case study environment common for most of the articles. After that this chapter introduces the most important findings in the individual articles which are relevant from the point of view of the research question.

4.1 Introduction of the case environment

The case organization, Lappeenranta University of Technology (LUT), founded in 1969, is located in South-Eastern Finland. The university has 5700 students (technology 76%, business administration 24%) and 950 staff. The turnover of LUT is approximately EUR 78 million per year, almost two-thirds of which is related to research. The basic state funding of LUT amounted to EUR 44.3 million in 2011. External funding totaled EUR 31.3 million, originating from the following main sources: Finnish research councils (7.3), Tekes (20.1), and the EU (3.9). In recent years LUT has become more focused on external relations and research. LUT has also recently tried to take a more active role in the commercialization of university-based inventions and creation of spin-off companies, with a new investment company, Lappeenranta University Research Company having been established for this purpose (Lureco, 2013). The target of LUT is to be a leading scientific actor and an attractive partner for cooperation in its strategic focus areas of expertise of green energy and technology, sustainable value creation, as well as an international hub for relations with Russia (LUT, 2014). The organization of LUT (2010) is shown in Figure 10.

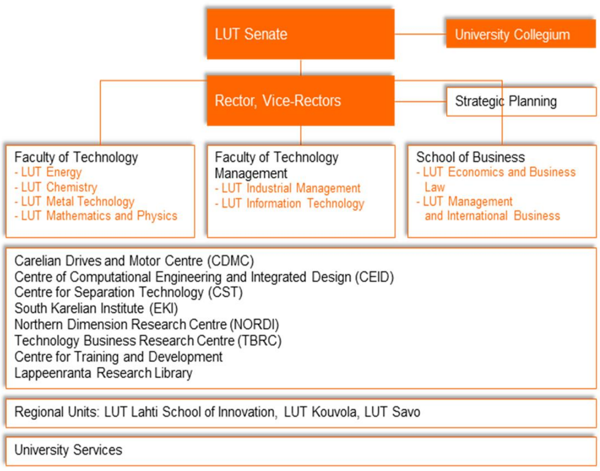

Figure 10 LUT organization chart (2010).

Figure 10 illustrates the organization chart of LUT. In the LUT senate most of the members come from industry and business. LUT has three faculties/schools producing research results which could be easily implemented into technology and business development in different companies. Figure 10 lists also the internal research institutes/centres of LUT. The list of regional units indicates LUT´s societal role, LUT offers university level research and adult education in three regions where they do not have a university of their own (Päijät-Häme, Kymenlaakso and Etelä-Savo).

Lappeenranta University of Technology hosts an interesting research institute called Centre for Separation Technology (CST). CST is not the only university-based research institute in Finland, as there are lots of similar concepts in many universities. However CST has many unique characteristics to be a good case study within the context of this study. The first essential issue is that the research results of CST can be utilized in different industries (eg. pulp & paper, mining, chemical, etc.). Collaboration with many industries maintains continuous dialog and exchange of information concerning industrial needs and scientific possibilities. Secondly, CST it has been active since 1997, and during that time collaboration relations have developed in several research projects and the important trust has been earned. Third, the CST membership system with annual fees is not common among universities.

Separation technologies are unit operations used widely in different fields of chemical and process engineering (e.g. distillation, filtration, crystallization, etc.) which enable separation and concentration of different chemical compounds from mixtures. Most of the common processes in pulp and paper, chemical, petrochemical, pharmaceutical and food industries are based on these unit operations, albeit operated with different parameters. They are also suitable for water purification processes. The center has its own rules and regulations inside LUT. The primary objectives of the institute are to boost the quality and quantity of research in the field of separation technology, to accelerate technology transfer from research to industry, to improve collaboration between different laboratories and research groups inside LUT and to develop their networking with domestic and international partners, as well as to develop the research facilities for empiric research and organize training and education in this field. In practice LUT CST has acted as a “foreign office” of a university department in matters linked to industrial collaboration in its early days, and has later on functioned in a similar capacity with academic research partners globally. This arrangement strives for the functionality of a “one-stop shop” which tries to make collaboration easy and fluent for all members.

The members of LUT CST represent different industries, e.g. mining and metallurgy, chemical engineering, and pulp and paper. Another interesting characteristic of LUT CST is that the member companies are in different positions in the value chain. Some of them are clearly technology providers, some are process owners, and the rest are in the role of expertise providers. This situation is also challenging for public project financing. In the cluster-based national innovation system (Sotarauta, 2012) LUT CST operates with several clusters.

The expertise of LUT CST is based on the Department of Chemical Engineering of LUT, where the staff consists of 10 professors and more than 50 researchers primarily at the doctoral level. Today, CST has 26 member companies from different industries. The companies are mainly global players of Finnish origin, e.g., Outotec, Kemira, Flowrox, UPM, StoraEnso, etc.

In recent years CST has also expanded its international research member network. The network currently covers three universities in Russia, one in the Netherlands (Delft) and two in Germany (Berlin and Dortmund Universities of Technology), Ecole Polytechnic in Canada (Montreal), Innventia AB in Sweden and the Forest Products Research Institute in Scotland. The national research network has also evolved; Technical Research Centre of Finland (VTT) and two universities of applied sciences (Saimaa and Mikkeli) are CST members. The research focus of LUT CST is shown in Figure 11.

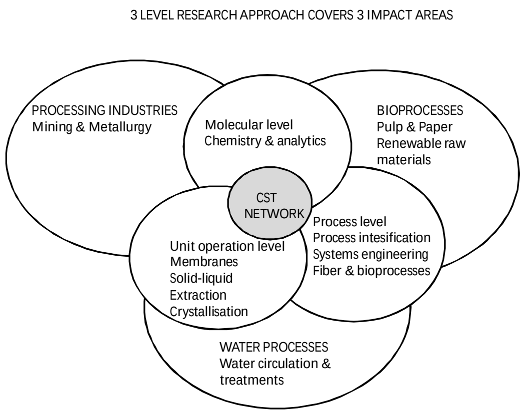

Figure 11 The research focus and research impact of LUT CST.

Figure 11 illustrates the research focus and impact of LUT CST. The research of CST covers three levels related to chemical engineering: molecular level, unit operation level and process level. The molecular level is very close to chemistry and analytics, unit operations concern the solid/liquid separation, membrane technology and other separation methods used typically in the industrial scale. To avoid the partial optimization with unit operations it is important to understand also their effect on the process level where several unit operations are connected.

There are also three impact or application areas which are essential to the academic research of CST. Actually the same academic research results can be used in the following three fields of industrial applications: bioprocesses, processing industries and water processes. The raw materials in bioprocesses are renewable, but in the processing industries the raw material itself is non-renewable even though the materials can be reused. Most industries use lots of water, and industrial water treatments (fresh water, waste water and water circulations) are important challenges also to CST scientists.

4.2 Publication I - Mapping the activities between a public research organization and interest groups: Case study LUT CST in Finland

The management of interest groups is the key element of fund raising and project development for a public research organization (PRO). Management is never a simple task. However, its complexity increases considerably when the research field of the PRO is generic, with numerous potential industries utilizing the research results. This paper discusses the identification and managing of interactions between a PRO and its interest groups. The research question in this article is "What are the elements of common interest in joint project development in the university-company partnership?"

To deepen the discussion concerning the development and management of different project types they were categorized in three different types shown in Figure 12.

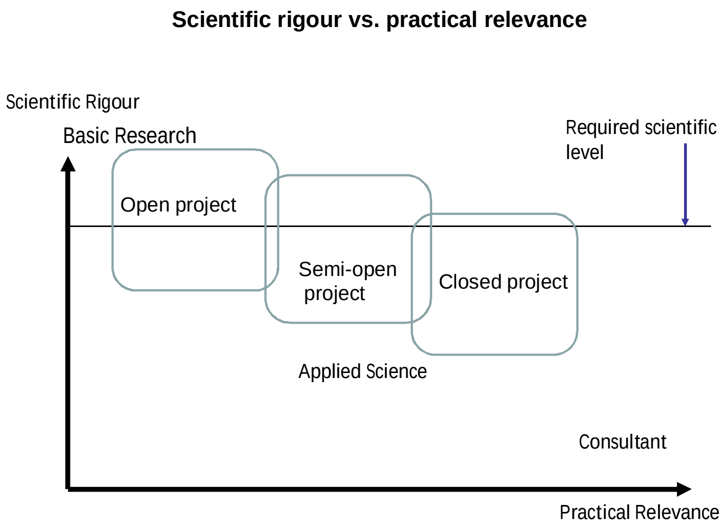

Figure 12 Project types

Figure 12 illustrates the typical project types in university-company collaboration on the project level. It also shows that in all project formats the university has to take care that the required academic standard must be achieved. An open project is close to the classic "free" science where the university has the full lead and also rights to intellectual property rights (IPR).

Actually according to the Finnish law (Työsuhdekekeksintölaki, 1967) the rights belong to the inventor(s). Depending on the company or university there exist different procedures of transferring the rights to employer and receive personal incentives. In the open project model the individual researcher is sometimes the applicant, not the university. This case is typical when dealing with The Academy of Finland or some private foundations. With semi-open and closed project models the university is typically the legal partner.

A semi-open project model is typical when dealing with SHOKs (see Chapter 2.4). In that case the objectives and IPRs are controlled by the consortium together with the participating companies and universities. The closed project type is led by a company and these projects also have IPRs. Table 5 shows the characteristics of different project types on the practical level.

Table 5 The characteristics of different project types on the practical level.

	Open project	**Semi-open project**	**Closed project**
In accordance with PRO´s own strategy	Usually not possible to influence the titles of open calls. Sometimes difficult to follow PRO´s own strategy.	Possible to influence the research agenda	Usually the task is given by the customer, but normally these arrangements are based on long term partnership and trust
Expected hit rate to get funds	Small	Normal	Good
Competition	Hard	Normal	Small
Number of possibilities	Huge	Limited	Small
Ownership of the IPRs	University	According to the consortium agreement	Customer
Possibility to publish the research results	Full	Delayed (usually a permit from consortium required)	Limited
Required industrial funding	Max. 10 %	Typically 40-50 % on the consortium level	100%
Required trust between partners	Normal	High	Total
Number of required partners in general	Open structure, collaboration required, also on the international level	Mostly from the consortium in addition to relevant international contacts	Case by case, but seldom more than a few

For a PRO it is essential to identify the current situation on the project level. All the project types characterized in Table 5 are relevant and possible to manage if the PRO understands the different cases. The danger, especially with closed projects of a research organization in a university of technology, lies in focusing on more or less industrial R&D instead of classic free research.

Sometimes industrial partners ordering scientific subcontracting from a university are mainly interested in getting an independent "proof of concept" label to their novel product or process, or faux-scientific marketing curves. In these cases it is not recommendable to participate in the project if the required scientific level cannot be reached. Table 5 shows also the relation between the level of the expected hit rate, the required trust and possibilities for research result dissemination. Competition means in this context competition between universities and research institutes.

The management of the interest groups on the university or PRO level requires identification of potential partners. After that it is possible to classify the partners and decide the right models for the management actions. Figure 13 illustrates the interest groups of LUT CST in the Triple Helix frame added by the operational level.

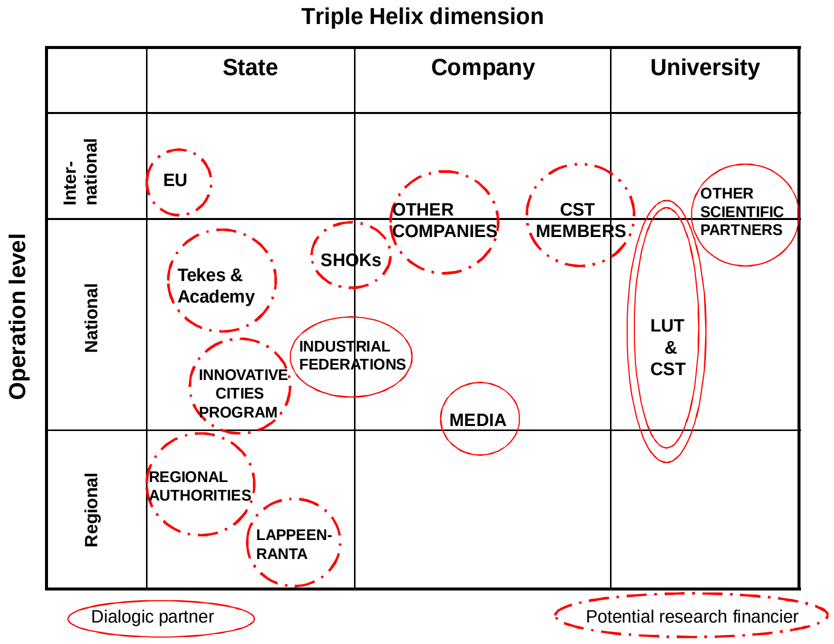

Figure 13 Identification of LUT CST interest groups

Figure 13 illustrates the most important interest groups relevant in this case. The interest groups are divided into the categories of potential research financiers and dialogical partners. In most cases the national and regional public research financiers operate according to the same strategy, but the funding instruments and their terms vary. The dialogical partners are important sources of information with regard to the industrial market trends and new legislation which might lead to research ideas. Their role in achieving general publicity is also valuable.

In all universities there is a lot of experience for reactive actions; how to prepare an interesting research plan and send it to open call. This is important, but the more challenging task is somewhere else. The results presented in Table 5 and Figure 13 emphasizes the importance of proactive actions by a university or research institute towards their identified partners. The message should be very clear and the dialog must be continuous. These basic elements are still in the core position in the managerial "tool box" in developing joint projects. The situation is the same in the big picture when trying to influence the specifications of future novel open calls. Even though the possibilities to affect open call subjects are always limited, it is still worth trying. The larger the interest group is, the better changes there are to get "our message" to the decision makers directly or via partners.

4.3 Publication II - Types of connections between plant location selection and the long term corporate level value creation and methods of their identification

Many engineers see plant location selection only as an interesting task and a minor part of process and plant engineering. At the same time plant location selection is an important part of corporate-level strategic management and decision making. This paper discusses the types of interactions between plant location selection and strategic long-term value creation at the corporate level. The research approach used in this case study is a combination of the classic value chain model and the core elements of plant location selection methods. The findings in this article answer in the context of this thesis the question “technology push or holistic understanding of industrial needs?”

LUT CST collaborates typically with heavy process industry (see Chapter 4.1). The process plant type selected for this article is in the pulp and paper industry (PPI) but, there are many similarities with other process industries, such as mining and metallurgy, oil refining and chemical industry. The similarities include the enormous scale of the plant, continuous raw material flows, capital, and energy intensiveness. Further similarities are found in a very lengthy expected life cycle, required amounts of water and other utilities which set limitations to the plant location. In addition, the process industry is business-to-business by nature. The product is typically an intermediate product heading out for further refining of a raw material for an end-product. Further refining or end-users can be geographically in different places with regard to the production plant. Dealing with renewable raw materials (typical in pulp and paper and biorefinery industries) offers an extra challenge when compared to the processing of non-renewable ones.

The elements of the chemical engineering plant location selection are shown in Table 6.

Table 6 Elements of the chemical engineering plant location and selection (Sinnot, p. 891).

1 Location, with respect to marketing area
2 Raw material supply
3 Transport facilities
4 Availability of labour
5 Availability of utilities: water, fuel, power
6 Availability of suitable land
7 Environmental impact and effluent disposal
8 Local community considerations
9 Climate
10 Political and strategic considerations

The research frame used in this article is a combination of Porter´s value chain (see Figure 4) and the above-mentioned elements. The result of this combination is shown in Figure 14. The original figure shown in Publication II has been developed to fit the context of this study better, by adding links to the possible other offerings of LUT, not only of LUT CST. The LUT faculty (e.g. school) level structure is shown in Figure 10.

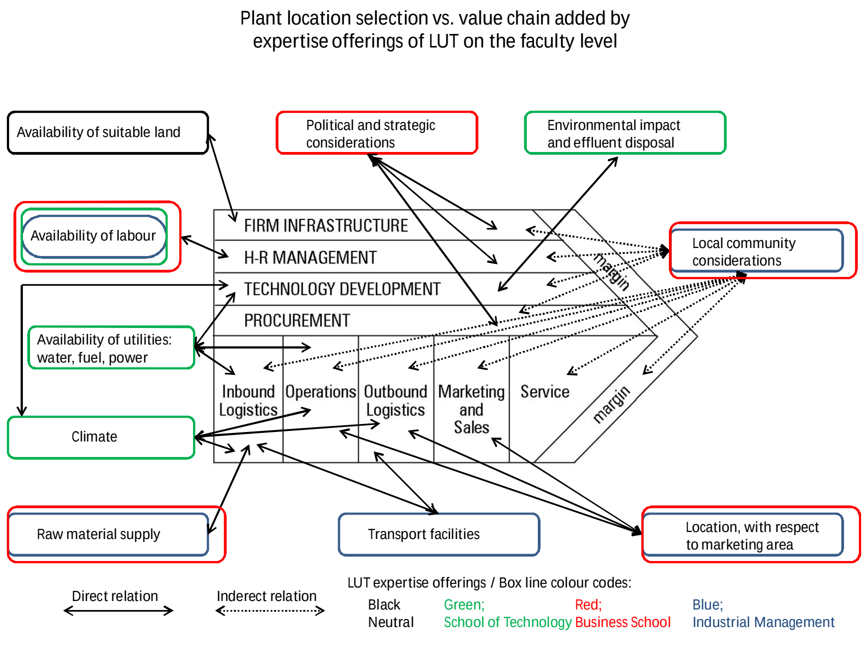

Figure 14 Interactions between plant location selection vs. value chain added by expertise offerings of LUT on the faculty level.

The Figure 14 illustrates the interactions between plant location selection vs. the value chain. The most important finding was the impact of the long term availability and expected price development of raw material. In this case the raw material price included also the inbound logistics costs. The second important factor in decision making was technology, as it determines the ability to meet the quality requirements of the customers and also enables the continuous development related to environmental issues, long term product quality improvement and energy savings.

The findings include an important message to technology-oriented research institutes like LUT CST. This is the reason why the potential offering of LUT was added to Figure 14. The expertise offerings by different LUT faculties are shown in the figure with different colours. In some cases several faculties have simultaneous possibilities to collaborate with the observed spots.

It is wise and correct according to the institute level rules and regulations of LUT CST to keep the focus on technology. At the same time it cannot be forgotten, however, that when dealing with huge global companies they obviously have also other than separation technology-related interests which can be offered by LUT.

In the future LUT CST could be an innovation platform offering also other LUT level expertise like energy, supply chain management, value networks, manufacturing processes (machineries), environmental engineering, innovation and strategy research etc. by the case-by-case principle. If this is the way in the future, it must be tailored according to the company. The use of the three categories introduced in Figure 12 is one way to start the tailoring.

4.4 Publication III - A tuned value chain model for university based public research organisation. Case LUT CST

Porter´s value chain model was originally introduced for strategic business purposes. During the last decades also universities and university-based institutes have started to use actions similar to private business concepts. University-based institutes are not independent actors like companies, but there are interest groups who expect them to act as if they were. This article, publication III, discusses the possibility of utilizing a tuned value chain in public research organizations (PRO). Also the interactions of the tuned value chain model in an existing industrial network are discussed. In the context of this thesis this article answers the research question "How to define the different forms of added value in university-company joint projects?"

The original Porter´s value chain was shown in Figure 3 above. It has a very generic form, and therefore it was renamed and fine-tuned to fit the university environment better. The result is shown in Figure 15.

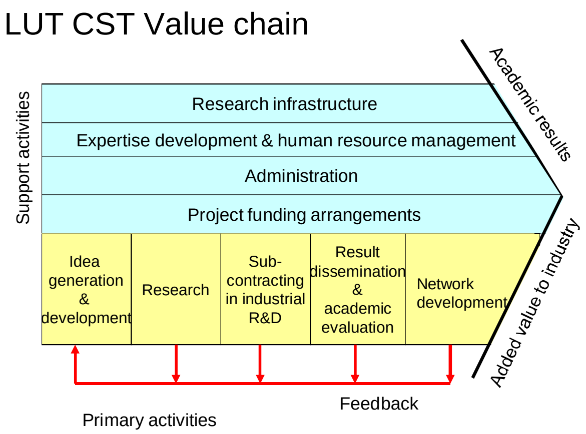

Figure 15 The tuned value chain model, case LUT CST.

Figure 15 shows that the support activities are owned by the university, which in this case is LUT. The primary activities are directly linked to the project development, starting from the idea generation and ending in network development after executing the individual project. The important idea in this figure is that the output serves both academic results like scientific articles, doctoral dissertations etc., and added value to the industrial partners can be achieved during the project. In practice these objectives are difficult to reach without high quality project design and definitions related to the roles of the partners. Another interesting finding is based on the Figure 15. The search for external funding from university-company collaboration is not the most important issue for to the university. External funding is actually the tool which enables the required output measured by academic output and societal impact. In Figure 15, the term “subcontracting in industrial R&D” is used. A better formulation of this may be scientific participation in industry led development projects. Participation in company-driven projects offers the university usually also the possibility to get relevant empiric data which can be used in scientific articles. Especially when dealing with process industry, this opportunity is important in matters related to the scale-up.

Assuming that the individual industrial company operates according to Porter´s original value chain model, it is possible to define different university-company interactions depending on the categorization of companies. In this study, the companies are divided into three categories which can be found also in the LUT CST member network. They are named as a technology provider, process owner and expertise provider. Table 7 shows the interactions on that level.

Table 7 Interactions and targets between CST´s tuned value chain and Porter´s original format of CST´s members.

Category	Input to CST	Output of CST
Technology provider	Idea development Project funding Subcontracting industrial R&D Network development	Technology Marketing & Sales
Process owner	Idea development Project funding Subcontracting industrial R&D Network development	Technology Operations
Expertise provider	Idea development Research Network development	Technology Service

Table 7 shows that in all cases the impact to the support activity technology and network development is obvious. The situation is different in the case of the effect on the primary actions. The technology provider can use novel research results (usually created together in common R&D projects) to boost their marketing and sales activities. The process owners use the results to improve their process performance (e.g., to reach top quality with a high operating time ratio). For the expertise providers, service is a very important issue because this business needs continuing renewal of expertise.

According to the CST member enquiry, the most desired issues wanted from CST were innovativeness, research collaboration in general, international networks, collaboration between different research groups inside LUT, and project development.

Innovativeness includes in this context new openings (e.g., how to implement novel scientific research results into processes and business) and a proactive part where the industrial partners should be informed of new project ideas in advance. The members have also noticed that LUT CST is not active in expanding its offering to cover the other fields of expertise inside LUT and trying to include that part in the projects. The requirements for project development are easy to understand as well. Even in bigger companies there are seldom many experts available with lots of experience of research plan design and public funding instruments.

By understanding the differences and common things in the value chain, it is possible to reach an excellent start for successful joint project development on a win-win basis. In the collaboration to the universities one of the most important issues is the possibility to make high quality research and scientific publications as shown before in Figure 12.

4.5 Publication IV - Public research organization navigating in the cluster based national innovation system

The main purpose of this paper was to give an overall picture of the Finnish cluster-flavored innovation policy. The research approach was the 'semi-open' innovation model which is typical for Strategic Centres of Science. In addition we explored the need for a new policy instrument for cross-cluster interactions. As a case example, the Centre for Separation Technology (CST) hosted by Lappeenranta University of Technology (LUT) in Finland was used. The main findings of the paper are that it is important to understand the role of the semi-open project type in the context of collaboration with various clusters and their interfaces. The strategy match between a public research organization (PRO) and different clusters helps in the identification of common fields of interest, but also the knowledge of potential research project financiers boosts the possibilities for developing joint projects. As key results, the article identifies the position of the research institute in the national innovation environment and the need for a cross-cluster innovation platform related to the semi-open project environment. This article answers the question "What is the position of a public research organization in the cluster-based innovation system?"

The cluster-based innovation system of Finland is introduced in Chapter 2.4. The cluster-based system has clearly some benefits, but in the real operational environment there is always some overlapping linked to the research themes and objectives between the clusters. This leads to the simultaneous need for collaboration and competition shown in Figure 16.

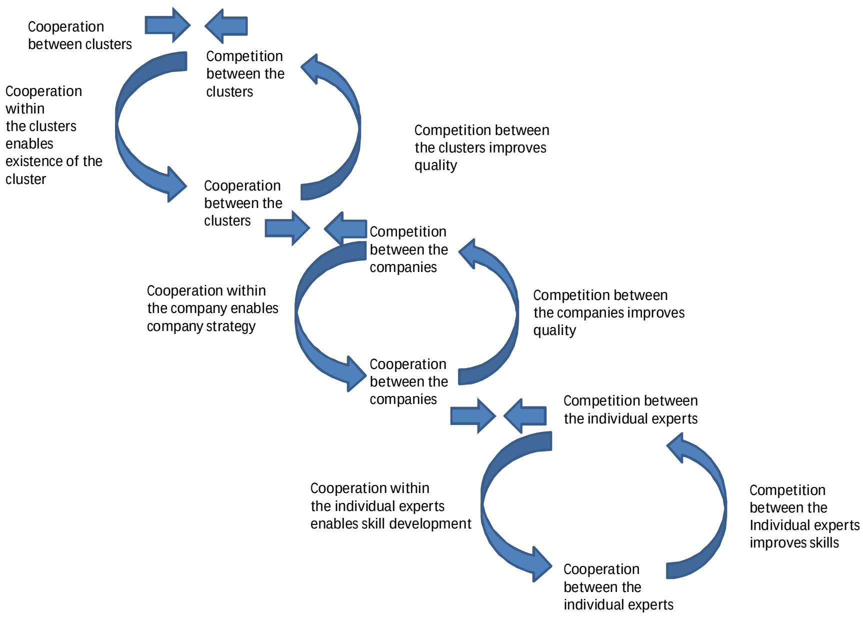

Figure 16 Multilevel competition and cooperation in a cluster-based innovation system (Adapted from Bar-Yam, 2004).

In the Finnish national innovation system the SHOKs have a very important role. Their strategies were compared in the article to the strategic research impact of LUT CST. The following elements were compared to the strategic research agendas (SRA) of each SHOK: material efficiency, process level energy efficiency and water. The SRAs of the SHOKs were not built on the same template, which made direct comparison difficult. The results of the strategy match are shown in Table 8.

Table 8 Comparison of SHOK strategic research agendas and the strategic research impact of LUT CST.

	Material efficiency	**Energy efficiency**	**Water**	**Other remarks**
CLEEN	+	+	+	
FIBIC	+	+	+	
FIMECC	+	+	+	*
RYM	+	+	+	**
SALWE	-	-	-	***
DIGILE				****

* Intelligent solutions research theme
** All elements are present, but the RYM approach is not process-industry oriented
*** The SalWe strategy is linked to the output of LUT CST indirectly through novel pharmaceutical separation processes
**** DIGILE is focused on promoting the development of digital service know-how for business needs, which may create new possibilities to process automation etc.

The strategic research agendas (SRAs) of SHOKs are in most cases very detailed, but for the accuracy relevant in this paper, the big themes were required; material and energy efficiency and water. There are two exceptions among the SHOKs where those themes are not in direct focus; SALWE and DIGILE. The mentioned themes exist in their SRA, but their role is smaller in them. It is clear that they are all important and valuable to all industries, but it is also very interesting to see them as cross-section issues in general.

The similar thematic approach like in SHOK SRAs is present also on the policy level in the EU and Finland. The identified "expertise gaps" are tackled on both levels by thematic programs (e.g., Horizon2020 on EU level), and on the national level the Academy of Finland and Tekes have done it for years. The main objective of these programs is to develop expertise in selected fields to respond to the predicted needs of the future.

Table 9 shows more a detailed picture of the situation between the CST member companies and their ownerships in SHOKs.

Table 9 Participation of LUT CST member companies as shareholders in SHOKs.

CLEEN	FiBic	Fimecc
Andritz	Andritz	Andritz
Kemira	Kemira	
Metso	Metso	Metso
Outotec		Outotec
StoraEnso	StoraEnso	
UPM-Kymmene	UPM-Kymmene	
VTT	VTT	VTT

Table 9 indicates that there are seven LUT CST members that are shareholders in several SHOKs. All these companies act globally and they are among the leading companies in their fields of business. They are forerunners in developing and implementing new technologies, and there are both technology providers and innovative process owners among them. The role of VTT (VTT Technical Research Centre of Finland) is remarkable. VTT is a shareholder in all SHOKs. VTT is a globally networked interdisciplinary applied research organization, the biggest of its kind in Finland, and has a very active and important role in the innovation system. The results from Table 9 can be also seen as an indication for industrial convergence (Bores et al., 2003; Bröring et al., 2006; Gambardella and Torrisi, 1998; Hacklin et al., 2013).

The motivation on the company level to be shareholders in several SHOKs was studied by interviews. Industrial convergence was present in company level strategies. "*The companies today are not operating according the standard industrial classification. This is one reason why they are interested to find novel ideas wider than before. Also as shareholders they become insiders and they have possibility to effect into content of forthcoming new programs in SHOKs."*

The position of SHOKs in the national innovation system is shown in Figure 5. The figure gets a new layout when it is illustrated by company and all the core elements are the same but there are variations in the names of specific operations. This is shown in Figure 17.

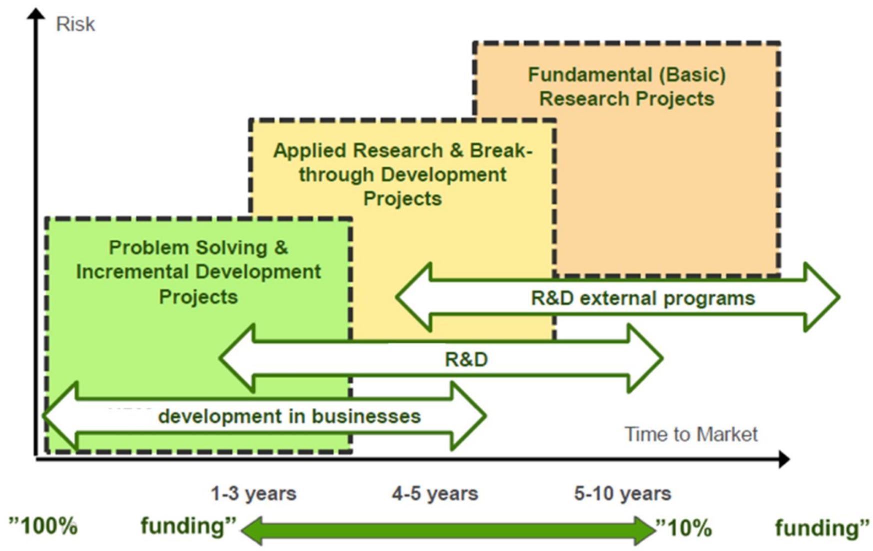

Figure 17 Classification of company-level R&D portfolio based on risk, time to market and required own financial support.

Figure 17 shows that in the beginning (upper right hand corner) of the project the "funnel" company is interested in many scientific research projects and options (normally this requires max. 10% of their own funding) according to their strategy. The mentioned 10% of industrial funding is typical for university-driven traditional Tekes-funded research projects. The joint projects with SHOKs are typically in the next category (applied research & breakthrough development projects) where the results from basic research are refined into a form which is more suitable for the companies. The project group closest to the implementation is normally executed with 100 % company funding.

Figure 17 shows also a correlation linked to the IPRs. The longer the time to market is, the fewer possibilities there are for one company to own the IPR. In the SHOK programs the IPR belongs to the consortium operating the program. The independent companies and also universities participate in different SHOKs simultaneously to enable this important networking and funding possibility to develop their research project portfolio (including new, ongoing and ending projects) according to their strategies to carry on their continuous renewal of expertise.

For public research organizations it is important to understand how the national innovation system works, including the public funding possibilities. Also the position of the key partners is useful information. Combining these two elements gives a good basis for joint project development with the option of using different kinds of public research financing instruments. Strategy is in a very important role; actually on the national level, above strategy is common policy which is implemented to the actions via operators (e.g., SHOKs). If the institute/university level strategy fits the policy and the strategic goals of the most important private partners, it is possible to manage the situation.

5 SYNTHESIS OF THE FINDINDS AND DISCUSSION

This chapter discusses the findings of the individual publications described in Chapter 4. The most important output is a synthesis of the findings. Also some ideas for a managerial contribution based of the findings are presented. Finally, a credibility assessment of this study is made.

5.1 Research findings and academic contributions

Identification of the interest groups is the starting point for successful joint project development. Identification of potential partners is important, but understanding the roles of the doers in the innovation system is even more important. In case of CST, the identification is easy due to the structure of where they have memberships. On the university level company identification is more challenging but not impossible. The role of the university is to renew its expertise. Research and international research collaboration are the core tools in this task. At the same time it is important to understand that also the university-company relations have their lifecycle in the fast changing world. Thus it is wise to update the existing partnerships time to time and to check their relevance. Some new potential partners should always be checked in the development phase.

Policy and strategy match is one of the core means enabling collaboration. It is important to start this inside the university if it hosts several “independent” research institutes. In this case the strategy match between LUT (green energy and technology) and CST (energy efficient processes, material efficiency and water) has no contradiction. The university strategy has to fit the EU and national level policies, as it does. In these policies the chosen themes are implemented by ministries, public financiers (The Academy of Finland and Tekes) and finally partly operated by the SHOKs. For the universities, the policy check is not enough. They must be active and especially proactive in trying to influence the coming political decisions in time.

This study was done in the LUT CST membership network. According to its rules and regulations, the mission of CST is to tackle the industrial challenges in the field of separation technology expertise. This approach covers only purely technological issues. The big picture related with the heavy process industry is much wider, and there are lots of issues which are in close interaction with each other.

Understanding the situation above opens up novel possibilities to develop university-company relations towards strategic partnership. Actually LUT with its huge amount of expertise in technology and sustainable value creation could be an excellent innovation and collaboration platform for university-company collaboration. This kind of actions were expected from LUT and CST in the CST member enquiry in the form of innovative openings and contribution of industrial needs at the LUT level, not only at the CST level.

The term innovative openings include many issues. One important issue is the discussion concerning recent research results and trying to find industrial needs which could be implemented into the industrial production scale. A second issue is proactive discussion concerning forthcoming research ideas to check if there are possibilities to joint project development. A third issue is related to public research and R&D financing opportunities, open calls in the near future etc. Industrial partners often expect positive surprises from universities, and with this subject it is a benefit to be proactive. It is easy to see interaction between innovative openings and the will to understand industrial needs.

Value creation as a process is mostly identical in companies and universities. It is important to note that the required output in companies is mostly economical benefit to the shareholders. For the universities and their research organizations like LUT and CST, the output is novel high level research publications, innovative education and societal impact, which actually combines also research and education. In this context external funding is the tool to execute their mission. This was the motivation to rename Porter´s original value chain and localize it into the academic environment. Another form in university-company collaboration concerns access to industrial data like process values etc. With this data it is possible to create interesting scientific articles where laboratory-scale trials can be proved in production scale.

The added value in university-company relations varies depending of the status of the company. The company needs are different for process owners, technology providers and expertise providers, because they operate in different positions in the global value networks. This challenge can be solved by continuous dialog between the partners which helps to understand the long- term goals on both sides. This is an action which helps to define the common interest which will lead to shared added value. In some cases this may lead to the need to expand the fields of expertise in collaboration, which opens novel possibilities to a multidisciplinary research approach for the researcher. These things are often expected by companies.

The cluster-based innovations system like the present one in Finland is challenging when studying organizations whose scientific output fits the needs of many clusters at the same time. This means the presence of more actors than before on the system level. On the national innovation system level, the start-up with SHOKs changed the structure a lot, and increased the number of national strategic programs like Cleantech, Bioeconomy, etc. as well. These renewals have been positive. For the research institutes with a very generic scientific output (e.g. huge amount of potential industrial applications in different industries) like LUT CST, this change has meant an increased number of important strategic partners.

In this study the execution of research projects was divided into three categories; open, semi-open and closed projects. The semi-open project model gained most attention in this context. The semi-open project model is difficult to define because it has elements of the two other models (open and closed model) as well. The importance of the semi-open project model is emphasized when dealing with SHOKs where the programs are typically based on a consortium. The consortium model is a typical functional mode also on the EU level (e.g. Horizon2020).

The SHOKs use consortiums that have both industrial and research partners to develop novel programs, and the consortiums have an important role also in executing the programs because they comprise the program level steering group. Universities or research institutions should be present always when new programs are planned. Sometimes it is difficult to achieve a remarkable role in the SHOK program after the consortium has been created. To avoid this situation, proactive work and discussions with the SHOKs are essential.

Checking the possibility of receiving public funding to the project even in university-company projects is normally a task the university should execute. Normally this does not affect the jointly developed research plan. A more challenging issue to companies is normally how the IPRs are shared when public research funding is present. This issue has been discussed in this study and it is related to three research project categories; open, semi-open and closed projects.

The main research question of this study was: "What are the characteristics for successful university-company partnership development and how to identify them?" By combining the findings related to the individual research questions presented above it is possible to introduce the process describing successful university-company partnership development. This process is shown step by step in Figure 18.

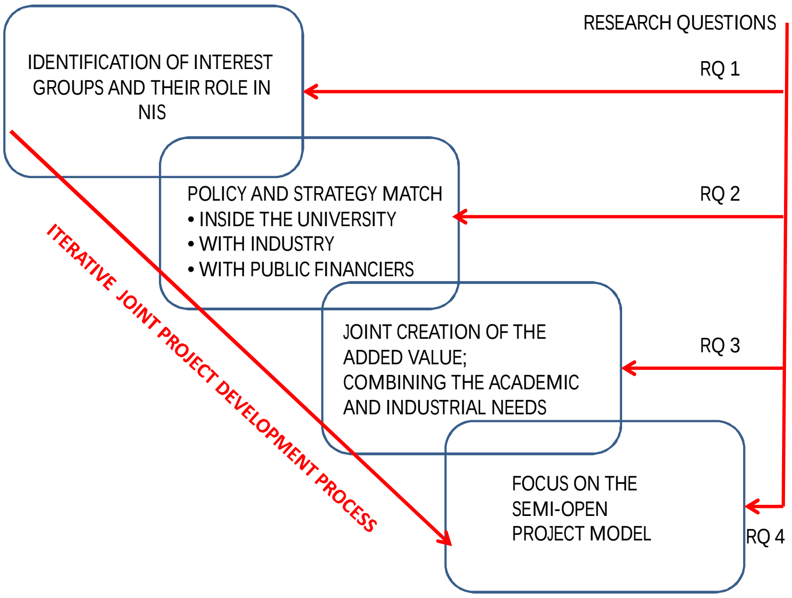

Figure 18 The findings and their contribution to the main research question.

The Figure 18 shows the relations and interactions between the chosen research approach (i.e. research questions) and the most important findings on the thematic level. It also shows that joint project development is a continuous process. This means that universities and research organizations must pay attention to the changes in the operational environment on all levels, starting from policies and processing to the strategies and actions of individual companies.

The process shown in the Figure 18 is also iterative. All the required actions “live” in time. Observing the changes and their relations in the operating environment is an essential element in this process. The changes may occur on many levels where the policy and strategy are typically the biggest.

The Figure 18 illustrates holistic approach to the title of this study, identification of characteristics for successful university-company partnership development. The identification of interest groups including individual actors and their role in the national innovation system reflects to Triple Helix model (Chapter 2.1), university-company collaboration (Chapter 2.3) and national innovation system (Chapter 2.4). Policy and strategy match emphasizes the governmental dimension of Triple Helix model (Chapter 2.1) as well as SHOKs (Chapter 2.4).

The joint creation of added value links to Porter´s value chain (Chapter 2.2). Euros and dollars are easy to measure but in this context the added value shows also in other forms to partners participating to the joint operations. In practice the added value is often new expertise and knowledge which can be developed to top level scientific articles, patents or competitive products and processes. The semi-open project model is more demanding to plan, manage and execute compared to the other project forms (Chapters 2.4.1 and 4.2) and thus it needs special attention.

The general output shown in the Figure 18 is not only the successful execution of university-company joint project. Even this is the focus of this thesis it is important to understand that above mentioned project is only one part of the societal impact which also boosts the societal renewal and wealth creation to the nation through improved capabilities, networks and innovation system.

5.2 Managerial contributions

This study has focused on the identification of characteristics which enable successful joint project development between universities and companies. Despite the fact that some of the research results are easy to implement on the managerial level in universities, the following ideas could be included in the development process introduced in Figure 18.

Figure 18 illustrates the priority and interactions of the most important characteristics in successful partnership development in university-company collaboration. Depending on the case (e.g. companies) and the frequency of proactive discussions with them, it is not always necessary to follow the development path shown in the figure step by step. In many cases it is possible to start directly by defining the joint project if the company and its strategy are familiar enough. Vice versa, with new partners lots of attention should paid to two first boxes in the figure (upper left corner).

Because personal incentives in many universities do not encourage professors and leaders of research groups to wider collaboration inside the university by crossing the organizational faculty borders, this is a managerial challenge to the top management of the university and also to the deans on the faculty level. If this issue is not in order, there is no way to avoid partial optimization on the personal level. This is the reason why a common internal joint project development policy is valuable.

The university representatives dealing with SHOKs or other similar doers should be very well informed concerning all the research possibilities and novel research ideas in the home university, not only the professors´ own scientific interests. In this case it means that also the CST staff should represent first the whole university (LUT) and secondarily the subgroup (CST) of it.

In practice the issues discussed above can be solved on the university level by encouraging incentives for internal collaboration and networking. Another important issue is wider collegial discussions inside the university before important meetings to ensure that the university participant really has the latest information concerning the whole university at his/her disposal.

5.3 Credibility assessment

This subchapter introduces self-evaluation of the research quality of this study based on the literature related to issue (see Chap. 3.4). "Trustworthiness" includes credibility, transferability, dependability, confirmability and applicability.

The results of this study have good credibility because the research object was real and the same case was used in several theoretical frames (e.g. value chain and Triple Helix). The transferability of the results is still limited and in this phase it covers only LUT and CST, but many of the findings could be directly implemented by other universities and research institutes in Finland. To reach a wider geographical implementation area for the findings, more cases from different countries and innovation systems should be studied.

The dependability of this study is on a good scientific level. Even though the number of respondents in the different questionnaires and interviews were relative small, they were in right positions in their organizations and had a relation with the research object. The confirmability of the findings is reliable. The results fit well the selected theoretical frames and no paradoxes in that area were found. The findings and the results have also high applicability in the spirit of action research within the research topic.

5.4 Suggestions for further research

The contribution of this study concerns university-company partnership development. The study is exploratory by nature and the results show preliminary understanding of the interactions occurring at the interface of university-company relations. The case study used in this study gives of course only a limited view to the genre and this leaves lots of possibilities for further research.

First, it would be interesting to deepen this study to cover also the identification of interactions between all actors in the whole interest group network. In the long term it could be interesting to evaluate the results of systematic interest group management implementation in several cases.

Second, one doctoral thesis is too limited a space to discuss the interaction between interest group management and managerial tools, but it would be an excellent topic for new research. To reach wider credibility of the results of this study, an international comparison of different innovation environments should be executed.

Third, to generalize the findings of this study, it would be interesting to compare the results of this study to the situation in different countries where the national innovation system is similar to that in Finland.

Fourth, it would be interesting to achieve deeper understanding of the IPRs and the “birth” of inventions leading to patents. Is the university-company joint project collaboration a better platform for patents than separately operating companies and universities? Another side of this context is the number and quality of academic research papers.

6 CONCLUSIONS

The university-company relations have become increasingly important due to changes in the business and academic environment which have forced universities to become more entrepreneurial. This means that besides the conventional university missions, research and education, the third mission of the university has become having an impact on industry and the surrounding society.

The main research question of this study was the *identification of the characteristics for successful university-company partnership development*. The driving force in selecting this subject was the huge changes in the operative environment of universities during the last two decades. Today universities and their research units depend on external funding more than ever before.

The main research question was divided into four sub questions:
1) What are the elements of common interest in joint project development in a university-company relationship?
2) Technology push or holistic understanding of industrial needs?
3) How to define the different forms of added value in university-company joint projects?
4) What is the position of public research organization in a cluster-based innovation system?

The research questions were answered through qualitative methods in the four individual publications that form the second part of this thesis. The main findings and the synthesis of them are introduced in Chapter 5.

6.1 Main findings

Synthesis of the most important findings in the individual articles was executed. The synthesis emphasized the following issues in this order: identification of interest groups and their role in the national innovation system; the policy and strategy match between a research institute and its potential partners; combining the academic and industrial needs; and finally the importance of the semi-open project model. Overall, these four determinants dictate how the university value chain is managed and balanced. These aspects are necessary in the Finnish university system, although not always, sufficient for the successful operation of a public research organization. In other environments the requirements can be different. In order to validate further, the results a similar case study with a different setting should be conducted, including more interviews and different research methods in order to create a more holistic perspective.

The identification of interest groups and their role in the national innovation system is the first step in characterizing the elements for successful university-company partnership development. According to the Triple Helix model, the doers in the innovation system can be categorized into three groups: state, academy and companies. The identification of the partners in the interest group is not difficult. The more challenging task is to understand their roles in the innovation system. The nature of the university-company relationship in this context is not constant, it varies in time and case by case.

In this study the identification was made for the Centre of Separation Technology (CST) hosted by Lappeenranta University of Technology. The members of the interest group were divided into two categories: potential research financiers and dialogic partners. This categorizing includes actually a paradox, because in practice the potential financiers need more frequent attention and dialog than the others. To carry on, *continuous dialog* and *proactive dissemination of information* are important characteristics in interest group management.

The importance of *policy and strategy match* is the second issue. In this context the policy level means EU and Finland whereas strategy is related to the independent companies. It is always a benefit for the university or its research unit that there is no incompatible content with the current policy. The policy gives the upper level guidelines which are implemented by ministries, national programs and public research financing instruments. These are huge enablers for the research organizations and companies as well.

On the university-company level it is important to check the strategy match as well. In this study, the strategy match between LUT CST and SHOKs (Strategic Centres for Science, Technology and Innovation in Finland) was done. The strategy match showed an interesting issue related to the research unit with a generic scientific output. Generic output means that the research results have many fields of applications in different industries and processes. The research results of CST are useful for most of the SHOKs, but actually separation technology itself is not the top expertise in the strategic research agendas of SHOKs. The same in a smaller scale means that the strategies of the university and its research institutes should match.

Joint creation of added value is the third subject in joint project development. The added value was studied through the value chain model. A tuned value chain for LUT CST was developed. It is important to understand how the university value chain differs from the company level value chain. The shareholders´ benefit is always the top issue in companies. With universities, the increased need for external funding is still a tool for executing high-level research projects which lead to academic added value like scientific articles, doctoral theses and improved societal impact.

The inputs and outputs between the company value chain and the tuned university value chain were also discussed. The companies were categorized into three groups; expertise and technology providers and process owners. This was an important approach and it showed that joint project development with different companies cannot be executed in one standardized manner.

The fourth important issue is the management of a *semi-open project model* which is the most demanding joint project model illustrating the university-company collaboration on the practical level. The semi-open project model is a typical consortium-based operation used in EU programs (e.g. Horizon2020) and on the national level in Finland in SHOKs. This study showed that the semi-open model needs more attention compared to the two other project types; open and closed models. The definition of the semi-open project model is not totally clear because it includes elements of the two other models.

The consortium basis means that the university or its research unit must be very proactive to get a position in the preliminary discussions where the headlines of the forthcoming research plan are usually defined. Afterwards it is normally difficult to influence the work packages of the research plan. One characteristic depending on the project type concerns the IPR. In the open project type where the share of industrial financing is relatively small (typically max. 10 %), the IPRs belong to the university, and in the closed project model which is totally financed by industry, the IPRs belong to them. In the semi-open model the consortium normally owns the IPR or at least the IPR is specified in the consortium agreement.

All the four most important findings described above can be seen as an *iterative process* where the steps are in close interaction with each other. This model was developed and introduced in this study.

The *contribution* of this thesis includes academic and managerial elements. The academic aim was to take a holistic approach in the identification of characteristics for successful university-company partnership project development. The operative environment on the university level is complex and there are lots of factors present all the time and these factors are in interaction with each other. To avoid the partial optimization, it is important to recognize all these factors. All national innovation systems have their own specific nature. The scientific novelty of this thesis is the holistic approach to the university-company relations in the Finnish innovation system.

Some of the findings can be easily implemented into the managerial operations of university concerning external networks and stakeholder management. The focus of this thesis was to identify the most important factors and their interactions. The management concept with its organization, responsibilities and indicators was not the core output of this thesis, but the findings can be implemented for that purpose as well.

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PART 2: INDIVIDUAL PUBLICATIONS

PUBLICATION I

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Mapping the Activities Between a Public Research Organization and Interest Groups: A Case Study of LUT CST in Finland

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ABSTRACT *The management of interest groups is the key element of fund raising and project development for a public research organization (PRO). Management is never a simple task. However, its complexity increases considerably when the research field of the PRO is generic, with numerous potential industries utilizing the research results. This paper discusses the identification and managing of interactions between a PRO and its interest groups. The case example is the Lappeenranta University of Technology (LUT), hosting the Centre for Separation Technology (CST).*

Background

The expansion of a university's mission from traditional teaching and research to entrepreneurial pursuits (Clark, 1998; Etzkowitz, 2003) has been one of the major changes in the academic world. Nelson (2001) states that to be effective in the long run, universities should stay focused in the arenas of open public science and education, this being their comparative advantage in national innovation systems. However, given the new realities of expansion with regard to the universities third, entrepreneurial, mission, research organizations have had to become more business-oriented in order to sustain their role in society. The question for a public research organization (PRO) is how to survive and respond to the changes in an environment where university research is, to an increasing extent, funded by industry. In the transformation Clark (1998) identifies five irreducible

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minimum elements: a strengthened steering core, an expanded developmental periphery, a diversified funding base, a stimulated academic heartland and an integrated entrepreneurial culture.

There are several reasons for this change, the most important being the change in basic funding from the government. In Finland this has caused a situation where every university of technology in the country gets only about 50% of the budget directly through this traditional model. The basic funding in most cases allows only for providing education at the bachelor's and master's levels, but not for research. There is a "free for all" research fund available from the government, but the competition for it is very severe. Following the changes in public funding, universities, to an increasing extent, have to argue for their economic role and demonstrate their societal impact in order to obtain public funding. This had led many European countries to conduct university reforms resulting in greater autonomy, more competitive-based funding and increased commercialization of the results of public research.

The "Triple Helix" (TH) literature (Leydesdorff & Etzkowitz, 1996, 2000) argues that the acceptance of commercialization as a central university task constitutes an academic revolution. In this innovation model, universities and science-based technologies originating in academia play a strong role. Public–private partnerships have been argued to be signifiers of the new era of academic entrepreneurship. Furthermore, it has become common practice to use the TH as a metaphor to describe and analyse university partnerships with public and private organizations. The TH type of innovation activity focuses on producing high-tech innovation based on the latest research and technology knowledge. The Quadruple Helix extends the traditional TH by including some fourth group innovation actors into the TH model, e.g. in systematic collection, as well as in the utilization and involvement of users, thus emphasizing a broad cooperation in innovation (Carayannis & Campbell, 2009; Arnkil *et al*., 2010).

This paper provides insights into a Finnish University's (Lappeenranta University of Technology (LUT)) research institute's (Centre for Separation Technology (CST)) ongoing efforts in coping with a changing research environment. The aim of the paper is two-fold: to (1) describe the changing university environment and (2) define the actors and main processes through which success factors can be identified. The paper discusses the importance of interest group management for a PRO. This is essential to all PROs, but when the scientific output of a PRO is generic and could be utilized in many industries, interest group management becomes even more important. As key results the article identifies the position of the research institute and the interest groups in its operational environment, and presents the success factors in the public–private research collaboration.

The paper is structured as follows: first, the changing role of universities in general is discussed. Next, the methods and the case selection criteria are provided. Subsequently, the empirical part of the study illustrates the main features of the operational environment and provides a descriptive analysis of the case results. In conclusion, the findings are discussed based on the study literature.

The Changing Role of Universities

Since the 1980s, there has been increasing pressure on academics to collaborate with industry partners and to commercialize the results of their research. A ("paradigm") change in the university system from research universities into entrepreneurial universities has been observed (Rothaermel *et al*., 2007). In the literature, some authors (Siegel *et al*., 2004; Van Looy *et al*., 2004) have seen this as a natural evolution of a university system that emphasizes economic development in addition to the more traditional mandates of education and research. Many universities have built more or less full-range support mechanisms for entrepreneurship, such as technology transfer offices and incubators or science parks that spawn new firms. Increasingly engaging in interactions with industry, the core of the university system has expanded to include activities outside basic research with the goal of transforming inventions into innovations. This is an area where we have seen an increasing amount of academic entrepreneurship activities, such as contract research, consulting, patenting, licensing and spin-off firm creation (Klofsten & Jones-Evans, 2000; Perkmann *et al*., 2013). In many countries university reforms have been carried out in order to support commercialization and technology transfer in general.

Universities, to an increasing extent, have to argue for their economic role and demonstrate their societal impact in order to obtain public funding even for basic research. Universities can contribute to economic development both by interaction with existing industry and by other types of commercialization of knowledge, such as university licensing or the establishment of new firms. Increased societal interaction can enhance universities' public image, which in turn can lead to accountability for funding. The change in the universities' mission opens the possibility for many universities to get a broader funding base through other non-governmental sources (Rasmussen *et al*., 2006).

New expectations and a changed funding structure are two major changes in the academic world. There are still diverse views of the implications of this change as some scholars suggest that a more entrepreneurial university strives for more applied and problem-solving research and thus interrupts or even threatens academic freedom (Powell & Owen-Smith, 1998). More frequent concerns include worries about shorter time horizons in research and tensions related to impartiality and conflicts of interests (Etzkowitz, 1998) as many institutes need to operate in a manner similar to private companies (Etzkowitz, 2003). The third mission of universities as regional engines of innovation and economic growth has increased the importance of partnership management and a focused strategic direction in both academic and economic development of goals (Etzkowitz *et al*., 2000; Etzkowitz & Klofsten, 2005). Regardless of the ongoing discussion about the future of the universities' basic missions and open public science, it seems that it is possible to manage both the academic and entrepreneurial pursuits. For instance, Gulbrandsen and Smeby (2005) argue the relationships can be complementary and mutually beneficial. They found a significant relationship between industry funding and research performance, as faculties with industry funding conduct more applied research, collaborate more with external researchers both in academia and in industry, and report more scientific publications and entrepreneurial results (Gulbrandsen & Smeby, 2005). However, for example in different project (open and closed) types, there is need for institutional policies for ensuring that the public sector mission is not compromised.

It is widely recognized that technological innovation plays a central role in the long-run economic growth of a social system and its emerging technologies. The TH model, theorized by Etzkowitz and Leydesdorff (Leydesdorff & Etzkowitz, 1996), suggests that in a knowledge-based society the boundaries between the public and private sectors, science and technology, university and industry are increasingly fading, giving rise to a system of overlapping interactions which did not previously exist. In practice the model is seen, for example, as universities performing tasks that were formerly assigned to firms and vice versa. While the academic work is being redirected towards commercial applications, industry–university collaboration is becoming a critical issue; and wider industrial and political interests are integrated into the planning and organization of university research. The TH thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies. Therefore, academic researchers have to take into account the impacts that the scientific outputs of their work have on industry, and at the same time researchers working in industry need to be updated on the evolutionary developments of science (Leydesdorff & Etzkowitz, 2000; Ughetto, 2007). Naturally, the TH model does not exclude focusing on two of the three dynamics—for example, in studies of university–industry relations. However, one can expect more interesting results by studying the interactions among the three sub-dynamics. At the very least, the third dynamic of the TH model should be identified as another variable while discussing the said sub-dynamic interaction (Leydesdorff & Etzkowitz, 2000).

Finland has been a member of the European Union (EU) for years. The EU has invested a lot in science and innovation, like about 70 billion € in the Horizon 2020 programme 2014–2020. The EU regulations emphasize collaboration between different research organizations from different countries and the university–-industry collaboration.

In recent years the national innovation system has changed a lot in Finland. One of the drivers has been the new balance between the supply and demand-side innovation policies. The new policy in Finland includes the broad-base and systemic approach to boost the national productivity improvement. These should lead to pioneering and forerunner character as a part of innovation policy (Veugelers *et al.*, 2009; Sotarauta 2012). The new strategic emphasis given to universities as sources of national economic competitiveness in knowledge-based innovation business. From the perspective of competitiveness, universities are not approached merely as providers of basic research and skilled academic workforce, but increasingly as major players in the global and European “innovation business” with their own “product portfolios” and engaged stakeholder networks. The academically oriented research in Finland has been moved to universities and the remaining duties have been re-organized into four to five PROs (Veugelers *et al.*, 2009). There are also new instruments to boost the initiatives launched by the Prime Minister’s office such as national Bioeconomy and Cleantech strategies.

The ongoing university reform is the system’s most important change in several decades in Finland. Its most important objectives are to improve research quality, societal impact and to support internationalization of universities. The most important qualitative change in the funding of research is in the redefinition of “strategic research” via Strategic Centres of Science. The policy shift can be seen as implying a redefinition of strategic to mean research that has the approval and/or collaboration of specified target groups in the industry.

This change has also meant a new expanded role for universities with regard to their “third mission”—the societal impact. However, in many universities no additional funding is provided for the various forms of collaboration that are invoked in the name of the third mission, resulting in many universities facing a situation of functional overload (Clark, 1998; Jakob *et al.*, 2003). The dilemma is that the expectations concerning the output of universities have increased but at the same time the financial resources have decreased. The reductions of governmental financing in basic research coupled with academic “third mission” activities in universities have been one of the major factors behind the university’s changing role in the management of interest groups. This has forced the redefinition of the research focuses in all universities. All of them are looking for particular strategic niches where they could have enough critical mass to undertake world-class research.

The LUT hosts an interesting research institute called the CST. CST is not the only university-based research institute in Finland, there are lots of similar concepts in many universities. CST has many unique characteristics to make it a good case study within the context. The first essential issue is that the research results of CST can be utilized in different industries (e.g. pulp and paper, mining, chemical, etc.). The collaboration with many industries maintains the continuous dialog and the exchange of information concerning industrial needs and scientific possibilities. Second, the CST has been active since 1997, and during that time the collaboration relations with members in several research projects has developed and the important trust earned. Third, the CST membership system with annual fees is not common among universities.

Method and Case Presentation

This study is based on the theoretical data received from the literature review and on the empirical data related to the case organization (LUT CST). The approach to data collection taken for this study has been descriptive and qualitative. One of the authors has practical experience with, and insights into, LUT CST and also the national innovation system from Tekes (The Finnish Funding Agency for Technology and Innovation) in order to understand the case in its context. This enabled first-hand knowledge of the funding mechanisms and could thus be the basis for this study. The fact that the empirical part of the study relies on the single informant poses some severe limitations in terms of generalization and includes risks in misjudging the representativeness of the case. However, from the perspective of reporting, this approach allows great depth and richer description (Voss *et al*., 2002). The in-depth approach provides a concept for designing an optimal organization model for a public research institute in a changing research environment.

Empirical Case

The case organization, LUT, founded in 1969, is located in South-Eastern Finland. The university comprises of 5700 students (technology 76% and business administration 24%) and 930 staff. LUT's turnover is approximately EUR 78 million per year, almost two-thirds of which is related to research. Basic state funding of the LUT amounted to EUR 44.3 million in 2011. External funding totalled EUR 31.3 million, originating from the following main sources: Finnish research councils (7.3), Tekes (20.1) and the EU (3.9). LUT has, in recent years, become more focused on external relations and research. Recently, LUT has also tried to take a more active role in the commercialization of university-based inventions and creation of spin-off companies, with the new investment company Lappeenranta University Research Company having been established for this purpose (Lureco, 2013). LUT's target is to be a leading scientific actor and an attractive partner for cooperation in its strategic focus areas of expertise of green energy and technology, sustainable value creation, as well as to be an international hub for relations with Russia. (LUT, 2014).

The separation technologies are unit operations used widely in the different fields of chemical and process engineering (e.g. distillation, filtration, crystallization, etc.) which enable separation and concentration of different chemical compounds from mixtures. Most of the common processes in pulp and paper, chemical, petrochemical, pharmaceutical and food industries are based on these unit operations, albeit operated with different parameters. They are also suitable for water purification processes. The centre has its own rules and regulations inside the LUT. The primary objectives of the institute are to boost the quality and quantity of research in the field of separation technology, accelerate the technology transfer from research to industry, improve the collaboration between different laboratories and research groups inside the LUT and to develop their networking with domestic and international partners, as well as to develop the research facilities for empiric research and organize training and education in this field. In practice the LUT CST has acted as a "foreign office" of a university department in matters linked to industrial collaboration in its early days, and has later on functioned in a similar capacity with academic research partners globally. This arrangement strives for the functionality of a "one stop shop" which tries to make collaboration easy and fluent for all members.

The LUT CST members represent different industries, e.g. mining and metallurgy, chemical engineering and pulp and paper. Another interesting characteristic of LUT CST is that the member companies are in different positions in the value chain. Some of them are clearly technology providers, some are process owners and the rest are in the role of expertise providers. This situation is also challenging for public project financing. In the cluster-based national innovation system (Sotarauta, 2012) LUT CST has to operate with several clusters.

The expertise of LUT CST is based on the LUT Department of Chemical Engineering, where the staff consists of 10 professors and more than 50 researchers primarily at a doctoral level. Today, the CST has 26 member companies from different industries. The companies are mainly global players of Finnish origin, e.g. Outotec, Kemira, Flowrox, UPM, StoraEnso, etc.

During the recent years, CST has also expanded the international research member network. The network currently covers three universities from Russia, one from the Netherlands (Delft) and two from Germany (Berlin and Dortmund Universities of Technology), Ecole Polytechnic from Canada (Montreal), Innventia AB and the Forest Products Research Institute. The national research network has also evolved; VTT and two universities of applied sciences (Saimaa and Mikkeli) are CST members. The research focus of LUT CST is shown in Figure 1.

Categorizing the Typical Project Types of a Public Research Organization

Perkmann and Walsh (2009) categorize different types of projects in university–-industry cooperation in four typologies: problem solving, technology development, ideas testing and knowledge generation. In this continuum problem-solving projects are typically applied research that is close to the market. At the other end of the scale, knowledge generation projects made only very generic references to markets, representing typical academic projects (Perkmann & Walsh, 2009). In our case the projects of PROs can be divided into three categories: open, semi-open and closed (Figure 2). Typically in idea testing and technology development projects, the importance of intellectual property rights (IPRs) increases, with the amount of research and development partners decreasing the closer to utilization the idea progresses. The open projects are typically classic academic research where all research results are public. Open academic research is financed

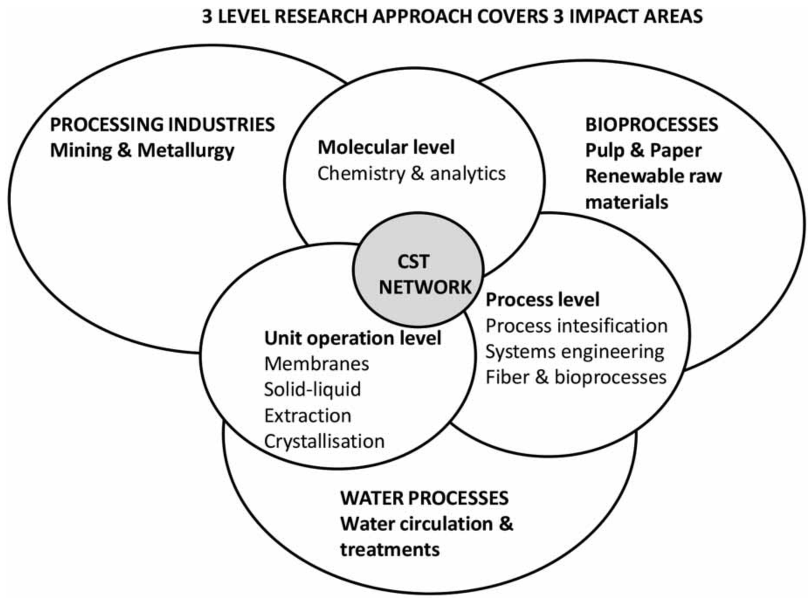

Figure 1. The research focus and research impact of LUT CST.

by budget funds and by a few public 100% funds from public and private institutions or foundations. Open projects are long-term research undertakings, and can thus continue as long as funds are available. In this research the aims are high-level basic academic results and the activities fulfil the requirements of tight academic rigour. Private company funds are seldom available for this purpose, as results are expected sooner. However, basic research is also the foundation for applied science and contract research.

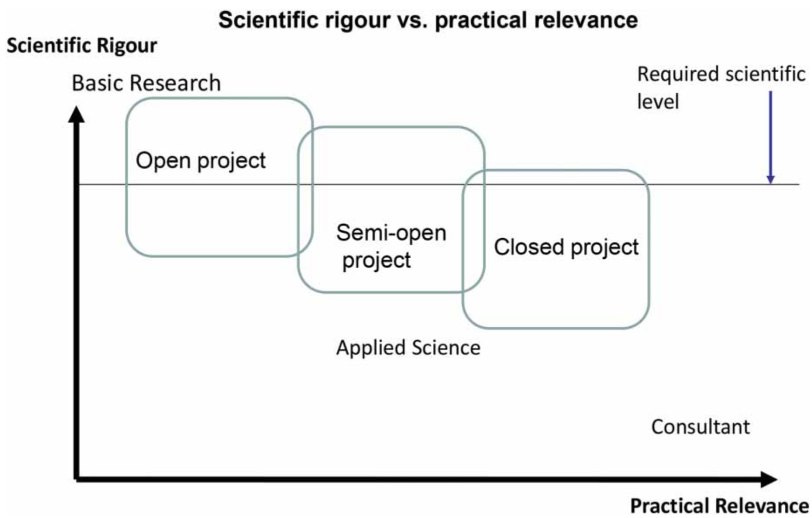

Figure 2. Project types.

With select public financiers, some private companies may also participate in the projects, but in the case of this study, said companies only have the possibility of viewing the results beforehand, as opposed to ownership of the research. The financiers, in addition to the state budget financing, in this case are the Academy of Finland, EU (direct funding and regional funding instruments) and the Finnish Funding Agency for Technology and Innovation (Tekes) research funding. "The IPR of the research belongs to the university", with some exceptions.

The need to set up the Strategic Centres for Science, Technology and Innovation (abbreviation in Finnish is SHOK). They have relatively large programmes (duration 4 years total, budget from MEUR 20 to MEUR 35). Programmes are generated and developed together by the shareholders of Strategic Centres for Science companies and universities. Semi-open research in a university's and company's joint research projects combine university researchers, large companies and small companies in solving short- and long-term issues. The short-term aims also include applied research but the aims of the larger projects include ambitious practical and academic research activities. These projects use public financing and company financing in a joint effort to attain common goals. Some of the results are public, but the steering groups of the projects may restrict publication to the scientific part of the results. Semi-open research extends the possibilities for researchers to learn and apply their skills and knowledge in research. Often this research also gives academic researchers empirical data and practical issues to solve. "All programmes have a consortium agreement which defines the distribution of ownerships between the partners' expected IPRs."

The third category can be called scientific subcontracting. The companies in many application development projects need academic backup in the proof of concept phase. Closed research projects are fully financed by the external partners. The partners get the results which they order, provided the concept works. The results of the service research are owned by the party which ordered the work. These results are not normally public. In these cases the phenomena-based understanding is required to generate solid marketing data and to show to the potential customers that the novel equipment or process is really running as promised. The big companies usually have a so-called long-term frame agreement in which all the issues related to the IPR and confidential matters are defined. Contract research may even the work load of the separate institute and thus may help the management of work load. "Usually all IPRs are owned by the company."

The relation between scientific rigour and practical relevance with these three different project types is described in Figure 2. In university research, articles in top scientific journals are the backbone of university operations. However, the value of results lies not only in high-level scientific journals, but also in patents, innovations and new business activity.

Figure 2 illustrates that a semi-open project type might include elements from the other types. Categorizing different project types is not always easy and clear. This is the reason why there is overlapping between different project type boxes. The area of the boxes does not correlate to the importance or turnover volumes, actually these parameters vary a lot in different years. The managerial instrument is utilized and it is linked to the potential research financier in different project types.

For a PRO it is essential to identify the current situation on the project level. All project types characterized in Table 1 are relevant and possible to manage if the PRO understands the different cases. The danger, especially with closed projects of a research organization in a university of technology, lies in focusing on more or less industrial R&D instead of

Table 1. Examples on the differences between the project types

	Open project	Semi-open project	Closed project
In accordance with PRO's own strategy	Usually not possible to influence the titles of open calls. Sometimes difficult to follow PRO's own strategy.	Possible to influence the research agenda	Usually the task is given by the customer, but normally these arrangements are based on long-term partnership and trust
Expected hit rate to get funds	Small	Normal	Good
Competition	Hard	Normal	Small
Amount of possibilities	Huge	Limited	Small
The ownership of the IPRs	University	According to the consortium agreement	Customer
Possibility to publish the research results	Full	Delayed (usually a permit from consortium required)	Limited
Required industrial funding	Max. 10%	Typically 40–50% on the consortium level	100%
Required trust between partners	Normal	High	Total
Number of required partners in general	Open structure, collaboration required, also on the international level	Mostly from the consortium in addition to relevant international contacts	Case by case, but seldom more than a few

classic free research. Sometimes industrial partners ordering scientific subcontracting from a university are mainly interested in getting an independent "proof of concept" label to their novel product or process, or faux-scientific marketing curves.

Identification of Interests Groups

For the PRO a stable funding base is a key issue in developing long-term skills and doing fundamental scientific research. For the state it is important that government-funded research results in commercialized products that benefit the public, enable increased wealth by creating jobs and new business opportunities, and promote economic prosperity. As currently academic work is being redirected towards commercial applications and the importance of external funding is increasing, the management of partnerships has become a critical issue.

The first phase in interest group analysis is the identification of the said groups and determining their position in the TH system. The second phase includes the operational level represented with its own information level in Figure 3. This approach opens a

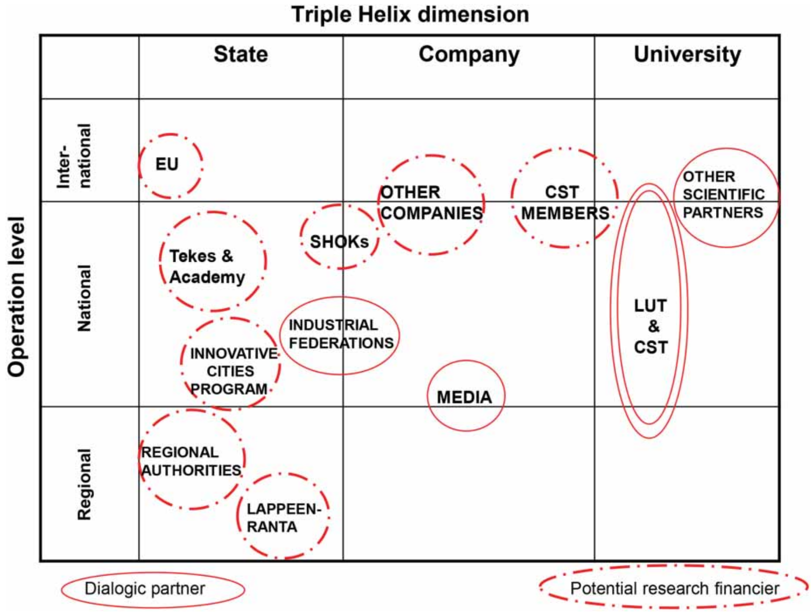

Figure 3. The identification of LUT CST interest groups in the TH and the operational-level framework.

new, important, dimension to this analysis as the fund raising procedures vary considerably between regional, national and international levels.

Figure 3 illustrates the most important interest groups relevant in this case. The interest groups are divided into the categories of potential research financiers and dialogical partners. In most cases the national and regional public research financiers operate according to the same strategy but the funding instruments and their terms vary. The dialogical partners are important sources of information with regard to the industrial market trends and new legislation which might lead to the research ideas. Their role in achieving general publicity is also valuable.

There are many reasons for academics to collaborate with industry and vice versa. Lee (2000) finds that the most significant benefit realized by firms through collaboration is an increased access to new university research and discoveries, and the most significant benefits by faculty members is complementing their own academic research by securing funds and by seeking insights into their own research (Lee, 2000). In the LUT CST member network context study the industrial partners especially sought innovativeness and novel openings from the university (new R&D projects), active research collaboration with the industry R&D departments, international networks including the leading universities, better internal collaboration inside the LUT, long-term skill development and systematic project portfolio development (Karvonen *et al*., 2012).

The most frequent interest group is naturally the host university "LUT" (Table 2). The types of interactions are mostly related to the common IT system, project accounting, etc. which are all organized by LUT. There is daily interaction and as an internal institute in the LUT, CST keeps the rules and regulations. CST follows LUT's rules and regulations in the

Table 2. The frequency of interactions, case LUT CST

Daily	Weekly	Monthly	Several times per year	Annually
LUT	Members	SHOKs Tekes Academy of Finland	Other companies Other scientific partners Innovative Cities Programme Regional authorities City of Lappeenranta Media EU	Industrial federations

described forms of interaction. The "member" expectations of CST include the industrial members expecting to get novel research results as an input to their own R&D processes. In many cases (especially with some larger companies) the long-term membership has created a trusted development platform. Industrial companies are partners and partial financiers in many research projects and sometimes they order direct research subcontracting. The research partners expect to get research cooperation which may be realized in the form of joint articles. Both expectations are in principle the same nationally and internationally. In August 2012, the national research organization VTT, The Technical Research Centre of Finland, launched a new operation: establishment of their novel research team in the field of separation technology research in LUT. All members view the wide member network of LUT CST as an innovation hub which offers a good platform for university industry discussion and joint project development.

The national innovation system in Finland is built on a cluster-based approach (Sotarauta, 2012), of which the "Strategic Centres for Science" are an example. There are several centres of expertise in different industrial fields, including energy, pulp and paper, machinery, energy and environment, IT and construction. They run large programmes with typical durations of 5 years with a budget of over MEUR 30. The Strategic Centres for Science link industrial needs with academic research. Because the expertise of CST is generic (applications have been implemented to several industries) CST is active in three different Strategic Centres for Science: FIBIC (Finnish Bioeconomy cluster/pulp and paper and biorefineries), FIMECC (metal and metallurgy) and CLEEN (energy and environment). All universities today are more dependent on external research funding. On the national level there are two major actors financing the universities of technology; The "Academy of Finland" whose role is to finance basic research and "TEKES" (The national agency for technology and innovations) which finances both universities and private companies. In most of the Tekes funded projects, university–company cooperation is required. These two national financiers are also the state actors in funding the Strategic Centres for Science.

CST also collaborates several times in a year with "non-member companies", which is one way to realize the societal impact mission of the university. Of course during this cooperation the researchers receive fresh ideas regarding industrial problems and challenges. The contacts and collaboration with other "scientific partners" are organized via active professors and researchers in the CST. Memberships and roles in many societies, such as The Filtration Society, the European Membrane House and different Working Parties of the European Federation of Chemical Engineering, provide a wider perspective for the whole institute. Moreover, CST has very intensive cooperation with non-member universities realized through common research projects and publications, e.g. South China University of Technology (Guangzhou), Technical University of Denmark, National University of Singapore, Max Planck Institute, Prague Institute of Chemical Technology, Tianjin University, Oviedo, Norwegian University of Science and Technology and Toulouse.

In Finland there is a national innovation instrument called "Innovative Cities Programme", started in autumn 2013. One core function of this programme is to transfer the latest research results from Strategic Centres for Science, Technology and Innovation to small and medium size enterprises which have good development ideas but seldom the required R&D forces to tackle them. This programme connects the actors both at a regional and national level. This programme is coordinated by Tekes and has five themes; bio-economy, sustainable energy solutions, future health, smart cities and industrial renewal and cyber security. Bio-economy, energy solutions and industrial renewal are topics interesting to the CST.

The "regional authority" is in this case mostly the Regional Council of South Karelia which is in charge of the local EU development funds. The Centre for Economic Development, Transport and the Environment in South-Eastern Finland covers two regions: Kymi and South Karelia. This organization is the local actor to some Finnish ministries. Regional collaboration is also important in a wider geographical area, as well as in the regions of South Savo and Lahti (The Päijät-Häme region).

The "City of Lappeenranta" is interested in CST expertise. The different kinds of water purification technologies studied in LUT are especially useful to the whole community. The City of Lappeenranta has also been a partial financier in many EU-based regional development projects where municipal funds have been required.

"Media" contacts are important to institutes like CST. CST has managed well in the academic dissemination of research results, but currently the general media is interested in results as well. It is always challenging to report research achievements to an ordinary newspaper reader, but also general publicity is important value for academic institutes today. Professional magazines such as *Materia*, *Kemia-Kemi* and *Paper and Timber* have published many CST-based articles in recent years, with papers having been published in the international *Filtration* journal as well.

Direct "EU"-funds are also an interesting and important source of research funding. There are several possible programmes in the ongoing Frame Programme 7 and the possibilities for funding will further improve after the Horizon 2020 programme starts in 2014.

The "industrial federations" are important partners for PROs as well. Many of them have enough resources for their own research, which offers an insider's view on the future needs in the industry. Because of the generic nature of the LUT CST, it has contacts to several federations, such as the Chemical Industry Federation of Finland, Forest Industries and the Association of Finnish Steel and Metal Producers.

All in all, the LUT CST member network plays the role of a coordinator and facilitator in engaging the university and industry in collaboration and fostering entrepreneurship. LUT CST has promoted entrepreneurship by extending its network system and involving non-governmental actors in entrepreneurial activities. The reductions of governmental financing in basic research coupled with academic "third mission" activities in universities have been one of the major factors behind the university's entrepreneurial activities.

Different Project Types and Interest Groups

The competition for research funding has increased and it is easy to predict that this trend will continue. This poses a huge challenge to universities and the executive role of their internal research institutions becomes more important. By gathering the expertise and research themes it is possible to achieve a better result compared to the previous situation where all professors and research groups tried to manage on their own, sometimes competing against each other.

It is essential to optimize the scientific role of the university and the collaboration with companies. The selection of projects for joint collaboration is one of the most important tasks for PRO management. The most difficult task is to evaluate the closed project category. What will be the academic output there and is the publishing of research results permitted? The researcher's view in this process is extremely important. Academic scientists' views have been typically based on an "open-science" community where academic scientists are able to freely establish new research lines based on their perception of opportunities, or on pure individual curiosity. Belkhodja and Landry (2007) found that from the researcher's point of view the most important determinants for the researcher's collaboration with the industry and the government are related to strategic positioning, the set-up of strategic networks, and the costs related to the production of the transferred knowledge and transactions (Belkhodja & Landry, 2007). One of the central tensions in the emerging discourse about entrepreneurial universities is created between supporters of entrepreneurship and those who see research as a public commodity. For example, Tartani and Breschi (2012) found out that a researcher's decision to collaborate with industry is significantly influenced by the perceived threats to a researcher's academic freedom. However, it seems that the majority of the authors (Siegel *et al*., 2004; Van Looy *et al*., 2004; Marion *et al*., 2012) have seen this as a natural evolution of the university system and the relationships can be mutually beneficial, as was in in the case of teaching and research earlier (Etzkowitz, 2003). Furthermore, in the universities of the technology in Finland with a more pragmatic goal setting, this has not become a great issue.

The financial administration on the university level takes care of the monitoring and progress on the project level. The reactive actions after funding call is launched are an everyday business. The importance of "proactive activities" in the interest group management is increasing. By proactive actions it is sometimes possible to influence future strategies and their implementation, and the relative chance of getting project funding improves. This requires a strategic action plan and remarkable commitment from all individuals in a PRO.

Discussion

In the university institution, research and education are the most important missions. The tasks related to these missions have to be fulfilled in any case due to societal need. The third mission, the positive impact on the industry and society, can be fulfilled only if the main tasks have been reached at a from-minimum-to-satisfactory level. The objective of this study was to describe and create a conceptual and operative model for the public research institute operations. In searching for the model of the PRO in the university the higher-level organizational missions have to be kept in mind. The mentioned basic missions, that is, research, education and impact on society are common for all universities. Currently on a university level, strategies are more definitive when it comes to outlining the scope of research belonging to the strategic focus areas of the university. In the case of Separation Technology (CST), the unit clearly belongs to one of the LUT focus areas, green energy and technology, and sustainable value creation. This means that the research projects of CST earn university support for attaining the targeted funding and results.

In conclusion, below is a summarization of the areas for consideration discussed previously in the text. Experience has shown that these functions are necessary for building a successful separate research organization in a university. Based on this example, we cannot claim that these features are generally sufficient aspects for consideration. Based on the study results it seems that value creation and funding, stakeholder management, project portfolio management and management of the IPRs have been the basic elements for building a successful institute.

Value Creation—High-Level Scientific Research and Research Funding

The core of the process is high-level scientific research. As the separate university institute is largely financed by the external competitive funds, all the activities which take place must be of value in the eyes of the external stakeholders. In the case of CST, all the research done in different stages of the technology life cycle has to earn its place in the CST institute. In the successful operation of the university research institute the different research types (open, semi-open and closed research projects) are always present. The management of this kind of project portfolio is challenging but they serve each other and the whole.

A stable funding base is a key issue in developing long-term skills and doing basic research. The recent developments have brought new challenges for the university institution, as almost half of the annual funding comes from competitive sources. This has led to new priorities in the use of time for the key persons in the university. On occasion, the preparation of research applications has replaced some of the available time for research. Organizational arrangement, such as a separate public research institute, is perhaps a solution to the issue. Naturally the time used for competitive applications may become shorter per successful research project if the aggregation of forces is beneficial for the partners. The issue regarding the funding of ambitious long-term basic research, when the work extends to the long term but the funding is for a short-term project, still remains unanswered. The answers to this issue are can be found at least partly with the operations of the Strategic Centres for Science, where the public and private company resources are combined for long-term research goals. From a general point of view it is good that the financing of the research projects is partly on a competitive basis as it should guarantee that only the best projects are carried out. This is a question of balance, that is, how large of a part of the research finance should be competitive.

In the university the organizational units are often small, as demonstrated by professors' fields, small departments or small one-professor research groups or teams. If the research of the small units is dependent on external finance, continuity is difficult to maintain. This means that the long-term work relationships become threatened, and the skilled and trained researchers are no longer available when the external finance opportunity finally becomes available.

The continuity and the balance between different kinds of research projects are easier to maintain when the project portfolio is larger. This is possible only if the internal and external resources are combined in larger units. With this the researchers' continuous education becomes easier, and may also include some multidisciplinary aspects.

One of the aspects in knowledge creation is to have experts with various kinds of backgrounds in the same research teams. In the multidisciplinary teams this aspect could be carried out. In the case of CST, this has not been widely tried as the Research Centre has been established so far only in the departments of Chemical Engineering.

Stakeholder Management

The management of different kinds of stakeholders in university research is a demanding task. Problematic features related to this task include: numerous stakeholders, varied expectations of stakeholders, the difficulty of combining the said expectations, as well as the time required for stakeholder management. Therefore, the aggregation of university resources for management of stakeholders is well argued for. As this also helps reaching the research aims by combining small and separate internal resources, such allocation of resources also serves the external partners. The aggregation may also be a solution for not constantly overloading the key scientific resources in research project applications.

When discussing the PRO doing genuinely multidisciplinary research where the use of scientific results can be found widely in different industries, the amount of interest groups compared to the situation where research institute is dealing with only one utilizing industry. The current situation provides a challenge to interest group management. How should resources be divided and correct research projects chosen for continued study? The nature of the collaboration with the interest groups is both proactive and reactive. In practice it is important to have a priority list of interest group management in the CST's annual action plan. Otherwise, it is easy to mix crucial actions with less important tasks. On the other hand, Finland as a country is fairly small, which makes interaction easier compared to larger societies, as it is possible to personally know almost all of the key players. Many individuals have different roles at different times in various interest groups, which makes everyday life much easier with regard to the challenges described above.

This paper also demonstrates the demanding requirements for the manager of a research institute such as the LUT CST. There are many interest groups to contact and collaborate with. The partners have different strategic and operative wishes, and are in many ways linked to each other, with the need for dialogue in order to achieve the compromise being omnipresent in the process of successful project development.

Management of IPRs

The commercialization of university knowledge involves economic utilization of intellectual property (IP). Thus, IP ownership is a widely discussed political issue. The US example has been particularly influential as the Bayh–Dole Act of 1980 dramatically changed the incentives of universities to commercialize their IP, with a notable amount of research papers evaluating the impacts of this legislative change having been published since (Mowery *et al*., 2001; Nelson, 2001; Shane, 2004; Mowery & Sampat, 2005). In Europe the ownership of IPRs varies between countries. For instance, Finland changed its legislation in 2007, granting universities intellectual ownership and giving them a formal responsibility for commercialization (Bruun & Välimäki, 2007). However, in open, semi-open and closed research projects the legal aspects have to be handled differently. In open research the results belong to the university or to the researcher. In semi-open research the results are divided between the financiers and the university according the consortium agreement made between the parties at the beginning of the research project. In contract research the results belong to the party ordering the work. Management of agreements is more straightforward in larger research units where only a few people need to become acquainted with this field of knowledge.

The owned patent portfolio may later become a valuable asset and in any case a competitive edge for the research institute or the university. Clearly the IPRs are a long-term issue, which have to be taken care of in the immediate short term. As a whole the changes in the Finnish university system have made IPR management a very acute and at the same time one of the most interesting and controversial issues, requiring further research.

Overall all these three broad determinants relate to how the joint value creation between university and different partners is balanced and the balanced working of the research institute in various aspects requires some kind of management. In overall portfolio management the primary goal is that the short-term, the medium-term and the long- term aims have to be balanced. In a company this often means balancing the sales, products and services, development projects and risks. In a research institute this means basically the same, but the operational emphasis may differ from the company in that the creation of knowledge is on level with the balance of the inflow of funds and project tasks. The diversity of the research projects increases the chances for building new knowledge and thus is aimed towards long-term goals.

The reasons for open and contract research projects have been explained in terms of reaching both short- and long-term aims. The turmoil in the external economies and related structural changes in the industries may advance the companies in searching for new knowledge and understanding from scientific research. New breakthrough discoveries and inventions leading to innovations in the market are perhaps more often in the agenda of the companies during economically unstable times, when they approach academia in joint research projects. In these kinds of research activities the academia may become invaluable for the industry. The breakthrough innovations may even become starting points for new emerging industries in the future.

Conclusion

The objective of this study was to describe and create a conceptual and operative model for a public research institute's operations. The said operative model has become increasingly important due to the business and academic environment changes that have forced universities to become more entrepreneurial. This means that besides the conventional university missions of research and education, the third mission of the university has formed into having an impact on industry and the surrounding society. The PRO operations can be beneficial and effective within the university in this effort. Three aspects have been identified as being crucial for the successful operation of the PRO in the university: value creation, stakeholder management and management of IPRs. Overall all these three determinants dictate how the university value chain is managed and balanced. These aspects are necessary, although not always sufficient, in the Finnish university system for the successful operation of a PRO. In other environments the requirements can be different.

The role of a separate research institute in a university has been discussed at length in this paper, with the case study having focused on the CST in the LUT. The qualitative case research design includes obvious limitations with regard to the generalization of results. Thus, the information-oriented approach was aimed at a more in-depth understanding of the subject by providing new information in order to explain the attributes related to university funding and to the third mission of universities. In doing this, it should be taken into account that the purpose of this paper is also to prompt further discussion and research on the subject. In order to further validate the results a similar case study with a different setting should be conducted, including more interviews and different research methods in order to create a more holistic perspective.

It would be interesting to deepen this study to also cover the identification of interactions between all actors in the whole interest group network. In the long term, it could be interesting to evaluate the results of systematic interest group management implementation in some cases. One paper is too limited a space to discuss the interaction between interest group management and the IP management framework, but it would be an excellent topic for new research.

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PUBLICATION II

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Types of connections between plant location selection and the long term corporate level value creation and methods of their identification. Case study; pulp and paper industry

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Types of connections between plant location selection and the long term corporate level value creation and methods for their identification. Case study; the pulp and paper industry

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Abstract: Many engineers see plant location selection only as an interesting task and a minor part of process and plant engineering. At the same time plant location selection is an important part of the corporate level strategic management and decision making. This paper discusses the types of interactions between plant location selection and strategic long term value creation at the corporate level. The research approach used in this case study is a combination of the classic value chain model and the core elements of plant location selection methods. The most important findings are that the plant location selection and the chosen technology are the core internal elements at the corporate level for long term value creation.

Keywords: plant design engineering; value chain; pulp and paper; P&P; production plant location; value creation; strategic management; strategic decision making.

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1 Introduction

This paper discusses which elements make the characteristics of the process plant unique compared to other production plants or mills. The process plant in this case is in the pulp and paper (P&P) industry but, there are many similarities to other process industries, such as mining and metallurgy, oil refining and the chemical industry. Paper in this context means printing papers, e.g., newsprint, magazine and catalogue paper grades. The similarities include the enormous scale of the plant, continuous raw material flows, capital, and energy intensiveness. Further similarities are found with a very lengthy expected life cycle, required amounts of water and other utilities which set limitations to the plant location. In addition, the process industry is business-to-business in nature. The product is typically an intermediate product headed out for further refining or a raw material for an end-product. Further refining or end-users can be geographically in different places with regards to the production plant.

All major process equipment is plant dedicated, meaning it is selected, dimensioned and manufactured only for a given plant. The level of process integration is high and the process has many internal circulations and several connections to the soil, water and air because of the side flows. This leads to an increasing demand for the management of environmental issues.

Dealing with renewable raw materials offers an extra challenge when compared to the processing of non-renewable ones. Non-renewable raw materials, such as metals in ores, can be utilised at the mine as long the ore is rich enough. With renewable raw materials (e.g., wood) it is important to understand the growing conditions around the potential mill site, because in many countries the renewability cycle might be several decades.

There is a number of research papers focused on value creation chain in different industries, but they are mostly concerned with strategic decision making or an investment viewpoint, rather than solely with the process engineering or plant design angle. This paper combines value creation and engineering fundamentals in plant location selection. The research question is: What kind of connections are there between plant location selection and the long term corporate level value creation?

2 Literature review

There are research papers linking the value chain and the P&P industry from many points of view. These papers include topics such as the value creation in knowledge-based companies (Woiceshyn and Frankenberg, 2008), the relation between profitability and working capital in value chain framework (Viskari et al., 2011) and the cost and cost structure management through value chain (Anderson, 2006).

The P&P industry is energy and water intensive and those issues are always present. The long term scenarios until 2030 (Szabó et al., 2009) present a framework for these issues in general as well as of the situation in the USA (Heath et al., 2010). Energy issues also have a connection to the sludge and waste water treatment (Stoica et al., 2009). There is also a case study related to this issue from Sweden (Thollander and Ottosson, 2008), and an example covering the greening strategies of the Nordic P&P industry (Luukkanen, 2003). A novel angle of biorefinery energy overview is available in Moshkelani et al. (2013).

The management of the supply chain is a core factor for the profitability of production. The green values of it are presented in general in Srivastava (2007), the special challenges of North-European paper industry in Koskinen and Hilmola (2008) and the supply chain planning models to P&P industry in Carlsson et al. (2009). The renewability of raw material and sustainability has been discussed in Pulkki (2001), and the wider scope in a bio-economy frame in Van Dam et al. (2005). The supply chain challenges and strategies on a global level have been studied as well (Koskinen, 2009). There are also other viewpoints in supply chain managing, such as flexibility in the supply chain using coordination (Arshinder, 2012), option and capacity reservation contracts (Gomez-Padilla and Mishina, 2013) and the use of multi-objective optimisation (Karimi-Nasab et al., 2013).

There has been a study of corporate social responsibility and sustainable competitive advantage (Li and Toppinen, 2011) as well as of the social acceptability of P&P industry (Mikkilä, 2006). The customer relationship strategies in the global paper industry frame have been reported in Alajoutsijärvi et al. (2001) and the typology of for the strategic moves of Finnish paper industry in Rusko (2011). The service is an essential element of the value chain. The service orientation in the P&P industry has also been studied (Davidsson et al., 2009).

The environmental impact of forestry and the forest industry has a remarkable role in ensuring the long term raw material flow. The added value in forestry operations in Norway (Michelsen et al., 2008) sheds light on the production chain; the environmental life cycle assessment case from Sweden (González-García et al., 2011) has also been documented. The sustainability of forestry has become more important during the last decades. This issue has been studied by Vehkamaki and Backman (2011). Studies have been conducted of the ideas of environmental regulations in P&P investment (Harrison, 2002). Case studies from the USA cover the impacts of climate change policies (Ruth et al., 2000).

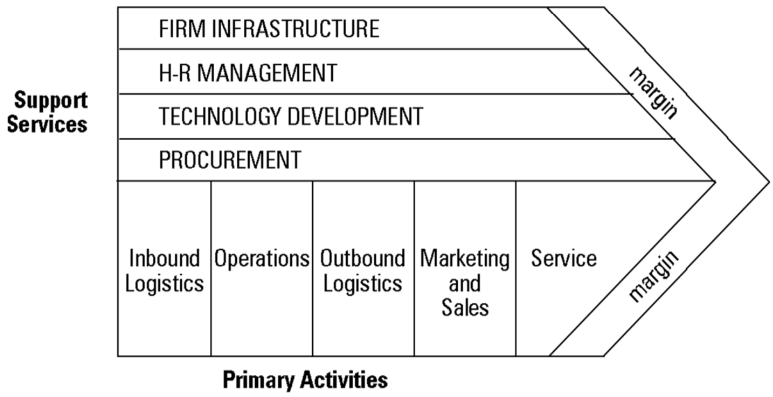
Technology itself is one of the core elements in plant design process. The role can be enabling (Van Horne et al., 2006) and it is converging technological environments (Karvonen and Kässi, 2011). The technology has a utilising role in processing renewable raw material (Narodoslawsky et al., 2008) and the biorenewables also offer opportunities towards next generation process systems (Marquardt et al., 2010).

Investment costs for novel P&P production plants are huge, depending on the capacity, these vary from 300 M€ to 1,000 M€. There is an optimisation methodology for the identification for uncertain process integration investments (Svensson et al., 2009) and the influence of the cyclicality of capital-intensive industries (Berends and Romme, 2001). The available operating time is important to the profitability of a plant. Garg et al. (2013) have studied this by applying the Weibull fuzzy probability distribution on the unit operation used in the paper industry. Case studies from the USA cover capital vintage (Davidsdottir and Ruth, 2004) and dynamics of material and energy use (Ruth and Harrington, 1997). Many case studies are located in China, where there are many novel investments to new capacity; the plantation-based wood pulp industry (Barr and Cossalter, 2004) and an analysis of supply-demand and medium term projections (He and Barr, 2004).

The P&P industry is very international today. Major companies own facilities in different continents and countries. The factors affecting location decisions in international operations have been studied (MacCarthy and Atthiawong, 2003), as well as integrating theories of international economics in the strategic planning of a global supply chain and facility location (Lee and Wilhelm, 2009), and the decision making for facility location using the PROMETHEE II method (Athawale et al., 2012). An academic framework for facility location evaluation has been reported and discussed (Xie et al., 2010), as well as a decision support system for locational analysis in paper industry (Braglia and Gabbrielli, 2012). There is also an application of an analytic network process for the selection of a plant location (Anand et al., 2012), and case studies of successful location strategies and their operational effectiveness (Smith and Clinton, 2009).

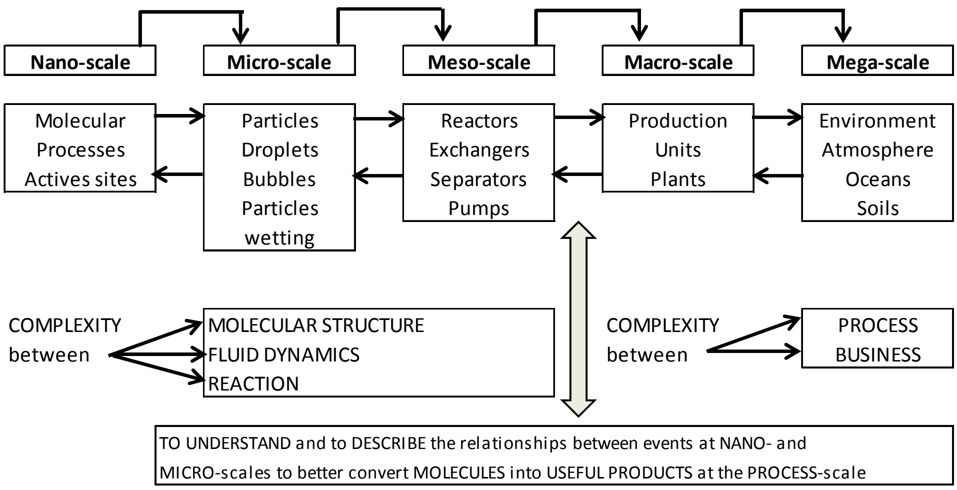
Figure 1 illustrates the classic value chain by Porter (1985).

Figure 1 The value chain



Source: Porter (1985)

Figure 2 Scales and complexity levels in process engineering



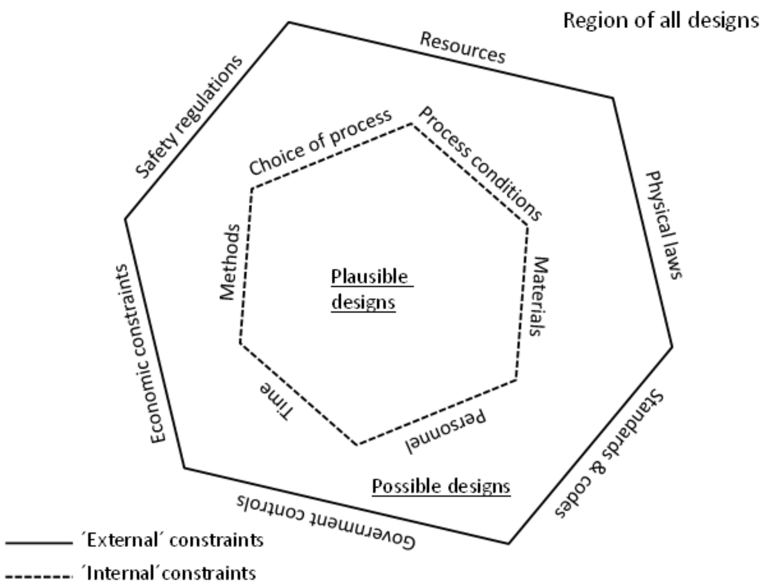
Source: Charpentier and McKenna (2004)

The path from micro-scale understanding of the phenomena into a production scale plant is shown in Figure 2. This scale-up management is a huge challenge for process engineering. Plant design constraints are shown in Figure 3.

3 Research frame

Before the connections between plant location selection and the long term corporate level value creation can be discussed, the relevant connections must be identified. In this paper the elements of Table 1 were added to the value chain model by Porter in Figure 1. The result is shown in Figure 4 which illustrates the research frame of this paper.

Figure 3 The plant design constraints



Source: Sinnot (1999)

Table 1 The elements of the chemical engineering plant location and selection

1	Location, with respect to marketing area
2	Raw material supply
3	Transport facilities
4	Availability of labour
5	Availability of utilities: water, fuel, power
6	Availability of suitable land
7	Environmental impact and effluent disposal
8	Local community considerations
9	Climate
10	Political and strategic considerations

Source: Sinnot (1999)

Porter's value chain model actually has basic aspects regarding the investment phase (support activities) and the production or operating phase of the plant (primary activities), Figure 1. In this case it is very difficult to focus only on those two activity sets. Because of the structure of the plant and the long life span there are also interactions which cross both sets of the activities.

In Figure 4 the most important direct and indirect interactions between different activities and their directions by arrows are presented. The arrows show the most important direct links between the elements of the value chain and the plant location principles. The dash line arrows show the indirect relations between the activities. The numbering in Figure 4 links the content to the sections in the following discussion.

Figure 4 The synthesis of the research frame implemented with the most important direct and indirect interactions between different activities and plant location rules (see online version for colours)

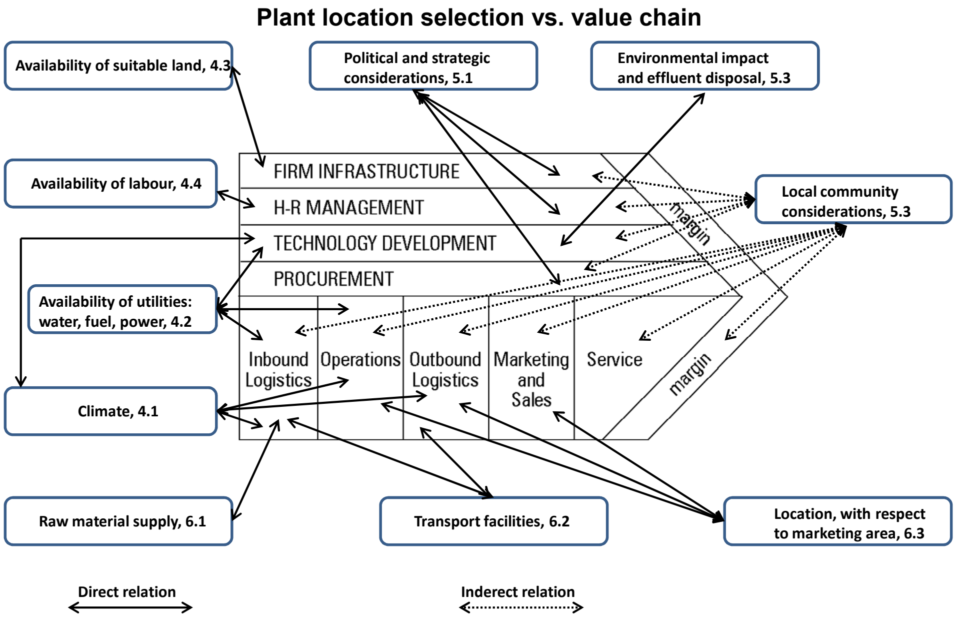


Table 2 shows as an example the cost composition of bleached hardwood Kraft production.

Table 2 Cost composition of bleached hardwood Kraft pulp in 2004, in US$/ton, CIF Europe

In US$/per t	*Brazil*	*Indonesia*	*US South*	*Portugal*	*Canada East*	*Finland*	*Spain*	*Global average*	*Average*
Wood	71	102	128	188	158	243	219	132	155
Chemicals	28	17	37	59	30	38	41	33	35
Energy	10	14	23	6	24	2	11	14	13
Variable costs	*109*	*133*	*188*	*253*	*212*	*283*	*271*	*179*	*203,5*
Labour	8	13	40	49	50	41	49	30	35
Maintenance	12	13	31	22	23	16	19	18	19
Other mill costs	24	25	50	37	35	19	36	31	32
Fixed costs	*44*	*51*	*121*	*108*	*108*	*76*	*104*	*79*	*87*
FOB mill	*153*	*184*	*309*	*361*	*320*	*359*	*375*	*258*	*294*
Ocean freight	44	37	53	18	73	38	26	43	42
Marketing and sales	17	12	10	5	7	8	15	12	11
CIF	*214*	*233*	*372*	*384*	*400*	*405*	*416*	*313*	*346*

Source: Reinhard et al. (2010)

Table 2 shows the variations in operating costs in different countries. The biggest tolerances are in wood costs which in this case also include harvesting and logistic costs to the mill (the so-called round wood mill price). Chemical, energy and maintenance costs are mostly dependent on the produced tons. The labour cost variations are remarkable in different countries. This table does not include the capital costs which are reported to be 13% according to the Indufor Report (2012). Table 2 illustrates the value of operational costs.

The discussion is divided into three sections. Section 4 discusses the solid elements in plant location. Solid elements are practically impossible to change after selection. Section 5 discusses the political and environmental elements which could be expected to change several time during a plant's life span. Another characteristic of said elements is that new decisions are made by international, national or regional authorities outside the operating company. Section 6 focuses on business environment variables which have direct influence to plant profitability. In the detailed discussion the elements from Table 1 are linked to different positions of Porter's value chain by *bolded text*.

4 Solid elements of plant location

4.1 Climate

Climate has direct impact to chosen *technology, operations and logistics*. With regards to technology, the climate might affect the equipment and pumping materials, especially if the annual temperature difference is high. As an example, in Finland the outside temperature annually varies between –40°C to +40°C. The climate has the same effect on the operations section as well. Which parts of the process must be indoor and how much energy can be used to non-process-based room heating? The demanding climate conditions are always a huge challenge to the reliability of logistics. In certain parts of the globe preparation for earthquakes, tsunamis and other major accidents also needs to take place. What will happen with global warming in the long term? In some cases in cold climates there is also a possibility for converting extra heat from the production plant into the form of district heat in order to sell it to the municipal or private partners.

4.2 Availability of utilities: water, fuel, power

The process plants are not only capital intensive but they also need huge amounts of water, fuel and power to be able to execute their production operations. The water itself is required for many processes and almost all processes need water for cooling and cleaning. The energy demand varies considerably between different types of processes, from high energy demand-ones (mining and mineral refining) to self-sufficiency (chemical pulping). Some processes produce extra energy, but despite this, during the operating time, the basic energy availability is essential to situations where the major process is down or is in a start up phase. For power transfer, a reliable grid is needed, as well as the possibility of a flexible connection between the plant's internal grid and the commercial basic grid. The availability of utilities has an impact on chosen *technology* and thus it affects the *operations* too. The limited availability of utilities causes increased volume in the *inbound logistics*.

4.3 Availability of suitable land

The availability of suitable land includes elements of every subtitle in this discussion section. It is a complex optimisation task to solve, but normally the basic infrastructure-linked utilities and the distance to raw material sources are the most important factors. Even if all elements are present it does not necessarily mean that the land is suitable for the plant. The characteristics of the soil are crucial, as well as the options for future expansions of the plant. What are the future trends in town and country planning in this selected area? Is it possible that in the future the plant will be located in the middle of the community, which might cause problems in logistics and surely will have an effect on the safety regulations? The above mentioned issues are challenges to the *firm infrastructure* at least at the site level.

4.4 Availability of labour

The modern process plants do not need much labour anymore. One reason is the increased level of automation in the processes where in the normal operation conditions the whole system can be managed with only a few operators. For several decades there has been an outsourcing trend in the process industry, which has decreased the amount of companies' own staff. Many essential services are purchased from independent specialised companies. Despite this process operators, process engineers, internal R&D experts, quality control staff and many other professionals are needed. Practically every process is unique, which means that even the well-educated staff from different educational levels (vocational schools, universities, etc.) must have a special training period organised by the host corporate or equipment/process provider. All this is a challenge for *human resources management*.

The globally growing markets in P&P business are in the emerging countries, especially in the so-called BRIC countries, Brazil, Russia, India and China. These markets and countries are different from each other and cannot be assigned to the general category of 'emerging countries'. However, they are different from developed Western markets and countries as well, and therefore at the minimum the underlying drivers should be taken into account. When it comes to the availability of educated, competent labour, it should be taken into account as one critical factor in establishing a business to a new area from the market or raw material point of view. If the school system is developed and recognised, and all levels in the educational system in place, getting professional, competent people will be possible. Process and product specific training will be arranged in any case by the company.

Table 2 shows variations in labour costs, but in most countries the labour union normally stabilises the salaries inside the country.

5 Political and environmental elements

5.1 Political and strategic considerations

The predictability of global and national political regulations is difficult. To evaluate these is of course the important task of the corporate management and the board. Especially with the process industry, where the life span of the plant is several decades, this evaluation is fundamental. This phase should also consist of criteria for future changes, not only in politics, but in the aspects of world economy related to strategy as well. What will happen to the profitability of a new production unit with expected trends in energy pricing, increased regulations concerning environmental issues, or market behaviour? Is land ownership in the planned harvesting region clear and transparent? This could be based on rent or very fragmented private ownership, and changes in these are to be expected. This issue touches *firm infrastructure, procurement* via heavy investments and the level of the purchased *technology* directly. Assessing the forthcoming changes in the world's economic situation, e.g., the change of the centre of growth from the West to the East, is a task for the corporate management and the board.

5.2 Local community considerations

The local community considerations have become more and more important with globally increasing green values. Heavy process plants do not have a good reputation at the present. Many local inhabitants have NIMBY ideas (not in my neighbourhood). Vice versa process plants still have remarkable importance as employers and a new plant usually also boosts local service networks (transportation, maintenance and other plant internal services), an issue linked to the corporate level *procurement*. Normally one industrial job provides a basis for three to five other jobs in the same area. This means a positive impact to municipal economy from salary taxation of staff added by possible annual company taxes in the form of *margin.*

The requirements to the community from the company are diverse. One of the most important is the town and country planning which should also enable the future expansion of the product plant. The availability of skilled work power might need new arrangements in local vocational education and training. In any case, most of the interactions are indirect but the cumulative impact of them is crucial.

5.3 Environmental impact and effluent disposal

The environmental impact and effluent disposal considerations phase starts long before the final site selection. The long term connection to the supply chain occurs through *technology* but in the production the *operations* is the relevant connection. The legislation requires a specific environmental impact assessment where all major flows and side flow connections with water, soil and air should be determined. When a new mill is planned and technology is considered, the normal requirement is best available technology (BAT) or even BAT+. This means in practice, that the choice of technology has to lean on a long term operational improvement possibility. The assessment is in many cases done by an independent third party, such as a specialised engineering company.

6 Variable long term value creation elements

6.1 Raw material supply

In most cases the production plant is located close to the raw material sources. This is a benefit to the *inbound logistics*. The product yield of the process line is never even close to 100%, actually the yield from round wood to the pulp is about 25%, measured in dry solids. This emphasises the need to optimise the inbound logistics, as is done in the mining industry.

The short rotation, short fibre raw material (eucalyptus) resources of South America have created a noticeable chemical pulp industry to Uruguay and Brazil. The rotation time of eucalyptus is six to eight years compared to the 30–40 years of birch and 40–60 years of long fibre softwoods, i.e., spruce and pine in the Nordic countries. The shorter rotation time reduces the price of the raw material markedly. In addition, development in paper making technology makes it possible to use less of reinforcement pulp, i.e., long fibre pulp, and higher amounts of short fibre. However, as the market for paper and print products there is not big enough, most of the pulp is exported to areas where there is a need for fibre, e.g., China.

On the other hand mainland China has very limited forest resources. The shortage of wood raw materials is compensated by using agro raw material as a source for paper making fibres. There is an extensive non-wood fibre production in China. However, in this case the economy of scale is not working. The raw material sources (the fields) are highly distributed and logistics are not very well developed, which leads to a small mill size which is supplying a limited area. However, here as well the logic of being close to raw material does exist, even if economy of scale does not.

6.2 Transport facilities

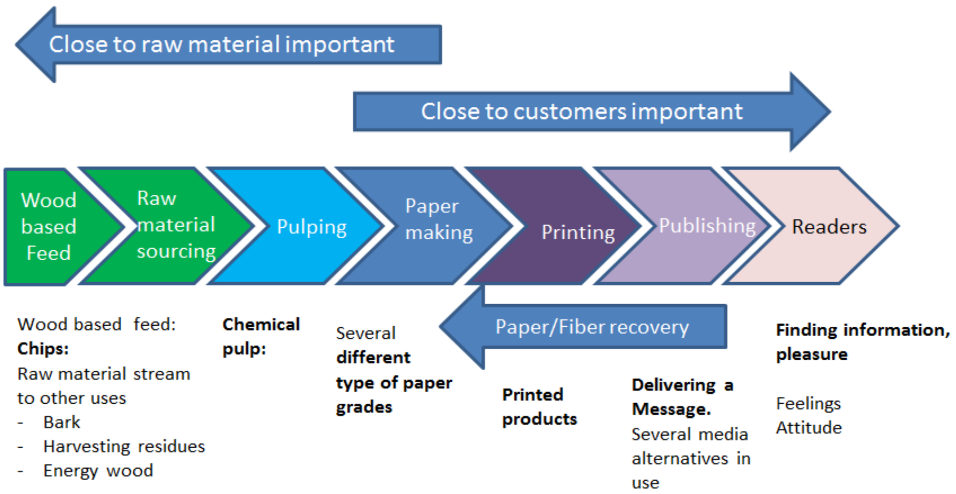
The plant location is a key element for both *inbound and outbound logistics*. In the optimum case, the new plant location is in the middle of huge raw material sources and at the same time in the middle of the market and end users. This equation is seldom realised. The outbound logistics take care of the added value product with a smaller amount of tons than the inbound logistics (typical ratio is 4 in and 1 out). The material flows are always huge and thus advanced transportation options (road, railroads and harbours) are required. The raw material flow is not the only important incoming flow to the production. Energy and many kinds of process additives, such as chemicals, are also needed for the production. The transportation facilities must be ready for use before the process starts up. There is enormous demand for inbound logistics during the plant construction period, including the installation of large scale core equipment.

These questions are relevant when production is geographically extended to new areas. Securing the existence of a logistic network, e.g., road, rail and sea network, and its condition and maintenance, is of high importance in this kind of industry.

6.3 Location, with respect to the marketing area

The process plants are generally located close to the raw material sources because of the reasons discussed above. Figure 5 shows the value chain of a traditional printed product. Colours in the figure illustrate the typical company boundaries in the value chain. In the path from forest to paper the product the value chain belongs to the forest industries in general, not necessarily to the same company. Printed products and publishing belong to media industry. The nature, actors and type of business environment are very different in these two businesses.

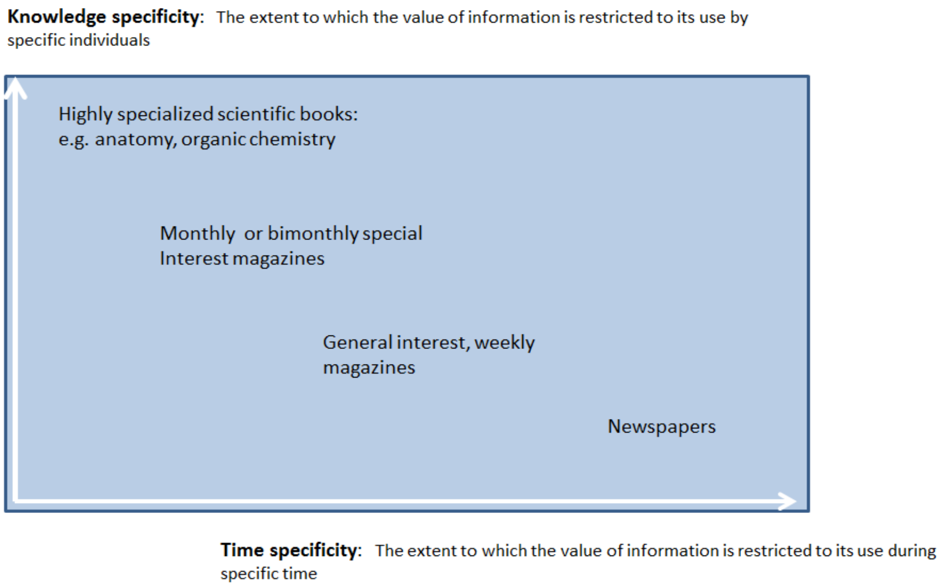
Figure 5 Value chain of a printed media product (see online version for colours)



Source: Modified based on the Porters (1985, 1990) models of value chains

However, some process plants can be located inside or pretty close to the market area if they are using recycled raw material or if the nature of the product is such. Figure 6 illustrates the nature of the information specificity of different printed products. Information specificity is the extent to which the value of information is restricted to its use and acquisition of the information is limited to certain individuals or during a specific time period (Jernström, 2000; Sampler, 1998).

Figure 6 Specificity of the information content of a printed product (see online version for colours)



Source: Modified based on Jernström (2000) and Sampler (1998)

When time specificity is high, as with the news/newspapers, the printed product is produced close to consumers/readers. In these products, information content is very dependent on short delivery and accurate timing. The supply security of raw materials – one of the critical ones being paper – is of utmost importance. Therefore paper mills are also often built close to the market. Whereas, if the knowledge specificity is high – typically professional and scientific books and magazines – the information is very specified and relevant only to few and typically not so time dependent. In these cases, being close to the market is not so important.

This kind of end-user approach also reveals the market stability or vulnerability. Printed products having high time specificity are easily substituted with electronic media. This can be seen in the quite strong decline in the newspaper demand figures during the past decade. Publishers typically are making choices between different media channels based on how efficiently they can deliver the message. In the case of the newspaper, fast delivery of information and readers' access to electronic media has favoured the format change and caused losses for print on paper. Porter's value chain in its original form, in Figures 1 and 4, does not emphasise the importance of understanding forthcoming changes in end-users' business and technology.

Another reason for being close to the market can be raw material supply. Examples of these kind processes are paper mills using recycled fibre, and steel production facilities using recycled steel as a raw material. The location has direct relations with *marketing and sales, outbound logistics and operations*.

7 Summary

The discussion in this paper shows that the value chain model is a useful tool in the identification of interactions between the value chain and plant location selection elements in the process industry.

The value chain introduced by Porter has been used to determine and explain the value creation in different industries during the last decades. Porter's value chain was also selected as a basis for this study, implemented with principles of plant location selection. This combination was the research frame for the identification of interactions. The connections and their directions were divided into two categories; direct and indirect, with the directions of interactions also being determined. This approach is suitable for covering the special characteristics of P&P industry.

This paper has focused on the so-called green field plant location selection process, where all elements have to be considered. Investments to existing production plants are of different nature but most of the discussion and findings are useful there as well.

The primary task was the mapping of connections between plant location and long term strategic value creation in order to cover the expected life span of a production plant. This paper uses three different characteristics to achieve this goal. The first characteristic is called the solid elements in plant location, which are practically impossible to change after once selected. The political and environmental elements represent the second characteristic and time level; thus they are expected to change several times during a plant's life span. These are typically external regulations for the companies provided by international, national or regional authorities outside the operating company. The third characteristic set included business environment variables which might change very fast. The discussion section is also subtitled according to this above described system.

This case shows that the plant location selection locks most of the internal value creation variables. This paper does not discuss the external variables, such as product market prices and the external utilities which have to be purchased to operate the production facility. However, in business to business industries such as printing papers, the changes in the environment of the customers' customers, as shown in Figure 5, can have a dramatic effect on the requirements, consumption and pricing of the product, as briefly mentioned in the paper.

The case study of P&P industry emphasises the importance of knowing the expected trends in the end-user's reading habits in addition to one's own business and technology. These changes can accumulate and be a driving force for structural changes in a whole industry field, which can be seen in the market development in printing papers.

The most important finding was the impact of the long term availability and expected price development of raw material. The important question is how can the operating company ensure the availability and price of the raw material in the long term?

The second important factor in decision making was technology, as it determines the ability to meet the quality requirements of the customers. Typically in the P&P business, the process is a unique combination of equipment which allows only very limited possibility to customising of products. In many cases it is possible to upgrade the process by debottlenecking to increase production capacity. Usually these kinds of investments are carried out to ensure the long term economical competence by decreasing the production unit price. This kind of incremental improvements are the dominant way to implement innovations in industries known from their capital intensiveness.

An interesting topic for future research would be to compare P&P companies based on detailed analysis of economical variables, including the comparison of essential cost types such as energy, raw material, logistics, work power and investment costs and the strategic choices of the companies in different cases, e.g., European and North American P&P companies.

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PUBLICATION III

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A tuned value chain model for university based public research organisation. Case LUT CST

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A Tuned Value Chain Model for University Based Public Research Organisation. Case Lut Cst.

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Abstract

The Porter´s value chain model was introduced for strategic business purposes. During the last decades also Universities and University based institutes have started to use actions similar to private business concepts. A University based institute is not independent actor like company but there are interest groups who are expecting them to act like they would be. This article discusses about the possibility of utilize tuned value chain to public research organizations (PRO). Also the interactions of tuned value chain model to existing industrial network are discussed. The case study object is the Centre for Separation Technology (CST) at Lappeenranta University of Technology (LUT) in Finland.

Keywords: value chain; public research organization; research collaboration.

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Background

From direct technology push we have moved through knowledge era (Landry et al., 2006) to innovation methodology (Hansen and Birkinshaw, 2007). The importance of implementation value strategy through the value chain has been studied (Walters and Lancaster, 2000) as well as market aspects of the same thing (Grunert et al., 2005). Mathematical models have been created to define value chain (Ropera et al., 2008).

There are lots of research papers about the nature of public research organizations (PRO) and their relations with industry. The research covers many angles from ethical dilemmas of university-company collaboration (Kenney, 1987) to the university research collaboration (Starbuck, 2001) in general, case study from Germany (Rohrbeck and Arnold, 2006) in selected industry and technology transfer (Lee, 1996).

The profile of public laboratories (Joly and Mangematin, 1996) gives good background as well as paper concentrated to public research organization and knowledge infrastructure (Dalpé and Ippersiel, 1999). Many institutes are operating like private companies (Etzkowitz, 2003) or business units but there are some differences.

The value chain plays also role in quality and innovation systems (Prajogo et al., 2008). University-company relations are today linked as part of the innovation system (Perkmann and Walsh, 2007) and also vice-versa situation in university-company relation has been studied (Orlikowski and Barley, 2001). The impact of transaction costs of collaborative academic research has been studied (Landry and Amara, 1998) and the impact of knowledge transfer from public research organization (Gardner et al., 2010).

There are research papers covering the role strain (Boardman and Bozeman, 2007), effective university-industry interaction (Barnes et al., 2002), market approach (Mindruta, 2008) and research collaborations of university research centers (Boardman and Corley, 2008). The development of university-industry collaboration has been interest area for research (Santoro and Betts, 2002) as well as the processes and performance in this relation (Johnson and Johnston, 2004).

Innovation approach is studied a lot in this environment. The links between customer relationships of PRO and technological innovation (Nordberg et al., 2003), importance of boundary crossing (Kaufman and Tödtling, 2001) and the impact to regional innovation system (Fritsch and Schwirten, 1999).

Many investigations of PRO´s impact on the national level in Finland has been executed like the transition of public research and technology organizations (Loikkanen et al., 2011) and the evaluation practices in public research organizations (Lähteenmäki et al., 2006).

Because the interest of this study is closely linked to chemical engineering (and any other capital intensive industry where the actions are similar) the studies of Kannegiesser (2008) are essential.

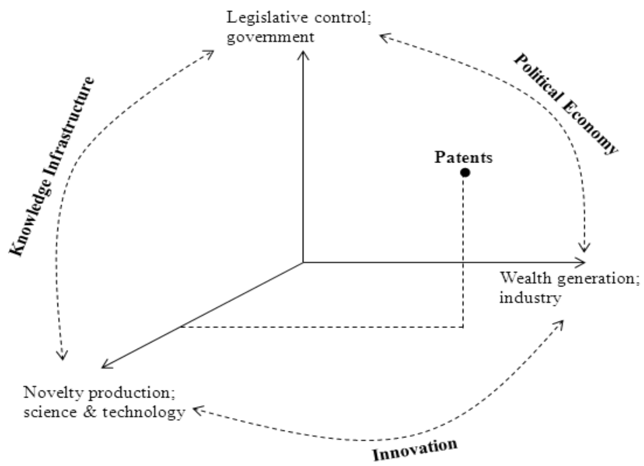
Bin and Salles-Filhoa (2012) studied the contributions to a methodological framework in science, technology and innovation management and an interesting case study from Brazilian university where the focus was orientation towards sustainable innovation is reported by Löbler et al. (2012).

Research framework

It is widely recognized that technological innovation plays a central role in the long-run economic growth of a social system and that emerging technologies. The Triple Helix model, theorized by Etzkowitz and Leydesdorff (Leydesdorff and Etzkowitz, 1996), suggests that in a knowledge-based society the boundaries between public and private sector, science and technology, university and industry are increasingly fading, giving rise to a system of overlapping interactions which did not previously exist. In practice the model is seen for example as universities are performing tasks that were formerly assigned to firms and vice versa. While the academic work is being redirected towards commercial applications, industry-university collaboration is becoming a critical issue; and wider industrial and political interests are integrated into the planning and organization of university research. The Triple Helix thesis states that the university can play an enhanced role in innovation in increasingly knowledge-based societies. Therefore academic researchers have to take into account the impacts of the scientific outputs of their work onto industry, and at the same time researchers working in industry need to be up-dated on the evolutionary developments of science. (Leydesdorff and Etzkowitz, 2000; Ughetto, 2011)

Patent markets can be considered as an example in terms of three coordination mechanism because of the "social contract" implicit in the patent system. In Figure 1, patents are considered as positioned in terms of three coordination mechanism of 1) wealth generation on the market by industry, 2) legislative control by government, and 3) novelty production by academia (Leydesdorff, 2012). Whereas patents are output indicators science and technology, they function as input into economy as others can learn from it and improve upon it. Their main function, however, is to provide legal protection for intellectual property. Leydesdorff, 2012 presents patents as events in a knowledge-based economy

Figure 1: Patents as events in the three-dimensional space of Triple Helix interactions (Leydesdorff, 2012)



which can be positioned in this three-dimensional space of industry, government and academia (Figure 1).

Naturally, the Triple Helix model does not exclude focusing on two of the three dynamics -for example, in studies of university-industry relations. However, one can expect more interesting results by studying the interactions among the three sub-dynamics or the third dynamics should at least be declared as another source of variation. (Leydesdorff and Etzkowitz, 2000)

Value chain approach

Michael Porter introduced value chain model (Porter, 1985). The classic Porter value chain approach is suitable for many industrial processes and manufacturers. Porter himself has reported of case studies carried out in different industries of his strategy and value chain. The value chain model can also be used for service companies because the basic elements are similar to industry.

The classic Porter model shows the value chain in original format, Figure 2.

Institutional frame; Case study public research organization

The Lappeenranta University of Technology - LUT

The Lappeenranta University of Technology (LUT) is founded in 1969. LUT has three faculties; technology, technology management and school of business. LUT has about 5000 undergraduate students and 930 staff members.

The strategic areas of expertise are following; energy efficiency and energy market, strategic management of technology and business and scientific computing and modeling of industrial processes. The fourth is expertise in Russian affairs related to the LUT´s areas of expertise.

The Centre for Separation Technology - CST

Lappeenranta University of Technology (LUT) hosts the Centre for Separation Technology (CST) which is a co-operative institution (founded in 1997) that integrates the expertise in Separation Technologies mastered by several laboratories and research groups at LUT Chemistry (Department of Chemical Engineering).

The research at CST aims at a multilevel approach covering molecular, unit operation and process levels. The molecular approach is represented in chemistry and analysis which give the solid basis to other level actions. In the unit operation level CST has focused on membrane filtration, solid-liquid separation, crystallization, ion exchange, chromatographic separation methods and extraction. On the process level CST has expertise in process intensification, simulation and systems engineering which all are required when connecting unit operations to the form of production processes. Of course, the deep understanding of chemistry and analytics gives the LUT CST tools for phenomena based research.

The research within CST is genuinely multi-disciplinary and applications of separation technologies are studied at CST can be found widely in the industry. However, regardless of the application field, the different technologies are based

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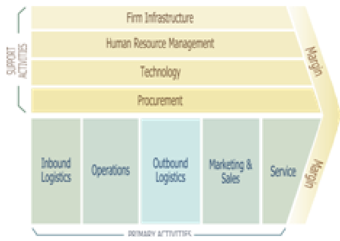
Figure 2. The value chain (Porter, 1985).



on the same basic principles and the deep understanding of chemistry and analytics. The expertise of LUT CST is based on the LUT Department of Chemical Engineering. The total staff of the department is about 85 including 10 Professors, about 50 researchers and 15 persons as technical staff.

The structure of CST is unique inside LUT organization. CST has today 25 member companies from different industries. During the last years CST has also expanded the international research member network and today the total amount of research members is 14.

The Centre for Separation Technology has three strategic research impact areas. The first is material efficiency which means better yield from low-grade raw materials with less side flows. The second is development of energy efficient processes to the improved use of internal energy in processes. The third one is water especially different kind of treatments for raw water, process water circulation and waste water purification. The above mentioned impact areas are directly linked to LUT strategy.

Collection of empirical data

Public research organization should create added value to whole society and in this case the primary target in it is the member network of LUT CST.

The scientists have of course their own idea what this added value should be and usually it is top level academic research which leads to the dissemination of the results to the high quality academic journals.

The added value is even more difficult to measure. LUT CST executed an enquiry to the members in the spring 2011. The material is shown in appendix 1. The motivation to this enquiry was to ensure the expectations of LUT CST members and to develop activities based on enquired facts.

What are the expectations? In this study the most important question in the enquiry was number 4; "What of the following subjects are most crucial subjects to be developed in the near future in the LUT CST to create added value to your company or research institute?" The results were introduced to the Board of CST in May 2011 and the subjects mentioned below where discussed.

The data is relatively small but the answerers are in the top positions in their private organizations like CEO, CTO, R&D-director level etc. The answerers from research and academic world are mostly Professors and Heads of the departments. In this case study the data is based on excellent expertise and long term personnel history in this field.

The five most important subjects were:

1. Innovativeness. The industrial partners expect to get novel openings from the University. Because of the complexity of many processes it is not anymore possible to solve existing and coming problems only by using one separation method or unit operation to this task.
2. Research collaboration in general. This means active collaboration with the R&D departments of member companies.
3. International networks. Industry is expecting to see international collaborations between universities especially on the international level. To achieve the best results the links between the leading universities are required.
4. Collaboration between different research groups inside LUT. This message was clear. The research groups in LUT are relatively small compared to bigger universities. To tackle bigger tasks diversified expertise is needed. Also in many cases it would be relevant to combine experts from different research groups to study one issue.
5. Project development. In many businesses the R&D-funds are bounded in the budget to selected actions for next year. This is challenge to PRO to inform all industrial members of the novel project ideas in time. Also the delay in getting partial finance agreement from industry has increased. All would like to have time enough to fit these requirements to annual planning.

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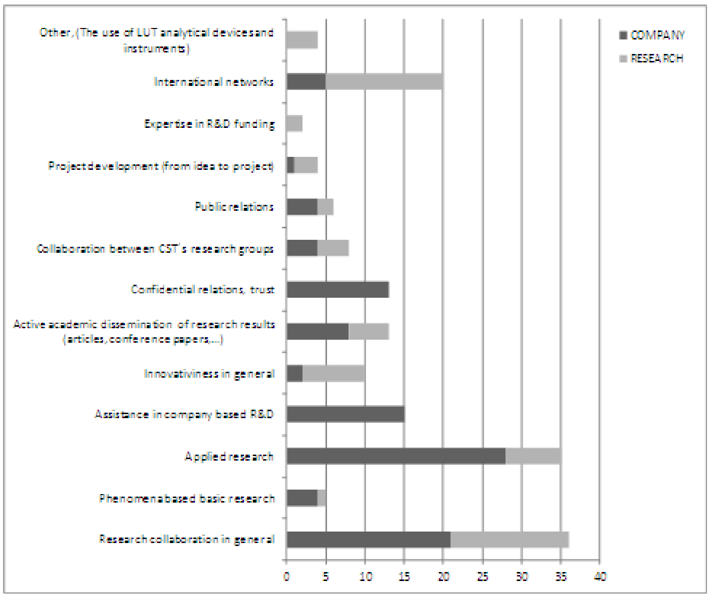
Figure 3. The results of the LUT CST member enquiry. (Appendix 1).



Analysis

Because the value creation is the focus for every PRO it was natural trying to transfer the results of the enquiry into familiar form of classic business management tool. In this case the classic value chain model by Porter was chosen to this purpose. This model is not novel but it is simple. There is also embedded characteristic which helps PRO to fractionize it´s activities to different parts. The support activities are mostly taken care by the host university but the primary activities and optimizing is interesting.

How this frame suits to university based research institute where the "brains" is the core factor in production and processes in creating new research results vary a lot case by case? Some examples of differences: procurement and inbound logistics are closely related to raw material and subcontractor management which are not the core activities in scientific work. The product of research is merely non-physical and thus there is no need for outbound logistics.

The "reason to live" function of private company is to create margin and profit to the share holders. In state university like LUT margin or profit is suitable but the success of the institute is mostly measured by academic results (articles, conference papers, master graduates, doctor graduates, etc.). Of course this basic academic function must be profitable enough to ensure continuous development.

The better description of the value chain to the academic environment needs the renaming of the original one. In Figure 4 it is shown the value chain of university based research institute in case study LUT CST.

Why to rename the Porter´s original value chain in Figure 2? The answer is clear. The goal is to localize this concept suitable to the academic world of technology research. To get more accurate picture of the value chain system to this case it is relevant to rename the subjects of the original Porter frame. Support activities:

Firm infrastructure. This is valid when we are discussing about independent companies but it does not cover the situation when research unit or institute is essential part of the university. That is the reason why the term research infrastructure is more relevant in this case. To the research organization this means more than firm infra alone. High level research needs modern research infrastructure. In this case, in separation technology research, the required equipment and instruments are related to chemical and process engineering and chemistry. It is easy to understand that it is very capital intensive to establishing and updating this kind of facilities. Facilities, maintenance of laboratory equipment and many other activities are organized by parent University.

The human resource management can be in this case replaced by expertise development and human resources management. To every expert organization the development of expertise is the core factor. Via new research it is possible to develop novel unique skills and expertise which are impossible to loan, borrow or simulate in the short term. This is the most important advantage to every expert organization. The quantity and quality of research power appear in the form of expertise of individuals. In the long run it is essential to develop the expertise of individuals to remain on the top level. On the other hand it is well known that management of expert organization to create innovative team spirit is challenging.

The administration is better term this case than technology. To achieve planned target in research oriented environment the administration (ICT, financial administration, legal advising activities related to IPR and contracts and other non-engineering support activities) are organized by parent University.

Procurement can be transferred into project funding arrangements. In many Universities (like in Finland in the field of engineering/technology research) every research unit has to get at least 50% of the annual budget out of the "free market". In practice this means national funding organizations, direct EU-funding and of course research subcontracting with the private companies. Practically it is project based and relatively short term (usually max. 3 years). This fact causes continuous need for project development and "idea selling" to partners and financers. This phase must be very proactive. Otherwise there might be lack of funding periods when it is impossible to keep the best experts in this institute. The delays in fund collection are long and hit rates are difficult to estimate.

Primary activities:

To the University unit the research is the most important thing. Because academic results are measured by the amount of the research the term inbound logistics is not needed. The primary activities process starts with the idea generation and development. As mentioned before the fundraising is essential and the success in it can be later measured by the amount of the refereed articles, international conference papers graduated masters and doctors is the core thing. To the service function to the industry this is also important because it gives to the institute or university scientific backup. Idea generation consist of development of novel research challenges into form of project theme. The basic ideas to this sub activity come both from researchers and industry where intensive networking and industrial collaboration is crucial and together they constitute idea portfolio. The industrial partners usually like to comment ideas and check the industrial relevance of new research themes. On the other hand this is important phase to preliminary negotiations to get partial financing from industry.

Research. Normally the research itself runs well according to the accepted research plan. The staff of LUT CST has excellent routine of this task. The role of the CST is merely to boost the task and ensure that research can be executed with modern equipment. The research can be categorized into the three classes by the publicity and IPR of the results: public, semi-public and industrial subcontracting. In the classic public research all results are public and the IPR belongs to the researcher and University. In the semi-public format industrial partners has usually to partial financing role which means that they have also limited rights to IPR. This case does not normally cause any limits to result dissemination.

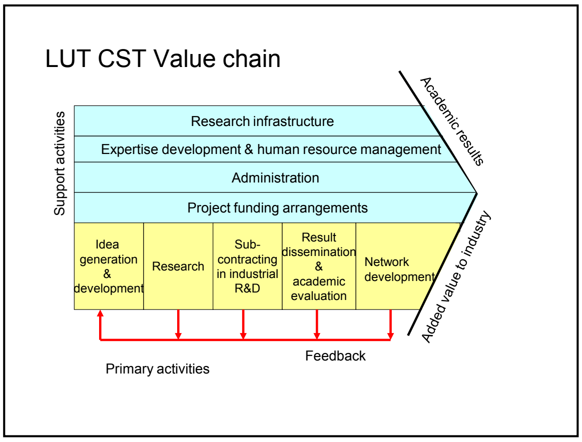


Figure 4. The tuned value chain model, case LUT CST.

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The research subcontracting role is demanding because the private company in the role as financier owns the IPR but in most cases dissemination process runs normally but sometimes there are some delays because of the simultaneous IPR process.

To the research unit in university the outbound logistics does is not relevant. The output of the research is mostly in "brainpower" which does not need a special logistics. The participation of industrial R&D as a subcontractor is more important term. This action creates new connection (measured by practical relevance of the research) and in the most cases it is possible to make also academic output out these studies. This research institute participates to industrial R&D projects as a subcontractor. Even these operations are based on the trust (usually close to novel IPR and business possibilities) it is normally possible to use this material also for academic publications. These actions are based on confidential relations and in most cases confirmed by bilateral agreement (company / LUT). One form of the subcontracting is technology transfer from basic research to applications.

The Porter´s function of marketing and sales are not familiar terms in many universities. As a University research unit it is important to take care of the academic development. In every case one university unit is not strong enough to cover all the needs alone. Especially with this case networking collaboration global science is more than expected.

The dissemination of academic credits in the traditional way is measured by the Ministry of Education in Finland. Of course this is a classic meter but today this is more and more important also for the industrial partners. For them it is a benefit to collaborate with an institute with high academic references because many industrial partners don´t have power enough to carry out basic research and in many cases it is not their role at all. They are merely interested in applied research which is close to the applications and profit. Result dissemination in academic scene is basic function of university. This task also implements the quality control function because as well known the top level research journals and international conferences wants to ensure the quality of the publications. Vice versa this action increases co-operation to the global academic world which supports networking.

The service action of the Porter´s original scheme can be substitute by network development. Today is relevant to say that any university can´t make top research without active international research collaboration. As well this section covers the interest group management (how to create added value to the existing network). Networks are connected to all elements of primary actions. It links together the whole process and adds all interest groups into the production. But it has also other functions. In many research challenges it divides the project into subprojects or tasks which can be carried outside LUT in CST member network. One form of the networking is public relations in form of CST Board meetings (three times a year) and CST Bulletin (four numbers out annually in PDF-format). Also hosting annual international workshops and seminars gathering scientists and participants from industry together evolve and boost the existing network and even expand it. One direction of the networking is financiers. CST likes to give preliminary information to them of future needs and trends in separation technology research.

In the Figure 4 the value chain output is not margin like in the original Porter figure but novel academic results and added value to industry. This formulation suits better to university based institute. The classic academic output in the case of LUT and LUT CST are research education and societal interaction. The nature of added value to the industrial partners is studied with an enquiry and the results are discussed later in this article.

The feedback operations

In the Figure 4 there is a feedback connection which shows the links between different operations on the primary action level. They can be described alone but actually primary actions create innovative processes where clear interactions between different actions can be found including the feedback effect. The feedback action varies case by case but in all cases it is crucial to use the information from the later steps in the beginning of the process. This is also one form of the quality control. This way it is easy to improve to performance during the whole process, learn from mistake and implement good practices immediately.

Vertical and horizontal connections of the tuned value chain

The value chain does not live independent life. It has connections both on the vertical and horizontal levels. In the vertical connection level; how does our value chain align vs. company value chain and R&D activities? LUT CST is dealing with many companies and industries. It is not simple to execute the vertical integration of LUT CST value chain into the all value chains of our member companies.

LUT CST member companies can be divided into the three categories. The first category is the technology providers (like Outotec in mining and metallurgy, Andritz and Metso in pulp, paper and bioenergy). They are companies who are offering both technology (knowledge) and process equipment to the customers. The second group is the process owners (like StoraEnso, UPM-Kymmene in pulp and paper business and Talvivaara in mining) who operate the processes but don´t themselves build the equipment. Of course the technological knowledge is always in the very important role in these cases. The third class is expertise provider (consultancy companies like Filter-Ability and Provenor) and other Universities and research institutes.

Discussion; from value chain to interactions in value network

To assume that all these three above mentioned categories are having their own value chain like Porter´s original (shown in Figure 2) what kind of interactions they will have to CST´s tuned value chain (shown in figure 4)?

The differences shown in the Table 1 base on following facts. Thinking about the original Porter´s value chain frame it is divided into the two kinds of activities, support activities and primary activities. This explains the different impact of CST impact on members´ value chain. In all cases the impact to the support activity technology and network development are obvious. In case of the effect to the primary actions the situation differs. To the technology provider it is more important to use novel research results (usually created together in common R&D projects) to boost the marketing and sales active where as the situation with process owners where it is more important to effect to the operations (to reach top quality with high operating time ratio). With expertise providers service is very important issue because this business needs the continuing renewal of expertise.

Vice versa. What is the feedback information from CST´s members and for what parts it is effecting in the tuned value chain model? The idea development is the common thing; it is good to get information of existing or coming problems of processes to get practical relevance for the idea development and titles for the new research projects. Project funding, subcontracting industrial R&D and network development are essential from technology provider and process owner categories. This offers possibility for continuous development and partnership; ideas can turn into the action. With member universities and research institutions it is possible (in most cases) to execute common public research projects which is not possible with industrial partners. In most case the IPR-case limits the so called classic free science.

There are many other research institutes and it is possible to have different opinions in strategic lines. This means that different research units can be seen like strategic business units (SBU). It is important to create a real connection between LUT level strategy and to value chains of separate units to avoid confusion.

One way to develop this vertical integration is the segmentation. Is it possible to use the service packaging of CST

Category	Input to CST	Output from CST
Technology provider	Idea development Project funding Subcontracting industrial R&D Network development	Technology Marketing & Sales
Process owner	Idea development Project funding Subcontracting industrial R&D Network development	Technology Operations
Expertise provider	Idea development Research Network development	Technology Service

Table 1. The interactions and targets between CST´s tuned value chain and Porter´s original format of CST´s members.

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expertise and create different impact for members dealing with different business? This action would offer more specified and more business oriented touch to members. The threat is to lose at the same time the role in technology transfer from one business to other. Actually the rate of integration is interesting. Is it possible to develop model which will deepen the collaboration and at the same time clarify the roles of university and member company R&D department?

One solution (in principle) is to segment members by geographical means. This is not relevant option in so small country like Finland. In most cases the most important R&D centers are still located in Finland even many companies are global players.

Conclusions

The classic Porter value chain includes all those elements which are adequate also for research organization. The importance of elements vary in this case compared to traditional industrial or service company and thus the renaming of those elements helps to get the right scope of support and primary actions. Of course depending of the research field there might be a need to create variations based on the tuned value chain model introduced in this paper.

It is clear that value chain model is useful also to other research institutes not only to this case study object. It is a tool in the strategic planning and management to keep the actions in the focus.

In the tuned value chain the feedback operation linking primary actions helps to understand the research as a process. The output of the process has usually more value than only the academic one. This emphasizes the total research impact.

The output of the value chain is interesting in this case. It can be measured by classic way via the academic output (research, education, societal interaction). The more interesting window opened by analyzing the results of CST member enquiry about the expectations of added value. The industrial partners expect to get following benefits from PRO: innovativeness, research collaboration in general, international networks, collaboration between different research groups inside LUT and project development.

Combining tuned value chain with the "original" value chain it is possible to describe the effects in value chain network; which actions/operations are creating input/output effects and where. In this paper three level approaches were used by categorizing members into the groups; technology provider, process owner and expertise provider.

Finally the results of LUT CST external member enquiry was discussed in the value chain frame.

The tuned value chain model looks to be important tool in understanding the basic function of research institute. It also helps to define the most important information transaction in generation the added value.

The future research needs based on this paper can be divided into two categories. It would be very interesting to study the suitability of this tuned value chain model in with some other research institutes.

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APPENDIX

The background of this enquiry:

Number of answers:
- industrial members, 8 (34 % of all industrial members)
- research members, 7 (58 % of all research members)
- Totally 15 answers which covers 43 % of all members

Sources of errors in this enquiry:
- Was the contact person in member company/institute relevant?
- How well the answerer knows the whole situation on behalf of the whole organization?
- Limited number of answers (absolute amount) but tolerable in per cents

LUT CST / ENQUIRY TO CST MEMBERS TO DEVELOP OUR ACTIVITIES			
FOR CST MEMBER COMPANIES AND RESEARCH INSTITUTES			
Plese answer to following questions. It will take only about five minutes.			
Your answer is important to us - it gives us ideas how to develop our activities.			
1. Collaboration with LUT CST. Our company / institute has collaborated with			
following expertises / research groups. Please select five most important,	**ALL**	**COMPANY**	**RESEARCH**
(5=most important, 4=second, …)	**ANSWERS**	**MEMBERS**	**MEMBERS**
	TOTAL	**TOTAL**	**TOTAL**
Chemistry, analytical chemistry	17	11	6
Chemometrics	2	2	0
Crystallisation	6	6	0
Advanced water treatment / PCD	10	8	2
Solid-Liquid Separation / Filtration	28	21	7
Membrane technology and polymer chemistry	20	14	6
Industrial Chemistry	8	8	0
Cromatographic separation	0	0	0
Physical chemistry	0	0	0
Process intensification, plant design	11	4	7
Systems Engineering	12	1	11
Fiber- and paper technology	17	8	9
2. What are the core expertises of CST needed in your company / institute in next 5 years?			
Please select five most important, (5=most important, 4=second, …)			
Chemistry, analytical chemistry	19	11	8
Chemometrics	3	3	0
Crystallisation	9	4	5
Advanced water treatment	12	6	6
Solid-Liquid Separation / Filtration	36	29	7
Membrane technology and polymer chemistry	39	25	14
Industrial Chemistry	12	11	1
Cromatographic separation	4	1	3
Physical chemistry	2	2	0
Process intensification, plant design	19	4	15
Systems Engineering	16	4	12
Fiber- and paper technology	17	5	12
3. What of the following subjects are working well in LUT CST creating added value			
to your company / institute. Please select five most important, (5=most important, 4=second, …)			
Research collaboration in general	36	21	15
Phenomena based basic research	5	4	1
Applied research	35	28	7
Assistance in company based R&D	15	15	0
Innovativiness in general	10	2	8
Active academic dissemination of research results (articles, conference papers,…)	13	8	5
Confidential relations, trust	13	13	0
Collaboration between CST's research groups	8	4	4
Public relations	6	4	2
Project development (from idea to project)	4	1	3
Expertise in R&D funding	2	0	2
International networks	20	5	15
Other, (The use of LUT analytical devices and instruments)	4	0	4
4. What are the most crucial subjects to be developed in the near future in CST?			
Please select five most important, (5=most important, 4=second, …)			
Research collaboration in general	24	12	12
Phenomena based basic research	5	4	1
Applied research	14	9	5
Assistance in company based R&D	14	11	3
Innovativiness in general	27	20	7
Active academic dissemination of research results (articles, conference papers,…)	16	7	9
Confidential relations, trust	3	3	0
Collaboration between CST's research groups	19	14	5

PUBLICATION IV

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