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High-Tech Commercialization Research Projects: A Pragmatic View

Master's Thesis

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ABSTRACT

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In the Finnish university society the commercialization research projects has not been a focus of interest until now. The reasons for the growing interest towards commercialization research projects are their possibility to develop our economy simultaneously by providing new technologies and products. This study focuses on the examination of what kind of high-technology oriented research can be commercialized and how. The aim is to generate understanding of how commercialization research projects should proceed and to find concrete ways of improving the of commercialization research projects.

As its research method, the study analyzes four different university high-technology research projects which have been commercially oriented and have to some degree been able to commercialize the product or technology developed during the research phase. The data has been gathered mainly by semi-structured interviews of people involved in these particular projects or cases. The findings from the interviews have been reflected to the final reports of the projects, provided by TEKES, and later on the data gained has been compared to each other. Also a literature review has been produced about the subject of commercializing university research with the purpose of providing known theories and framework connected with the subject.

The study reveals five main factors related to commercializing high-tech research. These factors are: *The Team, Market potential and competitiveness, Product and technology*, *Funding* and *Steering Group*. Also the uncertainties related to these factors have been addressed. As a conclusion the study provides the main aspects that should be considered when starting a commercialization research project. Also a combining hierarchical framework has been provided related to the five factors presented. In Chapter 5 the study addresses the main tasks or steps to be taken in order to get public funding for a commercially oriented research project and later on the actual steps to be executed in order to successfully commercialize these high-tech research projects.

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Suomalaisessa yliopistokulttuurissa kaupallistamisprojektit ovat vasta tällä vuosikymmenellä herättäneet kiinnostusta. Suurimpina syinä kaupallistamisprojektien kiinnostavuuteen ovat niiden mahdollisuudet korjata ja kehittää taloutta samalla tuoden uusia teknologioita ihmisten käyttöön. Tämä tutkimus keskittyy tarkastelemaan miten ja minkälaisia yliopiston tutkimuksesta kumpuavia teknologioita voidaan implementoida onnistuneesti halutuille markkinoille. Tarkoituksena on kehittää ymmärrystä ja löytää konkreettisia tapoja parantaa kaupallistamisprojektien onnistumismahdollisuuksia.

Tutkimusmetodina on käytetty neljän eri yliopistotason erikoisteknologian kaupallistamiseen suunnatun tutkimusprojektin analysointia. Tiedonkeruu on suoritettu pääasiallisesti puoli-strukturoiduilla haastatteluissa, joissa on ollut mukana kyseisten projektien avainhenkilöt. Lisäksi kerätty tieto on verifioitu TEKES:ltä saatujen loppuraporttien avulla. Tämän jälkeen kerättyä aineistoa on vertailtu toisiinsa samalla pitäen salassa yksittäisten haastattelujen sisältöä. Seuraavaksi työssä on esitetty syvällinen katsaus kirjallisuusaineistoon ja aikaisempiin tutkimuksiin, jotka käsittelevät erikoisteknologian kaupallistamista.

Tutkimuksen tuloksena on löydetty viisi tärkeintä tekijää, jotka ohjaavat kaupallistamisprojekteja ja niiden mahdollisuutta onnistua. Nämä viisi tekijää ovat: *Tiimi, Markkinapotentiaali ja kilpailukyky, Tuote ja teknologia, Rahoitus* ja *Ohjausryhmä*. Näiden lisäksi työssä on esitetty erilaisia epävarmuustekijöitä, jotka ovat yleisiä kullekin tekijälle. Yhteenvetona tästä työssä on esitetty hierarkkinen malli kyseisistä tekijöistä ja niiden välisistä suhteista sekä kymmenestä tärkeimmästä toiminnasta, jotka ohjaavat erikoisteknologian kaupallistamisen onnistumiseen. Viimeisessä osiossa on käsitelty kaupallistamisprojektien tehtävälistaa ja sitä kuinka ja miten eri tehtävät tulee suorittaa kaupallistamisprojektin eri vaiheissa. Tämän lisäksi on listattu erilaisia toimia, jotka tulee suorittaa itse projektin aikana, jotta voidaan maksimoida projektin onnistumismahdollisuudet.

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Peter C. Bebek
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Abbreviations

ELY	Centre for Economic Development, Transport and the Environment
GCI	Green Campus Innovations Oy aka. LURECO
HEInnovate	Higher Education Institutions
IPR	Intellectual Property Rights
LUT	Lappeenranta University of Technology
OECD	Organization for Economic Cooperation and Development
TBRC	Technology Business Research Center
TEKES	Finnish Funding Agency of Innovation
TUTLI	New Knowledge and Business from Research Ideas

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1 INTRODUCTION

Entrepreneurship and university spin-offs have become the next big thing in the university field. Wirght, Birley and Mosey (2004) argue that it is important to devote a greater amount of attention to the study of entrepreneurship in technology transfer, meaning the transfer of ideas to business solutions. These scholars state that the current literature focuses more on the necessity of university spin-offs and the definitions related to them, whereas the focus of future research should be on the study of academic entrepreneurs themselves and how they recognize opportunities, the nature of internal university environments that lead to commercialization, and the process of creation and development of university spin-outs (Wright et al., 2004). The focus of this study is to answer these later questions and, thus bring pragmatic answers to the question of *how to create university spin-offs*.

Powers (2003) on the other hand argues that the expanding rate of university spin-offs and the commercialization of university research has generated considerable controversy in *how* these projects of commercialization should be executed. Thus it is the aim of this study to create a baseline framework that can be used as a guideline in several commercialization projects, not focusing on any one given theme or project. This, of course, can generate a situation where the given framework is not specific and cannot directly be used, where as it can be used as a reminder of the steps needed to be taken in order to successfully execute a commercialization project. The next question would be why is this field of research particularly interesting in Lappeenranta University of Technology?

The new LUT Trailblazer strategy for 2020 has set a goal for the university to become Finland's leading entrepreneurial university following the guidelines of the OECD –criteria, also known as the HEInnovate ranking tool created by the European Union commission and the OECD (HEInnovate, 2014; LUT, 2014). In accordance to the new strategy of LUT a new entrepreneurial action plan has been created to achieve the goals set for 2020, of which the creator of this work has also been involved setting. The goals of the university are listed clearly: (Action Plan 2020 – LUT)

- 100 new start-ups or spin-offs
- Receive an accreditation concerning an entrepreneurial university and fulfill the criteria of an entrepreneurial university set by the OECD
- Solidify the entrepreneurial study minor as part of the basic studies provided by the university
- Develop the possibility for entrepreneurial studies in all study fields
- Create a brand as an international entrepreneurial university
- Support students' entrepreneurial activity

As the focus on entrepreneurship of the university has become so clear, it is only reasonable to create studies on how to accomplish these goals, which is also the underline reason behind this theses work. Still very little research has examined the factors that lead individuals to found university spinoffs. As Shane (2004) puts it: "In comparison to the mainstream entrepreneurship literature, which has examined a wide variety of psychological and demographic factors that lead entrepreneurs to found companies, the literature on university spinoffs has only examined a handful of characteristics, and even the evidence for these characteristics has been largely anecdotal."

To actualize the goals set in the strategy of the university, many of the research projects have become more commercially oriented. As a research project possesses a commercialization aspect it will have a much greater chance in creating a new start-up or spin-off, which is one of the main goals listed above. There are also newly founded or combined departments in the university that focus on the actualization of entrepreneurship in the university such as the Innovation and Entrepreneurship services, and Research Politics services (LUT, 2015)

As the literature regarding academic entrepreneurship and the possibility of executing commercialization research projects focuses mainly *what* these themes represent and *how important* these themes are, we should focus more on the pragmatic side of the subject and try to understand *how* these projects should be executed. According to Shane (2004): "While it seems that university spinoffs are different from other high technology firms, we need additional studies that carefully compare matched samples of university spinoffs and other high technology start-ups so that we can identify the dimensions on which these firms are similar to and different from each other." In other words more research is needed in order to identify the factors that drive technologies to be commercialized. As Shane (2004) adds: "In the absence of such research, policy makers will be unable to identify the levers necessary to increase or decrease the rate of spinoff company formation out of universities."

The Finnish Funding Agency for Innovation, also known as TEKES has also seen the potential in commercially oriented research projects, thus it established a completely new project category named "New knowledge and business from research ideas" or TUTLI. The aim of these projects is to provide the possibility for scientists to develop their idea further while preparing for the commercialization of that idea into a new business (TEKES, 2012). It should be noted that these projects are not the only commercially focused projects, and the cases used in this research focuses on both TUTLI-projects and other commercially oriented projects. Since 2012 the university has gained funding for 16 commercially oriented projects for over 7 million euros which is still a fraction from the total of 172 TEKES funded projects for a total of 55,77 million euros LUT has gained since 2003 (TEKES, 2015).

Still from the 16 commercially oriented project 10 of these projects have finished their funding. This work will analyzes the commercially oriented projects themselves to find consistencies and uncertainties that all of the projects possess, which have an influential effect on the projects chance to help create a new business. As the models used to explain the decisions behind creating and funding commercialization research projects are incomplete, the focus will be in creating understanding on the subject (Shane, 2004).

The aim of this study is to generate understanding of how commercialization research projects should proceed and to find concrete ways of improving the successfulness of commercialization research projects. To fulfill these goals the study firstly focuses on the reasons and factors behind commercialization research projects. In order to provide understanding on what commercialization research projects really are, a literature review has been provided. In this particular section the aim has been to:

1) Provide arguments for the importance of commercialization projects
2) Present known frameworks or theories connected to commercialization projects
3) List the common concepts related to commercialization projects
4) Examine the different technologies that can be commercialized

What was found during the literature review is that there are numerous studies focusing on the importance and aim of commercialization research projects, which in their way are important studies. Still as the aim of this study is to provide practical steps to successfully execute a commercialization project, the focus of the literature review quickly changed to the analyzation of research done on the fields of innovation and commercialization.

The empirical section, Chapter 5, focuses on how commercialization projects can be successfully executed and to provide concrete steps on doing so. This has been addressed by going through the different stages of commercialization projects and then needed tasks on these different phases. Also the study of gaining funding for starting commercialization projects in the first place has been addressed. At first it may seem that the study takes a leap to an completely different field of study, but during the process of creating this study, it has come more and more relevant to focus also on the funding of the commercialization projects as well as studying the steps of execution of these projects mainly because due to all sources of knowledge, gained by interviewing or literature, the funding of commercialization projects is the only way to start an actual commercialization project. This fact will not be addressed later on for the reason of generalization, as further study should be made on other possible ways on creating commercialization projects that have not or will not receive funding.

Lastly it should be noted that by the help of the company Clover Factory, which is focused in creating commercialization projects for different research institutions, by team creation, gaining funding and providing expertise has been one of the most significant reasons for the creation of this study. Clover Factory has also provided the possibility to test the findings of this study in actual commercialization projects during this research process. This has been done through the four, ongoing, commercialization projects in which the members of Clover Factory are involved in with Lappeenranta University of Technology and Saimia University of Applied Science: *Vmax, HS-Eden, Drive!* and *Kooler,* with the aim of starting two new projects in Fall 2015: *Smart Ambulance* and *HybDim*. All and all, the goal of the company is to generate successful commercialization projects firstly to the Lappeenranta campus, to provide public and private funding for these projects and to create project oriented jobs for students where they can be in close contact with the research done in the campus.

1.1 Objectives and scope

The aim of the research is to explain how the high-technology commercialization research projects can and should be performed, and also what are the different factors and uncertainties related to those factors in a successful commercialization process. In addition, the research will focus on the exploration of different drivers related to the found factors. This will better help to understand the complexity of a commercialization process of a research project. The goal is to generate an understandable framework for the creation of research projects aiming to commercialize a product or technology.

The next step is to create a framework for a funding application generally used in university societies when applying for funding from the public sector. This will help researchers to find simple and standardized methods for starting the project and the steps of commercialization. The study will also provide a sample of different work packages and executive actions related to those of commercialization research projects. This will better provide answers to what are the actions needed to successfully commercialize a high-tech research project.

As shown in Table 1 the research questions have been divided into two larger themes that will comprehend a larger part of the commercialization process. The *first* research question addresses the questions previously stated as *what kind of factors, and uncertainties related to those factors can be found in the high-tech commercialization research projects?* These questions will be answered in the

first empirical chapter, Chapter 4, by the help of data gathered from the in-depth interviews of people involved in the cases used in this study.

The *second* research question will focus on the steps that should be taken in order to successfully commercialize a high-tech research project. For this section a pragmatic view has been taken in order to provide a comprehensive analyzes of the areas connected to the commercialization. The aim is to provide a table of content of the funding application needed to gain public funding including the different areas of focus of a research project. Also similar frameworks will be provided for the gateway report as well as the final report of commercialization projects. These will be the compiled guidelines for the different aspects and areas of the commercialization research projects. The research questions are shown in Table 1.

Table 1. Research questions and objectives

Research questions	**Objective**
1) *What kind of factors, and uncertainties related to those factors can be found in the high-tech commercialization research projects?*	Identify the factors related to commercializing a research project and to understand the uncertainties related to those factors
2) *How can a high-tech commercialization research project be successfully executed and what are the steps involved in the commercialization process?*	Provide a baseline framework for gaining funding for a high-tech research project and determine the steps needed to successfully commercialize that project

This study is limited to concern only products and technologies commercialized for the use of other companies making the study B2B-oriented. This is mainly due to the direction the Lappeenranta University of Technology has taken in its overall strategy. Also the cases used in this study are all B2B-oriented, making them excellent study references. Also the work packages included in the latter empirical chapter, Chapter 5, will focus only on developing a framework for commercializing B2B products or technologies.

1.2 Structure and execution of the study

This study employs several in-depth interview for gathering qualitative data to bring new findings for the research proposals provided by earlier studies. The interviews have focused on experts related to previous commercialization research projects. To fully understand these projects also the final reports provided by TEKES have been analyzed to get an unbiased overall picture of the projects. Because of the lack of previous studies done in this particular subject the study has focused mainly on commercializing products to B2B-markets. The aim has been to explain the cases used in this particular study and reflect the finding into those used in previous literature. From this the study has been able to determine different factors related to commercialization projects which have been analyzed and compiled into a working framework. The execution of the study consists of four phases presented in Figure 1.

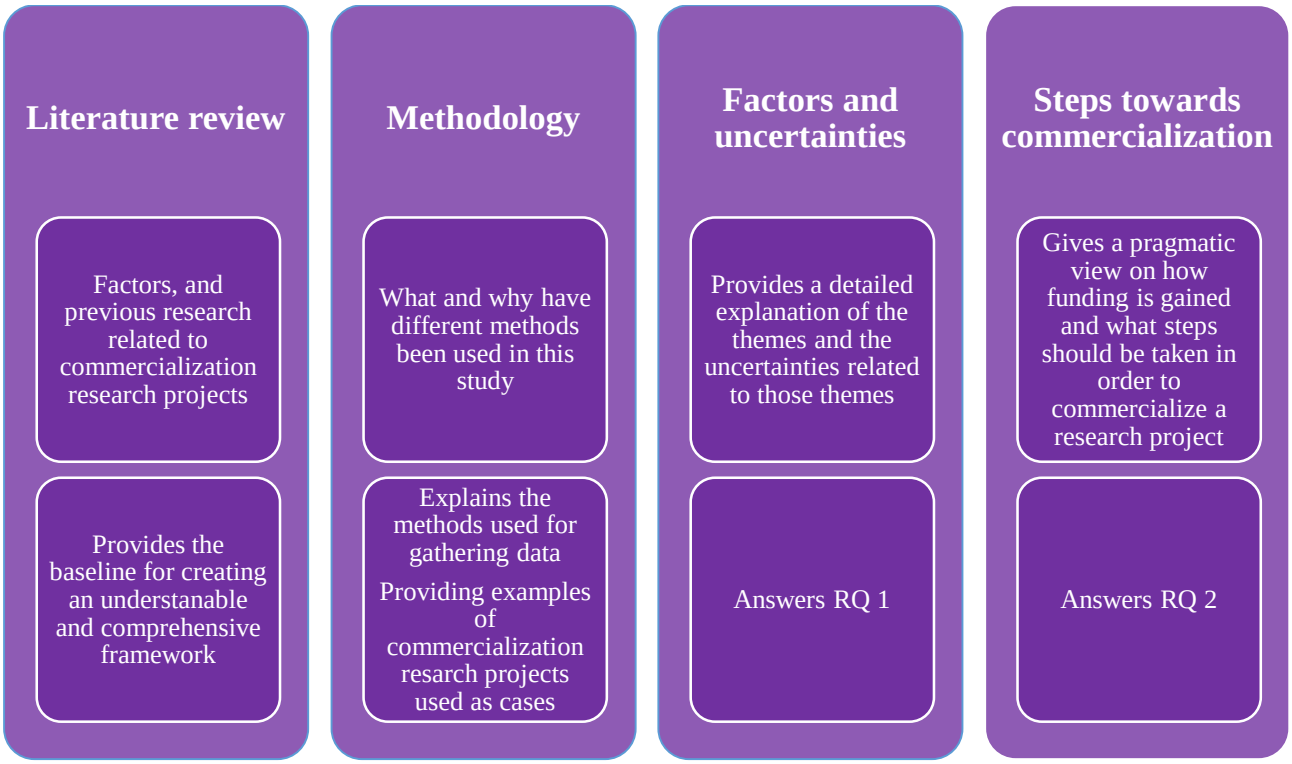


Figure 1. Execution of the study

The first phase, *literature review*, provides the theory section to this study by analyzing previous studies and known frameworks that can be used in later sections of this study. The aim has been to reflect the findings of this study to those of previous research. As it has been found, there is no single framework that could be used to explain the process of commercializing high-tech research. Thus this study has gathered reliable sources from different researchers to fully understand the various elements concerning the commercialization process. These findings have been the backbone for creating an understandable framework shown in the third phase of this study.

The second phase, *methodology*, explains and analyzes the different methods and cases used in the data gathering for this study. The aim has been to fully explain the purpose of these projects and reflect those experiences to other commercialization research projects. For the respect of privacy the study has analyzed the cases only in the later part so that the identities of the individual people and the cases themselves are not presented directly. The cases have been chosen keeping in mind the different stages of commercialization projects. Thus two of the cases used are from projects that have ended but from different reasons have not yet been fully commercialized. The reasons behind these have been analyzed later on. One of the cases used is a university spin-off that has gained all the necessary elements to successfully enter their target markets, but has yet to start its sales operations. Still all of the stages done towards a successful commercialization have been done according to the findings of these studies. The last case is one of the success stories of LUT, where a spin-off coming from high-tech research has grown into a remarkable business that is still expanding.

The third phase, *factors and uncertainties*, focuses on the development of a framework of comprised factors related to the commercialization research projects. This study starts by explaining the different factors individually, while explaining the different uncertainties, risks and factors involved in these factors. The data gathered from interviews has given additional weight to the accuracy of these findings thus providing tangible proof of their importance in the commercialization process. Also a list of the most important aspects of each factor has been provided. After the five factors the study will show a hierarchical framework including these factors and addressing their importance to each other. This has been done to answer the first research question.

The fourth and last section, *steps towards commercialization*, gives a pragmatic view on what a funding application should include, and what are the executive task needed to commercialize a project successfully. The study starts by explaining what the funding application should include and why and what kind of steps should be taken in order to create a successful application. Later on this study addresses the importance of the different sections as public funding has been granted and the executive steps needed to be taken during the first year of the project have begun. If and when there is a gateway report needed in order to gain funding for the second year of the project, this study will address the content of that report. Finally this study will address the last steps needed to be taken in order to fully use the potential of high-tech research projects so that they can be successfully commercialized.

1.3 Limitations of the study

This study is limited to analyzing the commercialization of products and technologies, not services as could also be the case. This is also due to the fact that the cases used in this study are mainly product oriented. This does not, however, mean that the frameworks studied cannot be used in commercializing solutions as is the trend of today's industries. The fact that the study is only product oriented is to simplify the overall process and thus further research should be done in order to notice the differences of commercializing products compared to those of services.

Regarding the funding of research projects the study mainly focuses on gaining public funding and only explain shortly the possibility of introducing capital investors and business angels. This is due to the fact the funding itself is a multi-step process involving several funding rounds with different goals and orientations. Thus the frameworks shown should mainly be used in applying for public funding. This is also important to understand as the aim of all research projects to be commercialized is to gain public funding for a period of approximately two years, where the proof of concept and business orientation will be developed. As is stated later on in this work the actual spin-offs hoped to be created out of the commercialization research projects will most likely need large amounts of private funding in several steps of the growth of the spin-off company due to the fact that developing and marketing a high-technology product or technology in the B2B-markets are highly expensive.

An area of the study that has also not been addressed in full is the protection or IPR of technologies developed before, during or after the research projects. This is also an important field of study that should be addressed in a completely separate work. Also the fact that the level of knowledge in IP-issues inside Lappeenranta University of Technology is seemingly high, thus bringing little more value to this study.

Also a study of a broader area of literature would be preferable, but for the sake of limitation the aim of the literature review has been more practical rather than philosophical. This is also due to the fact that most of the current literature focuses on the importance of university entrepreneurship and the definition of it, rather than giving practical information on *how* these projects should be executed. Thus the literature review focuses more on articles related to *innovations* and *commercialization* as they give more concrete examples on what the steps toward commercialization should be.

2 FACTORS CONNECTED TO COMMERCIALIZATION RESEARCH PROJECTS

In this chapter this study will provide a literature review of commercialization projects as well as the commercialization of a new product or technology. Even as the study on university research and the commercialization of that research is rather comprehensive, there is no single generally used framework that can explain the full process of a successful commercialization project. Also the uncertainty factors which can be ruinous for the project are not explained by any single theory. As the aim of this study is to provide practical steps to successfully execute a commercialization project, the focus of the literature review quickly changed to the analyzation of research done on the fields of innovation and commercialization.

The commercialization of a new technology most commonly includes the same elements as product commercialization in general do. (Simula, Lehtimäki, Salo & Malinen, 2010). In Figure 2 is provided an illustrative picture of what different themes are involved in commercialization projects. These themes will be separately explained in this chapter.

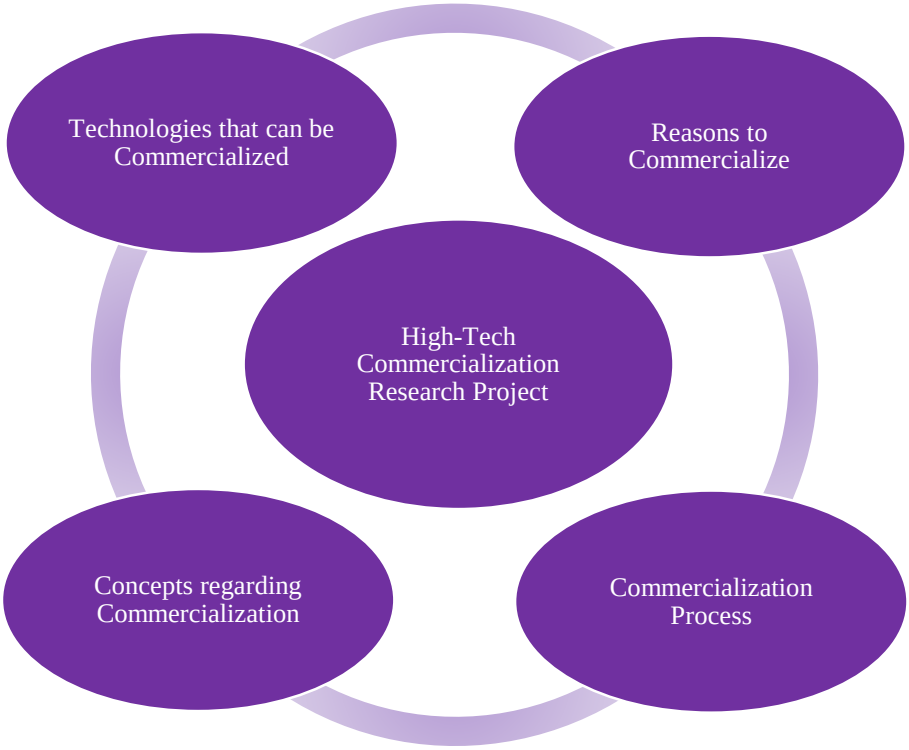


Figure 2. The elements concerning the commercialization of a product or technology

2.1 Importance of commercialization projects

University projects possess the essence of creating something new that have the potentiality to drive humanity towards greatness. Before this study can get so far there is the question of implementing the projects. To fully understand how or even why the results of research projects should be implemented one has to ask: "*what good can commercialized research projects have on the surrounding?*" For this Shane (2004) has a quite extensive answer which he has categorized into five themes. These themes are not in any way complete, but still they give a good idea about the situation. The five answers for why commercialized project are important are:

- They improve local economic development
- They are necessary for commercializing university research
- They boost the research and teaching in universities
- They are commonly high performing companies
- They can generate more income for universities than licensing

2.1.1 Commercialization projects improve local economic development

According to Shane's (2002) research there are four ways in how commercialized projects can improve the local economic development. The first one focuses on the *generation of economic value* that innovative products bring to the customers by satisfying the wants and needs of those customers. It is said that the indirect effects of the economic impact of commercialized projects can be even larger than the direct effects. This means that the increase of the economic diversification make the economy less dependent on old industries. According to Blair and Hitchens (1998) this kind of projects are also beneficial as they generate more novel products and services that can create even more innovative products and services than other technologies by competitors. The innovativeness of new products and services better serve the demand of greater wants and needs of customers. In other words the solutions enabled by high technology research created by universities can truly satisfy the normally unsatisfied class of customers (Dahlstrand, 1997; Hitchens, 1998). The second way for commercialized research projects can improve the local economy is by *generating jobs* and particularly for the highly educated people.

The third argument is that university projects *induce investments* in the development of university technology, thus furthering the advance of that technology. According to Mustar (1997) the spinoffs created from university projects do a better job in attracting investments to the development and commercialization of university high-tech research compared to that of other established companies.

This can be explained by the excess resources put in research and development (R&D) compared to those of typical star-up companies. The higher rate of R&D investments into university spinoffs compared to other star-up companies indicate the value of these firms in generating further technical advance in the same industry. (Blair & Hitchens, 1998; Shane, 2002)

The fourth and final way is the *highly localized economic impact* which means that the spinoffs created from university research are also important contributors to the local economy in financial terms. In other words, the business opportunities that are generated from commercialized university technology are directly related to the enhancement of economic growth. This can be explained by the locality of hiring employees, sourcing of supplies, production sites and so on, thus having a strong effect on the local economy. According to Lowe (2002) the new technology companies tend to cluster together having an even deeper impact on the economy. Mostly companies generated from university research will contribute more to the local economy then other firms as they will gain more from the services already well known to them (Shane, 2002). The related literature offer three reasons for the stronger economic impact gained from university spin-off companies compared to other established firms:

1) The university researchers who have found a high-tech spinoff from university research often make use of laboratories where their inventions are created at the university thus being able to generate more high-tech research (Wilson and Szygenda, 1991)
2) The geographic localization permit the inventor-entrepreneurs to remain affiliated with the university in which they work (Zucker, Darby & Armstrong, 1998b)
3) Once a place of operations is found it will most commonly be the final location the company stays, in other words ones the companies have been founded near the university or its parent city they most likely will not leave (Shane, 2002)

2.1.2 Commercialization projects are necessary for implementing university technology

The idea behind commercialization projects is the implementation of the developed products or technologies into the business world, thus creating a payback method for the university and other stakeholders. According to literature, there are two ways that commercialization projects enhance the development of technology. The first is by *providing a mechanism for projects to commercialize inventions that are too uncertain* for normal companies. Secondly, they *encourage inventor involvement* in the actual technical development which is crucial for the continuity of that technology.

The uncertain technologies are most commonly early stage university technologies that would normally go unfunded because of the great risk and uncertainty they poses. According to Thursby & Thursby (2001) early stage development innovations are the least funded innovations in the technology business and this is mostly due to the high failure ratings these technologies possess. This has led to the fact that most university innovations are funded by separate capital investors that are willing to take high risk, or that they are funded by the inventors themselves (Matkin, 1990; Lowe, 2002).

On the other hand, commercialization projects are important because they encourage inventor involvement. In most new inventions created inside a university there are only a handful of people that really know how the new technology works, thus making them the only people capable of further developing that technology. This leads to the deeper integration of those inventors to the commercialized technology (Lowe, 2002; Jensen & Thursby, 2001). Thus it becomes much easier to achieve inventor involvement through the formation of spinoff companies rather than licensing the technology to established companies. (Kenney, 1986)

2.1.3 Commercialization projects boost research and teaching

It can be said that spinoffs created from university high-tech research is one of the biggest boosters for the university's main missions which are research and teaching. According to literature these spinoffs help universities with their core missions in three ways: they can *provide further funding for university high-tech research*, they help to *attract and retain the faculties*, and they can *enhance the training of students* to the field of research and business. The support research gains from commercialized projects can be measured in scholarly means as well as financial means (Louis, Jones, Anderson, Blumenthal & Campbell, 2001; Doutriaux & Barker, 1995). According to Matkin (1990) the faculties involved in commercializing university high-tech research have a greater potential to co-operate more with other faculties and their staff which has shown to have a direct impact of the successfulness of research projects in general (Powell & Owen-Smith, 1998).

The last but not least way for commercialization project to boost research and teaching is by the empirical data faculties gain from starting new businesses also providing real life examples for students to learn about entrepreneurship in general (Richter, 1986). McQueen and Wallmark (1991) give a strong argumentation about the knowledge gained from commercializing new technologies in real life situations compared to that of a normal scholarly use for academic inventions. This is important when considering that most of the university student will end up working for the private

sector and not become academic researchers, thus needing the practical experience even more (Etzkowitz, 2003).

2.1.4 Commercialization projects create companies and generate income for universities

According to Shane (2002) spinoffs emerging from the commercialization research projects are significantly more like to receive funding from venture capitals or business angels than compared to those with non-university background. Statistically university spinoffs are also more profitable than those compared to a non-university background technology start-up. Moreover, it can be said that spinoffs sprung up from university research are in many ways more profitable than typical high technology start-ups, due to their academic skills combined with the real-life experience gained from start-ups. As a summary there are three main ways the performance of spinoffs can be measured: *The positive performance* of a company, *survival rate* and *the profitability of companies*. (Blair & Hitchens, 1998)

Not only are spinoffs created from university high-tech research better performing compared to typical start-ups with non-university background, they are also able to generate more income for the universities. Here is a list of ways of how university research based spinoffs create more income for the universities provided to us by Shane (2002):

1) Universities can easily take a larger part of the equity of spinoffs, with the statement that equity ownership is more profitable than compared to that of royalty incomes. Thus *capturing the value from creation*.
2) By holding equity, universities can gain *financial returns* from the technology in question. This is also due to the fact that university inventions often require further development after the technology has been launched.
3) The *inventor-founder adds* where the technology licensed does not leave the parent company so that the founding team might still continue with their vision, resources and other commitments to further the technological and business developments.

2.1.5 Summary

This section has explained why university commercialization projects are so important and why so much effort should be put on the study of the implementation of those projects as has been done in this work. The way in how university research projects effect the surrounding area as well as the university itself is significant and it can be measured in numerous ways. Thus the possible gains

compared to the risks are also rather high, making it an ideal focus for technical universities in general. If one is to argue that the main focus of universities is to do research and education and that the commercialization projects aid these goals, then it becomes an even more interesting topic to gain knowledge from. Now that this study have proofed the importance of these projects, this study can focus on the risks and uncertainties of these projects and start the analyses on how project should be started and executed to fully serve their potential. This is also one of the key focus points of this particular study. As a simplification a summary of the benefits and reasons for *why are university commercialization projects important* is shown in Figure 3.

Also the analyses of the importance of commercialization projects give validity to the study of means of executing these given projects. In other words, it has become more and more interesting to create studies that focus on the factors behind commercialization research projects as well as the different reasons and uncertainties related to these factors. In order to create a baseline framework for executing these projects a deeper understanding of the current literature should be done. This is also the focus of this literature review. Furthermore, some of the reasons behind the importance of these projects can only be found after the successful execution of these projects, as they presumably possess several elements that boost or limit the environment around them. Thus, the actual benefits, as well as the concreate application possibilities of the findings provided in this study can only be verified after several commercialization projects have been executed by the steps provided in this theses work.

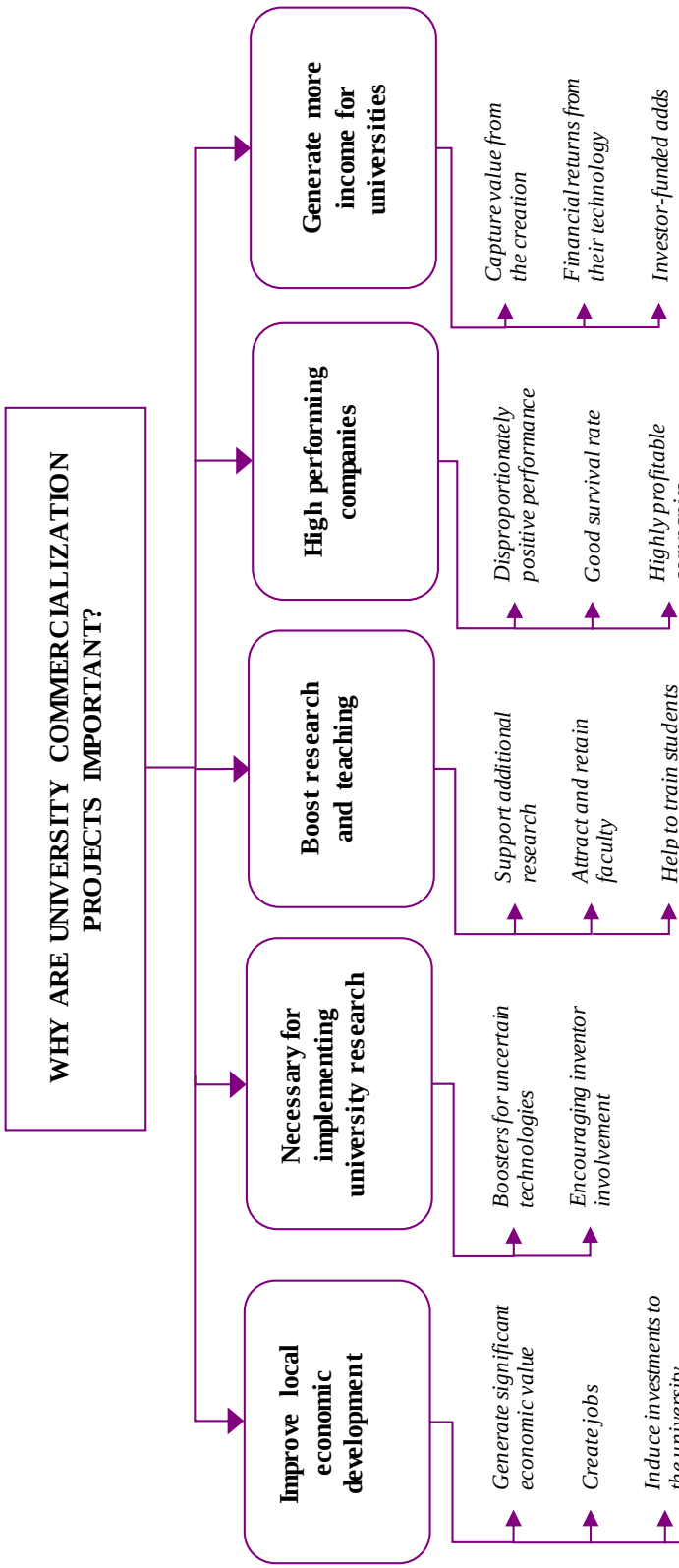


Figure 3. The Reason for commercialization

2.2 The commercialization process for a new product or technology

According to Kotler, Keller, Brady, Goodman and Hansen (2003) there are eight different steps for developing a new product or technology. The full process is shown on the next page in Figure 4. The first step is *finding or generating an idea* which in a university surrounding can happen as an individual, inside a research group or as a collective. The next step is understandably the *development of the idea* which can include pitching to colleagues or finding an objective viewpoint. The third step is called *concept testing* where actual test products or just components of that product are tested.

The fourth step includes the *marketing strategy* which takes the focus off the product and on to the potential customer and markets. The step between *concept testing* and *marketing strategy* can be rather great as the expertise on the two matters usually come, and should come from different people. After a successful formation of a *market strategy* a *calculation of technology's profitability* should be made in order to give validity to the possible research project. This step is also a rather hazardous one as there are many ways to measure profitability and as a personal note I would hope that the profitability of a technology is not only measured by its monetary profitability, which is usually the case. (Kotler et al., 2003)

Once the *profitability* has been assured by known calculation models the next step can begin. The sixth step goes back to the actual product, also known as *product development.* During this stage it is most important to keep in mind the needs and wants of the target customers who in this work will be other companies. *Test marketing* is the seventh step of the process and it allows the possibility of deeper interaction with the target market. This is usually the step when both the product and the marketing of that product are most intertwined. Ones all of these steps have been accomplished successfully it is time to take the last step on the process, *commercialization*. The whole process is shown in Figure 4. (Kotler et al., 2003)

On the other hand, in case that one of these steps is not fully completed or left uncompleted by any reason it is only natural that the project has to take a step back and re-evaluate its position. This is why every step should be taken with the upmost interest and focus. In the worst case, if a step is done incorrectly, it can affect the whole commercialization process in a way that will not allow the further development of the idea. This is also why using the expertise of the executive team is highly important. (Kotler et al., 2003)

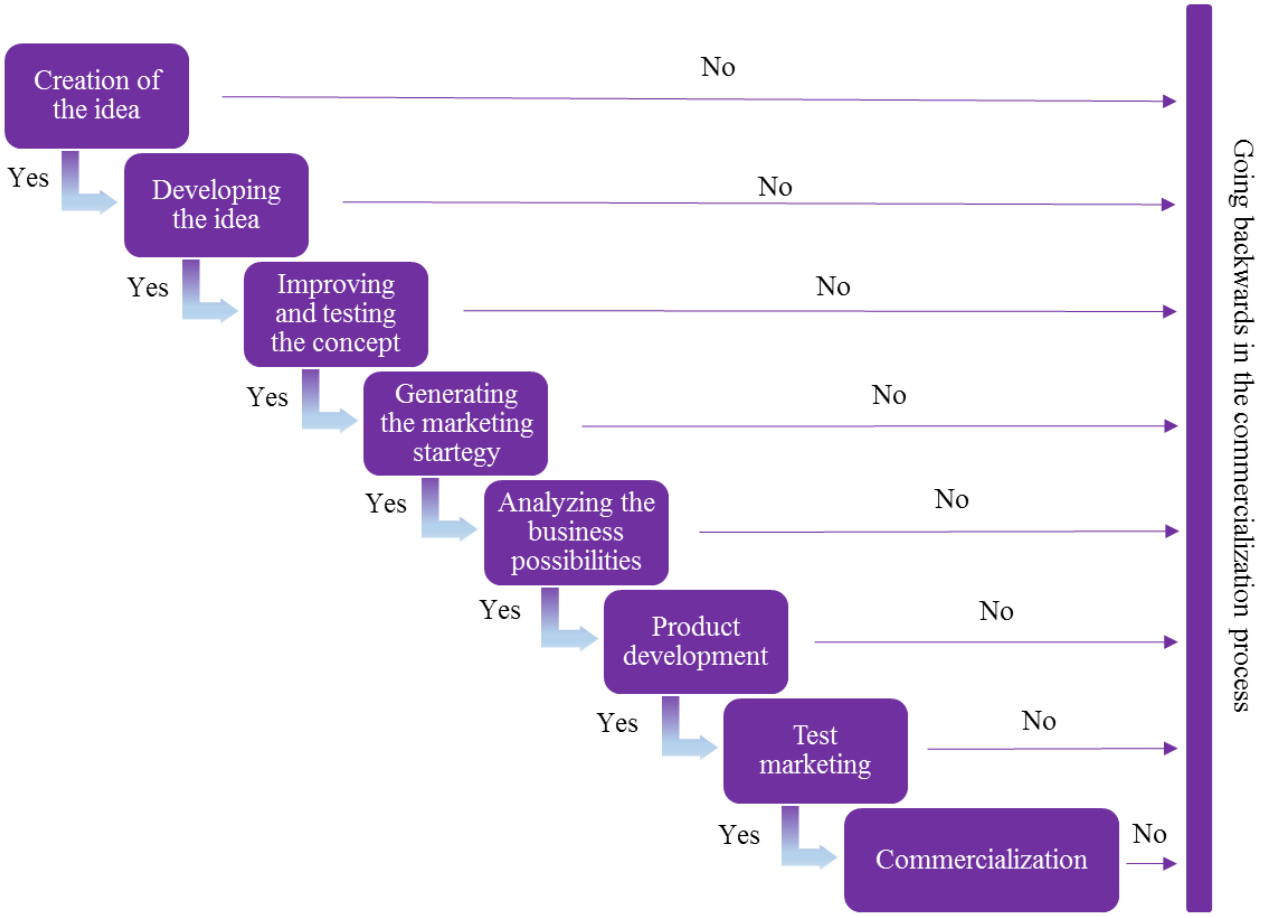


Figure 4. The commercialization process (Kotler et al., 2003)

2.3 Concepts regarding commercialization

Commercialization itself mean the planning and execution of taking a product or a technology to the markets. Operations concerning commercialization on the other hand mean the actions done to develop an idea to a product which will be easy for customers to buy and easy for salespeople to sell. Even the greatest idea cannot bring any profit to an organization without a successful implementation of that idea referring to the argument that commercialization is the implementation of a product or technology. Commercialization should be a natural part of a research project because all research, ones found to be of interest, should be implemented. (Simula, Lehtimäki, Salo & Malinen, 2010)

According to Teece (1986), *innovation* means the commercially successful product that brings new value to the target markets. The value coming from a new product cannot solely come from the technology itself but it should also contain the possibility to connect existing technologies together in a new way. An innovation can also be the use of a completely new business model for a new product or technology. *Radical innovation* on the other hand means that the product or technology

introduced is completely new which could also be the case in university research projects. It should be noted that it is not always wise to operate the commercialization yourself if you do not possess the needed expertise on the matter. This is also another example of the importance of co-operation between university faculties. (Teece, 1986; Simula et al., 2010)

A factor that most academics state in their findings is the importance of the *team*. A team should be able to set the bases for economic success as well as the success of the whole commercialization process. An advisable form of a team is a group of people with diverse but explicit expertise in different field. The important factor in these cases is the communication between the individual people in the team as well as whole departments with each other. One of the best examples is the high importance of the sales and marketing department working as closely and with good relations with the technical development department during the whole product evolution. Also people responsible for manufacturing, financing and management should all be in constant contact with other departments or people from those expertise areas. The products sold should fit well to the companies or university's strategy and guidelines. (Simula et al., 2010)

Benchmarking is a concept vastly used in the academic world. It means the comparison of the research team's technologies, processes, services or products to those of competitors or other actors. In academy benchmarking is also considered a form a validity ones your own work is compared to those of your peers. The target of comparison is most commonly the most successful object. In commercialization project the object can also be another research project which has a completely different technology, but has a similar process for commercialization (Hutt & Speh, 1995). This is also the situation in the cases presented in this work.

In the process table below the study shows an example of a benchmarking process (Zankgwill, 1993):

The goal of analyzing *market potential* is to find the needs and expectations of customers. For analyzing market potential a market research is most commonly conducted. This is most usually performed by a quantitate survey where the questions asked and the target audience have an important effect on the outcome. In a research project a survey is usually the simplest way to gain large amounts of data from the target market. Thus a market research is also a typical place to start a commercialization process. If the market research has been done correctly it will most certainly eliminate the possibility of developing a product or technology that the target audience does not want or need. Market research is can be divided into different types: (Hutt & Speh, 1995; Blythe, 2005)

- Customer research
- Sales enhancement research
- Product research
- Distribution channel research
- Sales research

The formation of a market research process is demonstrated below in accordance to Blythe (2005):

One of the most significant factor for an unsuccessful commercialization research project is the lack of co-operation between the research group and the customer. The calculation of market potential can also fail if the focus has been left too low or it has been too late. The goals of a project should be undergone during an early period of the project to ensure the unity of the goals inside the research group as well as any other partners involved in the project. Co-operation should be performed trough out the research project and the management of the project should stay as close to the original goals as possible to ensure the maximization of gain and results from the given project. This can be

accomplished by routinely meeting with the people involved with the project as well as those in the managing team. (Andreasen, 2002)

2.4 The technologies that can be commercialized

When talking about the technologies that can be commercialized one usually comes to a cross-road of different methods or forms of innovations meant for the market. At first, one could imagine that the commercialization of technologies are similar when comparing university spin-offs to established firms, but in truth they are not. According to Shane (2002) most university technologies are in fact licensed to established firms and that there is only a fraction of different types of technologies that can be commercialized as a separate entity via a spin-off company. As is shown in the Table 2, provided by Shane (2002), the university spinoffs that are founded exploit technologies that are: *radical, tacit, early stage* and *general-purpose*. The factors that these have in common are the significant value they can bring to customers or that the major technical advances they can provide. Also, as stated before, the intellectual property protection is generally high in technologies emerging from high-tech research.

Table 2. The types of technology that lead to spinoffs and licensing (Shane, 2002)

Spinoff firm	Established firm
Radical	Incremental
Tacit	Codified
Early stage	Late stage
General-purpose	Specific-purpose
Significant customer value	Moderate customer value
Major technical advance	Minor technical advance
Strong IP protection	Weak IP protection

Radical inventions are known to cannibalize existing technologies already in the market. They have a way of undermining the existing organizational competencies and are said to be often rejected by managers in existing companies. Spinoff companies become more common when the knowledge needed to exploit a technology is tacit than when it is codified. This means that tacit knowledge makes it difficult for anyone other than the inventor to understand how the technology should be

commercialized. Moreover, tacitness of knowledge leads managers in established companies to believe that an invention does not work, causing them to reject the technology. (Shane, 2001a)

Early stage inventions lead to the formation of spinoffs because ‘unproven’ technology cannot easily be licensed to established firms. This is mainly because managers of established companies can find it difficult to see the value of unproven technology. Also the existing products are usually more interesting to managers than early stage technologies, thus wanting to buy an already developed technology rather than developing the technology themselves. Also it is said that that spinoffs tend to exploit general-purpose technologies or basic inventions with broad applications in many fields, thus offering multiple market applications. This in return can generate significant value to a broad variety of customers. The major technical advances and the needed IP protection related to them are generally more common in spinoff companies created from high-technology research as they are easier to handle by smaller and more adjustable companies. (Shane, 2001a; Thusby & Thursby, 2002)

3 METHODOLOGY

In this chapter the study explains the different methodologies used in this work. First the study will explain the multiple case study method which is one of the key methods used. In this chapter each case is explained separately and then later on in the empirical section where the finding from these studies have been categorized under different factors also known as uncertainties or risks. This allows a deeper study of the similarities found in each case still making it possible to protect the identities behind the cases. In this chapter this study will also focus on the way most of the qualitative data is gathered – interviewing.

The interviewing is explained first by generally describing what interviewing is and later on how it is used in this particular work. The main method for gathering data has been through half structured in-depth interviews of highly involved people in the commercialization projects or start-up companies created from high-tech research. For this particular work a set of informal interviews have taken place with high ranking officials from LUT and other partner organizations to better understand the problems and needs of the university in commercializing its high-tech research.

To better understand what commercialization research projects hold, this study has analyzed separately four different cases that have all lead are leading to the commercialization of a particular technology or product via university research. The main reason why this study has first analyzed different commercialization cases has been to provide a baseline for this study in the way on which the factors and frameworks can be based upon. The results of the case analyzes has led to the finding of the factors presented in the empirical Chapter 4. These cases have been selected due to the fact that they have been recently executed and that they have been easily accessible via the contacts inside Lappeenranta University of Technology. Also the number of cases have been selected due to the need to analyze cases that are in different phases of the commercialization process, for this the cases chosen proofed to be both suitable and informational.

3.1 Multiple case study

Case study is a research strategy used in qualitative research. Its aim is to make a deep study of a case or several cases and thus provide understanding of a phenomenon. Like other qualitative research methods, case study is inductive and generally provides answers to questions of *how* and *why*. In a research strategy, case study provides means to specify the research focus and to construct the material or data. Case study in its self is not an analyses tool or meant for data gathering. Case study

has been described as an independent method and methodological academic approach starting from the 1960's (Glaser & Strauss, 1967; Yin, 1989). Using case study is popular especially in business and economic research.

For this study, case study was chosen because of the benefits of analyzing commercialization research projects for gaining a deeper understanding of the different factors and limitations concerning these particular projects. Also by providing examples of different commercialization research projects, the reader can better understand the nature of these projects and better reflect them on other, more academically oriented, projects. Also the aim of case studies is to provide detailed and intensive information from a chosen case or phenomenon. Even as cases used in research vary a lot, they most usually focus on a single entity. The data used in case studies and the analyses concerning it is meant to define and reshape the theories behind a given phenomenon by stating out paradoxes or inconsistencies. It is also meant to provide new observations and to show existing links between the given cases and their environments. Unlike in quantitative studies, a case study does not try to aim for generalization but to bring understanding and interpret deeply a singular case in its unique context (Eisenhardt, 1989). The data and understanding of a singular process gained from case study can commonly be used to understand and link larger entities which in turn can be used when studying other similar phenomenon. The generalization of a new data still requires a theoretical framework and concepts thus making the literature review a highly important factor of a given study (Hartley, 1999).

Following the same guidelines as other research methods or strategies case study also begins by defining the research problems and research questions. The selection of cases for the study is essential at this point of the research process so that enough data can be gathered from each case. In this work the data has been gathered through half structured in-depth interviews of highly involved people taking part in a given commercialization project or start-up company originating from high-tech research. It is typical for a researcher of a case study to be in close contact with the people of a particular case. After defining the individual cases and goals it is important to provide a literature review and to choose a theoretical framework well suited for that particular study. This will help to guide the focus of the research thus also providing the limitations to the study. After the theoretical framework and determining of the limitations has been done the researcher can start to focus on gathering the data needed to accomplish the study. To gain a deep understanding of the cases selected it can be beneficial for the researcher to execute a couple of informal orientating interviews (Hartley, 1997). For this particular work a set of interviews have taken place with high ranking officials from

LUT to better understand the problems and needs of the university in commercializing its high-tech research.

The benefits of using case study is its ability to understand complex phenomenon and bring out details and characteristics of a particular case. For example organizational behavior studies can be highly complex depending on the society that only a case study can provide a sufficient enough data to fully understand it (Clegg, Kemp & Legge, 1985). The findings of a case study are widely used in practice. On the other hand case studies are also criticized for their feeble generalization or the dependence of the researcher's skills and know-how (Hartley, 1999). Gladly the latter is not the case in this particular work.

3.2 Interviewing for qualitative research

An interview can be seen as a shared event of two people, the other being the interviewer and the other the interviewee, where the focus is on *what* they are talking about and *how* they talk about it. If one is to argue that there is no "objective" viewpoints to be taken in an interview, then the way the interview is structured has the upmost importance on the interview its self. Denzin & Lincoln (2011) as well as Roulston (2010) argue that most interview-based qualitative research approach the knowledge gained from interviews with a realist and relativistic viewpoint, which means that the reality one observes is actually a reality made from a social construction where we as individuals have a share in creating the truth.

A semi-structured interview is a combination of a formal structured form based questionnaire and a completely open and perhaps informal interview (Hisjärvi et al., 2009). A half structured interview is generally carried out by using themes as a bases for the questions. This allows the possibility to focus on a certain topic at a time while keeping the body of the interview well-structured and as similar to other interviews as possible. It is typical to a theme based interview that more questions are addressed according to the answers of the interviewee. This will help to achieve a better understanding of what the interviewee wants or means to say (Hirsjärvi & Hurme, 2010). The benefits of a half structured interview is indeed the possibility to gain a colorful answers from the interviewee to give more weight to the qualitative research. The questions can thus bring up topics that the researcher could have not anticipated or thought of beforehand. (Hirsjärvi, Remes & Sajavaara, 2009; Hirsjärvi & Hurme, 2010)

Interviewing has been chosen as one of the main methodologies in order to gain qualitative data straight from the people involved in commercialization research projects. By interviewing the key people we can gather new findings to take further the research already done by in previous studies.

In this work the original questions listed to all four interviewees were intentionally as similar to each other as possible to gain comparable and reliable data. Only a few questions were added to the original question list due to the growing understanding of the topic from previous interviews (Attachment 2). The main line used in the interviews was divided into two; the first and shorter section would focus on the interviewee himself and the second or longer section would focus on the case chosen for the study. The actual interviews were originally meant to be around 45 to 60 minutes in length, which proved to be an accurate assumption. All of the interviews have been done in Finnish and later translated in to English.

The theme consisting of the first and more personal questions involved questions like:

1. *From which field is your education from?*
2. *How long, if, have you worked in Lappeenranta University of Technology?*
3. *In how many research projects have you been a part of during your years at LUT and how many of these projects have been commercially oriented?*

The aim of these questions was to better understand the experience and know-how of the actual interviewees as they had been highly involved in the projects chosen as cases for this work. The next questions would focus on the actual project or case with the aim of understanding more about the case itself as well as to gain data to better understand the uncertainties or problems commercialization projects similar to these would have to go through. As seen from the questionnaires (Attachment 2) the questions focused more on the difficulties and problems of the projects as well as the positive feelings and actions that had stayed in mind during the projects. After an analyses of the data was done a more suitable form of asking questions could have been to concentrate the questions on the topics or themes most related to all of the cases. The original questions for the second phase were:

1. *Please tell shortly about the (case name)-project and your personal role in that project.*
2. *What were the main problems or worries you and the team had during the project period?*
    I. *How did these problems effect the commercialization aspect of the project?*
    II. *How did you overcome these problems?*
3. *What were the actions that were done right and what should have been done differently.*

All and all, these questions were the bases for more questions that sprung up during the actual interviews. They were meant to be, as they also turned out to be, more of a conversation starter that would lead the interviewee to the correct and most interesting path of the story telling. In total the questions and answers turned out to be a genuine success as the level of data gained from these interviews was substantial. To get more reliable and spontaneous answers the actual questions were

never presented to the interviewee beforehand and even during the interviews the interviewee had no idea of the follow up questions or the next theme of questions. This decision ended up being correct as the material gained from the interview were precisely the kind needed. With the interviewees a deal was made that any and all information released would be under their approval and that in the case that more material was needed an extra interview would take place.

3.3 Main data sources

The main source of qualitative data has been gathered by in-depth interviews from experts with experience in previous commercialization projects. As stated before it is important that the answers given and used in the empirical section of this work cannot be directly linked with the people interviewed. Thus the work process has involved four interviews based on a similar if not same question set. The answers have then been analyzed separately. Ones the transcript and analyzes has been finished a categorization of the answers begun. By this process the study has guaranteed a high accuracy of results and consistencies still keeping the individuals' answers unknown. To better understand the full process and actions related to these processes, this study has also analyzed the final reports from all cases to compare them to the statements of the interviewees. Still the findings of this study have been made mainly possible by the statements from these experts.

The people interviewed have been chosen from different commercialization research projects that have been done in Lappeenranta University of Technology. The cases them self were chosen from a rather limited list of commercialization projects that had been executed in this particular university and that had ended just before this study was started, so that the outcomes and different steps of those projects would be clear in the interviewees' minds. The people interviewed where chosen from these projects on the bases that they had key roles in the actual execution of the projects. The details of the interviewees are shown in Attachment 1.

3.4 Cases used in the study

In this chapter this study will go through the different cases used to gather qualitative data. The cases are all commercially oriented research projects or businesses originating from research projects. For this reason it can be noted that the cases used are closely related to the project intended to benefit from this study. The cases themselves have been chosen by the help of the Research and Innovation services in LUT. The main data has been gathered from in-depth interviews of experts involved in

these particular cases. Also the final reports of the research projects related to these cases have been analyzed in order to gain a deeper understanding.

There are four individual cases from which HEX.COM and ORC could have been also analyzed as separate cases as has been done in this chapter, still later on the findings of these two cases have been combined as one as the people involved have been mainly the same. The cases have been carefully selected so that they represent past commercially oriented research projects that have given way to the possibility of commercialization. Two of these cases have the possibility to be commercialized, but for some reason have not done so. One of these is already a company and ready to begin sales and the last is already a fully functioning international business. The level of commercialization, meaning mainly the stage that they are in is presented below in Figure 5. It should also be noted that all of these cases are B2B –oriented, which has been the original purpose.

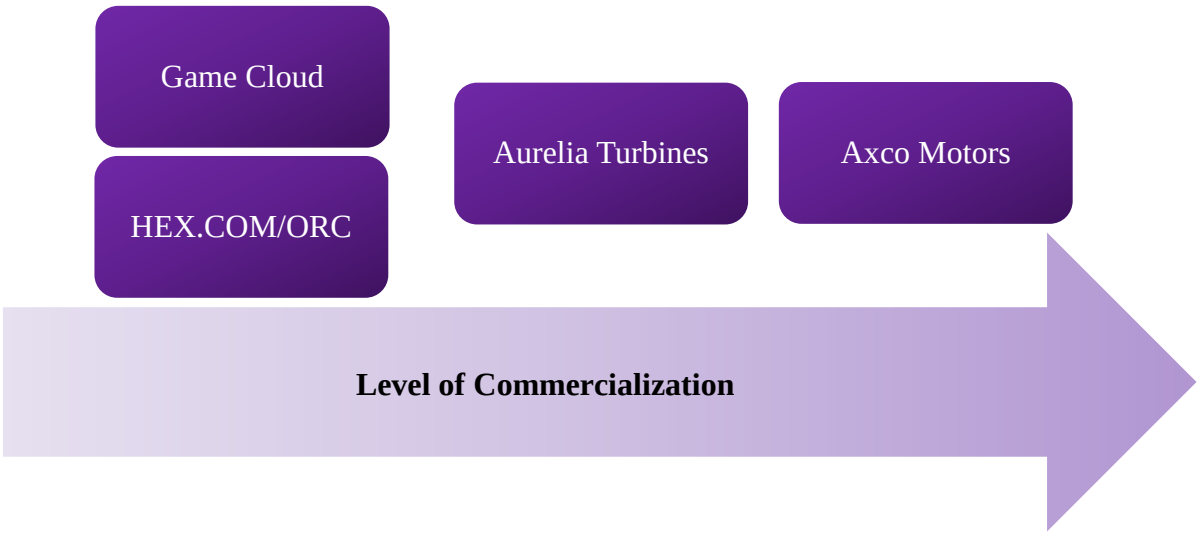


Figure 5. The level of commercialization of the cases used in the study

To understand better *what* commercialization research projects truly are, different case examples have been provided and explained in detail in this chapter. Furthermore, key people involved in these cases have been interviewed for the sake of gathering qualitative data. The summary of why these particular cases were chosen and what kind of data they were expected to provide for this study these are explained in Figure 6. The results of these cases studies have been analyzed individually and later on reflected to each other. The results of these findings are explained further on in Chapter 4.

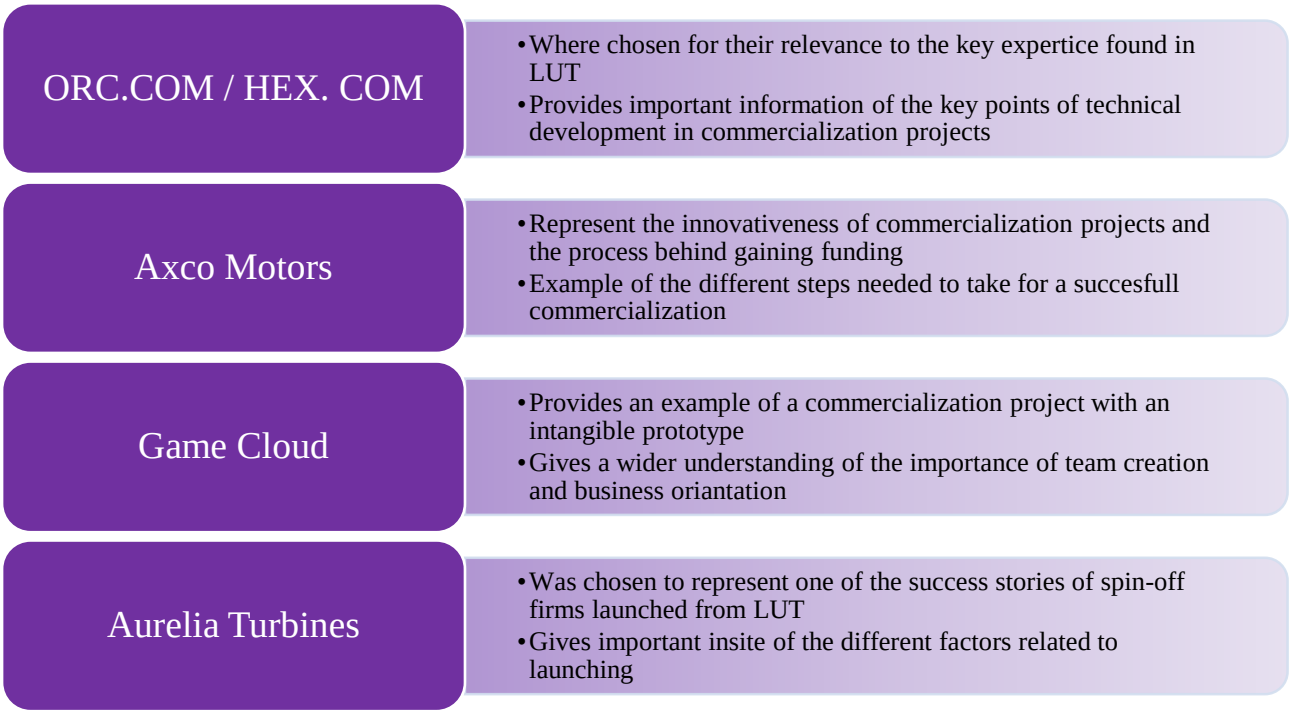


Figure 6. Summary of the cases used in theses

As can be seen in Figure 6, the cases chosen are all similar in the sense that they represent commercialization research projects, where the aim has been the creation of business from research ideas. Nevertheless, these cases were created and executed in rather different circumstances. This was calculated to enable a wider analyses of the different factors related to commercialization research projects, as these factors were emphasized diversely in these projects.

By reference, the ORC.COM and HEX.COM were chosen as they represent some of the key expertise associated with Lappeenranta University of Technology, the gas turbine, and heat and power plant planning. Also these projects provided important inside to the technical development -factor and customer orientation in the overall projects as well as the necessity of sufficient funding to commercialization projects. On the other hand, the Game Cloud –project was chosen to provide an example of an intangible technology that could be commercialized. Moreover, the effects of team creation and team dynamics to the overall project were highly influenced by the findings of analyzing this particular project. The factor of *Team* was also influenced by analyzing the Axco Motors –case. This case was chosen as it represents one of the ‘success stories’ of commercializing high-tech research. Moreover, the factors related to lunching a high-tech based company came Axco Motors and Aurelia Turbines, where in the later was highly recommended by Green Campus Innovations as a point for benchmark, with good reason.

3.4.1 ORC.COM

Organic Rankine Cycle or ORC was a business development process at Lappeenranta University of Technology, which was supported by the Technology Business Research Center New Venture Services or TBRC. The project started in June of 2012 and was set out to be a two year project under LUT Energy. (TEKES, 2012)

The aim of the research project was to bring generic knowledge and solutions that could be utilized to realize third generation ORC technology under 100 kWe size scale. The micro ORC-power plant markets have been growing significantly and the market potential for micro ORC- power plants has been counted to be highly potential. General applications for micro ORC-power plants are waste heat utilization of combustion engines, micro gas turbines, biomass utilization in heat and power production or heat and power generation in households. This particular field has been of interested in LUT for the past 30 years, thus making LUT Energy Systems one of the most advanced research specialist in the field. (LUT, 2015)

The actual idea of converting the waste heat from emissions to electricity sprung up in the 80's when particular research laboratories started building ORC –energy facilities. Still to this day the process of getting energy from heat is too limited as the temperatures are too low to be used in a traditional steam process to be converted into electricity. Thus Prof. Backman's team started researching the possibility to build a high speed turbo generator that uses an organic medium, in which the rotation speeds would get as high as 30 000 revolutions per minute or rpm. This is a goal that can only be achieved because of the advantages that have been done during the past 30 years.

According to Prof. Backman: "The turbo technology was the easiest part. The problems we had where in tribology [bearing technology] and in power electronics, as we had to convert the high frequency of 500Hz to 50Hz which is acceptable for the common electricity grid." Now after three decades of research it is finally possible to build a working solution. The project's focus was to gain as much energy from a piston engine (diesel motor), which burns either liquid or gas fuel. Normally a piston engine can convert around 40-45% of the used fuel to electricity, with a huge loss coming from emissions heated up to a couple of hundred degrees. "Our idea was to place a small powered ORC, which would take an additional 10kW of energy from a 200kW piston engine." as Prof. Backman explains. "It is not much, but when we want to develop the efficiency of piston engines, then it becomes an important addition which cannot be achieved by developing the motor any further." he continues.

3.4.2 HEX.COM

The project following ORC was called HEX.COM or in short HEX. The idea behind HEX came as the people involved in ORC started to see that the prototype was not going to finish on schedule. One of the most significant technical setbacks was that in the ORC project they had to use the already on-market warmth regulators, which were enormous in size. This meant that the prototype would have taken two to three times the space than with the intended, more updated, model. As Prof. Backman puts it: "You will get 10kW extra from a 200kW engine when you put this big thing right here, it just won't work."

The original goal of the team was to build an even more upgraded version of the system, but because of budget limitations they ended up using the old devices from the previous project. Still, the team was able to develop a completely new heat transfer component with two different versions of the same solution. The components ended up being successful, which resulted in two separate patent applications that are still pending. The project was set out to be a one year project, which would in parts be running simultaneously with the ORC –project.

The idea was to convert the 160kg heat transfer component which was already build to a component that would weigh only 8kg. This gives an idea how ambitious the project really was. The idea had bases on previously done theoretical reports on heat transfer ratios as well as the previous findings and expertise of the team involved.

This gave the team a spin-off idea to develop their own heat transfer system. The next logical step was to pitch the idea to TEKES. The team decided that they would need at least another half a million euros to get the project in the intended direction. Still the people involved where feeling optimistic and they ended up deciding that they would not work on a full scale solution, but instead just developed the actual heat transfer component which was the most important part of the whole solution.

The more limited funds also meant that the team had to work with a much smaller team than before. They ended up choosing three key people to the project, which would include Prof. Backman as the supervisor, a project manager for LUT Savonia and a master's theses worker from LUT KONE. The team was decided keeping in mind the possibility to start a business from the research right after the project was scheduled to end. In practice this meant that also the technical experts involved where focusing on the commercialization aspects of the project, even though the nature of HEX was rather technically oriented.

3.4.3 Axco Motors

Axco-Motors was founded in 2004 from a research project in Lappeenranta University of Technology. At the moment the company employs around 7 people and is still led by the founding member Mr. Asko Parviainen. The core competence of the company is the production of tailor-made permanent magnet generators and motors for small wind and water solutions. In 2013 the company's revenue was 1,95 million euros. (Kauppalehti, 2015) On the December 15th 2009 Axco motors got awarded the Innosuomi –price, which was handed out by Finland's president Tarja Halonen. The price was awarded for developing energy efficient electric generators, which enhance the overall solutions' dependability and efficiency. (LUT, 2012) The steady growth of the company has been made possible by the customer oriented production as well as the strong knowhow of the people involved in the business.

The idea behind the start of Axco Motors came originally from a TEKES funded project inside LUT. It was set out to be a two year project, where the actual development of generators and motors was just a small part of the project. The actual focus on the project mentioned was the development of induction motors. As the project was ending it was clear to the people involved that the project results would have potential for a new business.

During the first years the company made another important decision, which would help expand the business even further. This was the active seeking of outside funding. In addition to the private funds the founding members had put in, the company applied for funding from several public institutions. The work paid off ones the company got a positive resolution from FinVera, ELY and TEKES. As Mr. Parviainen would put it: "The company has to have at least a year's worth of financial ground to start working. So if it looks like that we could run out of money in six months, then it is most critical to start finding more right away. Because if you start when you have money only for a couple of more months, the investors won't look kindly on giving more. So it really brings credibility."

The company saw this as an opportunity to expand, and in 2007 the company had already around six employees. The logical place to find fresh recruits was the technical university, which was only a few blocks away from the company's first offices in Technopolis Lappeenranta, and in the end the company found a master's theses workers as well as a doctoral student to work on product development. Also a machine engineer and a heat simulation engineer were recruited to widen the knowhow inside the company.

3.4.4 Game Cloud

The Game Cloud project has its roots in the strong knowhow of information technology in Lappeenranta University of Technology. The idea behind Game Cloud is to solve the marketplace visibility problems that new platform games come across. The research focus was finding how games could operate in an interconnected way, which would also allow the games to promote each other. In other words the games would work as references to each other inside the game world.

The concept has been stretched even further as interests outside of the game world have been found. For example the idea that the players in a sports game would run a little bit faster if the player has personally gone jugging. As Assoc. Prof. Ikonen says: "By bringing some information from the customer's life, it is possible to alter the way the game is played." He continues: "Think about the possibility that by doing some extra work in your Swedish course you would be given the possibility to open a new power tool in the game. So the player would be able to use hers/his study achievements, or sports achievements as a kind of currency in the game." As a reference it has been found that there are already scenes were two different games try to work as one, but a similar ambitious project as the Game Cloud is new.

The actual funding for the project was received in autumn 2012. From the start the project involved three people, including Assoc. Prof. Jouni Ikonen. The other two people were also staff from LUT. One of them being a doctoral student from the business department and another a doctoral student from information technology. It was seen that the project had a strong bases to start with as the people involved in the project had both a strong knowledge of gaming and IT –systems as well as a highly educated person in economics. Still to this day the project is ready to be lunched as a working business.

A communication platform is being developed to further the cooperation between the games of different developers so that data can be shared with other developers through the same interface. The idea is to simplify the storage and transfer of game data so that game developers only have to implement the references to other games inside their own game world. The service would also provide the developers with additional use statistics. In other words there is a great potentiality to be seen in the Game Cloud project, which will help advance the growth in the gaming markets.

3.4.5 Aurelia Turbines

Aurelia Turbines is a company that is founded for the purpose of commercializing micro turbines developed in co-operation with Lappeenranta University of Technology. The micro turbine developed have the nominal power output of 450kW with a net electrical efficiency of 45,8%. This makes the

micro turbines unique in their class as the efficiency rate is much more than with any other existing technology (EASME, 2014). Furthermore, the easy recovery of excess heat from clean exhaust gas makes the micro turbine well suitable for almost any combined heat and power (CHP) application. The tagline for the company is: "The most efficient micro turbines in the world." (Ecosummit, 2014)

The developed gas turbine is considered to be perfect for the growing distribute energy markets. The test results show that the efficiency and overall effectiveness of the developed turbine out performs all the other generators that are used in the energy markets. (Ecosummit, 2014) The new design also enables the products to be as ecofriendly as possible having a minimal emission rate on NOx and other greenhouse gasses. Also the fuel flexibility for renewable fuels makes it one of the smartest solutions on the markets.

The new business idea was created by Mr. Malkamäki during his years in Greenvironment. At the time the company bought its micro turbines from Capstone, which made the world's largest micro turbines at the time. The company was not fully satisfied with the 30kW micro turbines they were purchasing and even the expanded version of a 65kW micro turbine was not sufficient. This gave way to the idea of developing a micro turbine of their own, which would be as effective as the ones they were already buying, but at the same time more efficient in the industrial use. As Mr. Malkamäki puts it: "It's like taking a car and making it a bus, you cannot just scale it up, the whole design has to be changed." "The idea that we had was not to do this basic gas turbine combustion chamber, but more of an industrial grade combustion chambers, so big and ugly." he continues.

The next step would be to work with the people in LUT to see if there was market potentiality for the idea of a more developed micro turbine. The deal was that Mr. Malkamäki would be in charge of the business development of the company as well as getting possible investors as well as customers onboard, and that LUT would focus on the technical development of the micro turbines. As Mr. Malkamäki puts it: "So if the project seems to be working in the long run we can move/buy the IP from LUT and LUT would get a nice share of the company trough Green Campus Innovations aka. LURECO."

Aurelia Turbines employs five people at the moment, but the company is actively searching for more people to join the growth company. Also Aurelia Turbines has full control over the Intellectual Property rights and exclusive access to the design of this micro turbine which, in part has contributed to having already signed Letters of Intent for the sale of 245 turbines. These turbines will be delivered in first three operational years of Aurelia starting in the end of 2015 and can equate to a turnover of more than 100 million euros.

4 THE SUCCESS FACTORS AND UNCERTAINTIES ASSOCIATED WITH COMMERCIALIZATION RESEARCH PROJECTS

When evaluating whether a university high-tech research has the potential to be commercialized or has the possibility to become the bases of a business, it is most important to know the uncertainty factors involved. By analyzing these factors it is possible to roughly determine the success rate of a business based upon a university research. According to Brashers (2001) the uncertainty factors in building a business can be specified as a state were the details are uncertain and complex, were information cannot be found or it is illogical. This uncertainty usually leads to state of insecurity among the participating members.

When analyzing the uncertainty factors involved in commercializing university research, it is important to clarify the difference between uncertainty and risk in this particular context. Risk is involved in situations where the options or choices are clearly seen and where the possibility of a certain risk can be calculated and reflected to the other possible choices. Were as uncertainty in its self cannot be calculated and the multitude of choices is unknown. (Bullen, Fahey & Kenway, 2006; Hall, Matos, Silvestre & Martin, 2011)

According to Bessant (2008) there are three levels of uncertainty in the creation of business: The markets, the technology and the operational environment. Souder & Moenaert (1992) also include the customers' needs, competing solutions, technology and resources as levels of uncertainty. Still, one thing can be said with confidence; by understanding the different aspects of uncertainty, one can minimize the risk that uncertainty brings to the business. (Rehn & Lindahl, 2011)

In this chapter this study will analyze the different uncertainty areas which are dived into five factors: *The team, market potential and competitiveness, product and technology, Funding* and *Steering Group*. All of these factor will be analyzed individually and the importance of them will be highlighted with the data gained from the interviews and final reports provided by TEKES. The aim of this is to give understanding of the importance of each factor and their effect on the overall project. In a sense they have been put into order by their level of importance, but it should be stated that all of them have to succeed in at least some level for the project to succeed. This will also provide an answer to the first research question: *What kind of factors, and uncertainties related to those factors can be found in the high-tech commercialization research projects?*

As the uncertainties related to these factors bring such a drastic weigh on the success, a short list has been presented of failures connected to a high-tech research projects that Kotler and others (2003) have presented for us:

- The focus is on the technological development even as the market potential seems to be inexistent
- The idea is excellent but the market size is over scaled
- The product has not been designed to satisfy customer needs
- The product has been wrongly segmented to the markets
- The product has not been marketed or is over priced
- The distribution channels have been wrongly chosen
- The manufacturing costs are unexpectedly high
- Competitors respond better to your product than expected

In the last section of this chapter this study will shortly go through the conclusion to the first subject of factors and uncertainties related to commercialization research projects. This study will also provide an illustrative hierarchy to better present the results for the first research question. This hierarchy will be explained in detail in its appropriate section.

4.1 The Team

According to previous research the composition of the team is the single most important aspect when determining the potentiality of commercializing university research (Feeney, Haines Jr., & Riding, 1999; Kaplan & Strömberg, 2003; Sudek, 2006). In this regard, it is said that when building a business there are three aspects to consider, which are: leadership, leadership and leadership (Lahti, 2008). Robbins (1998) on the other hand states that a successful team is build out from five factors:

1) Integrity: honest and truthful actions
2) Competence: in human relationships and technical features
3) Consistency: trustworthiness, predictability and good situation control
4) Faithfulness: the will to protect other members in the team
5) Openness: the will to share ideas and information freely

The absence of a comprehensive and working team is also one of the main factors in failed research projects. In most of the cases the problems are concerned with insufficient know-how or experience,

lack of passion or commitment to the project, lack of trust inside the team or the ability to withstand and handle risk and uncertainty. (Mason & Harrison, 1996b; Lumme, Mason & Suomi, 1998;).

The importance of the team can be displayed by at least four different situations:

1) The survival of a research project as well as a newly founded business is depended on thousands of decisions that the team has to make during the whole process.
2) The know-how capital is much more important than financial capital
3) The key people in the project are irreplaceable as the information is cumulated to the people
4) Success comes from the ability to act and make the right decisions

The research or business plan is an indicator that defines the team's ability to make the project work. Also if the project is ever to gain the trust and belief of outside investors, the team will be the first thing that will be analyzed. An example of how venture capitalist would see a good team is stated by one of the interviewee (1) "We had an excellent team dynamic, everybody wanted to be in the company that could spring up from the project. Also the people who were working on the technical features and those on the commercialization side had good communication. It is probably because everybody working in the team was a specialist in their own field."

According to previous research the most successful teams are made out of a heterogenic group of individuals with different areas of expertise. Development and the creation of something new can only be achieved by social interaction between the team members as well as with the involved stakeholders. Jalonen (2011) argues that the uncertainty created inside the team is a consequence of personal interests and that by every addition to the team creates a new interest contradiction inside the team. In addition the team members commonly experience feelings of uncertainty as they cannot anticipate all of the consequences that the team's actions can have to themselves, to their inner circle or to the surrounding. Thus it could be a wise decision to use an outside resource for gaining expertise in an area that is not fully covered - as one of the interviewees (1) states: "Sometimes it is just best to find someone trough company contacts, so that she/he doesn't come from the same working environments as the rest of us." This is confirmed as well by the statement from another interviewee (2) "It really is lot of work to learn everything yourselves, sometimes it just is easier to hire a person from outside (industry)."

Gales and Mansour-Cole (1995) as well as Koch (2004) define teamwork and the interaction involved in it as paradoxal – at the same time as the team tries to eliminate uncertainties by teamwork they create more uncertainty as teamwork always is the result of aligning personal interests with those of others. This is better explained by a comment provided by an interviewee (1): "One of the team members,

a theses worker at the time, was enthusiastic about starting a company out of this. He was a mechanical engineer. Because we couldn't get everything working at that time, he ended up leaving to another company." In the long run this uncertainty can build up "over conservatism", which means that by trying to avoid disagreements and contradictions between the team members they end up doing nothing. A similar view is presented by Parjanen & Melkas (2008) who use the term "cognitive lockdown", which states that the will to avoid contradictions and disagreements inside the team can be so extensive that methodologies and ways of working will rarely be questioned by other team members. This can also have a positive effect when people in the team have mutual respect and trust in each other's work, which can be seen in one of the interviewees (1) statement: "Everybody knew who was good at what and everybody respected the work other people were doing"

"Our team dynamics had some problems as well, I mean we had a good technical working group but some people from the commercialization side were not present here in Lappeenranta, so it was definitely difficult to keep in touch. Especially as they were doing different projects at the same time as well. I think the best way would have been to have everybody who was working on the project on the same corridor to get daily updates on what was going on."

(Interviewee 4)

The statement given provides us with a clear view on how the problems in team dynamics can affect the overall outcome of the project. If the people involved are not located near each other there can be a lot of difficulties in keeping contact, as well as changing ideas inside the team. This can lead to misunderstandings and thus enhance the uncertainties already existing inside the team. Figuring out a problem or a direction together as a team enhances the possibilities of success which is also stated by one of the interviewees (4): "The next most important step is just to put all the people involved in the project or company to one room for a day and let them brainstorm. The more different people you have the better."

Individuals can also feel a sense of uncertainty in situations where their values, attitudes and beliefs or personality traits are in conflict with other members of the team. This is particularly seen when one of the team members is threating things that are important to other people in the team. This same phenomenon is described by Rajaniemi (2010) as "superiority of own profession" in relation to other team members and their efforts. This can also have a destructive effect on the surrounding and build a structural inhibition against other team members. This finding can be easily confirmed by the statement given by an interviewee (4): "I think one of the difficulties in working with our team was the differences in our research areas and the differences in work methods that this brought. Although we learned a lot about how other branches of science do research. In some ways it was too theoretical for us to be used in our project which was very commercially oriented."

Even though Zacharakis & Shepard (2001) state that analyzing team dynamics is much more important than for example market potentiality, it can be highly difficult to evaluate the different aspects of the area from an objective view. In the end analyzing team dynamics consists mostly from a subjective viewpoint and is emotionally based thus enhancing the uncertainty. This state of uncertainty should be avoided by all costs within the project team, which can be achieved by continuous interaction between the team members and the building of trust for future operations. As a conclusion this study has conducted a list of things to keep in mind when team formation takes place. The list is comprised of the qualitative data provided by the interviewees. These are also the major findings of this section. This is shown in Table 3.

Table 3. The Team -factor

The Team	Find team members from out of your usual working surrounds, e.g. from the industry
	It can be easier to find a person from outside the working group than learn everything yourself
	An energetic, experienced person to take the project forward from the beginning (leadership)
	You need a leader with a clear vision
	The best team dynamic comes from the mutual respect and trust for those working in different fields of the projects
	A bad team dynamic can have a dramatic effect on the team e.g. people leaving the project
	Exspecially in the beginning everybody should know what everybody else is doing
	Different working methods can make the working environment difficult
	People working on sales have to know what the technical people are doing and vice versa
	People working in the same project should be working physically close to each other

4.2 Market potential and competitiveness

Market potential describes the company's possibility and probability for growth and value increase, which is one of the most important factors for measuring success. Market size gives the requisites for understanding a company's growth potential. Mason & Stark (2004) state that sometimes the potential for growth can be seen even as the market size is limited. Market potential can be associated with market competitiveness. Generally market potential describes the situation from the market dynamics point of view, were market competitiveness focuses on the strength factors inside the company. In an

optimal situation both aspect are well funded. Generally when working in a research project where the aim is the commercialization of a product or service the market potential and competitiveness are subject of high importance which should be the matter of focus from an early start.

Market dynamics on the other hand include the competitors, operating models and rules for operation which all can wary depending on the industry in question. By analyzing the market dynamics one can assess the future prospects of a given market. The challenge in marketing and sales is attracting the potential customers. This being said the distribution chain should be already included in the research agenda.

The market competitiveness according to Sørheim (2003) is mainly based on a company's social capita. This means that the competitiveness of a company can be measured by the network and relationships a company possess. This means that the time spend on researching and developing a potential product or service for markets should also involve active communication with potential customers as well as with other partner organizations. In a wider meaning of competitiveness one can presume that a team's ability to work in the target market better than others is the single most effective measurement. In other words, the team has some know-how or contacts which it can use to create a business model that will allow it to penetrate the markets. A company's competiveness can also be based on a product or technology which is protected by a patent or other form of intellectual property. What should be remembered during the research phase is that a single product company will not be interesting for a longer period of times where as a product portfolio created around a protected technology will allow the business to develop next generation solutions.

"In the end of the project, we had several companies that were interested in our project. They said that they will come talk with us, right after the machine start working. This was all thanks to the early contacting that we made." "One of our first customers was a partner of our research project, so definitely it had helped that they [research group] had made initial contacts. At least there was some start for business because of the work done when everything was just a project." (Interviewee 1 & 2)

Aspects that kept coming up during the interviews was the importance of early customer contacting. By contacting potential customers the project team got a better idea of the target markets and what kind of a solution was needed on those markets. Not contacting customers and possible partners is usually the biggest reason behind an unsuccessful commercialization project. As stated before, using an outside workforce can be a beneficial way to start contacting potential customers if the know-how is not found inside the team. This is verified by one of the interviewees (1): "During this project it was the first time we saw how a professional does the commercialization. The difference was like night and day." Also it should be noted that for the boosting of team spirit, usually nothing is better than a successful deal done with

a potential customer as is stated by an interviewee (2): "Our first deal was where we had a feeling of success, the feeling that we had done things right." In addition to this, early contacting of customers gives a good image to possible investors, which will be addressed later on in this work.

"First thing to do is buy yourself a flight ticket and go to the potential customer! Five minutes with a customer is much better than a month searching the internet. Especially in a university society, you should just really go to the customer. Pitching the concept to potential customers is just so critical. Second most important thing is to do benchmarking on similar projects which have been successful." (Interviewee 3 & 4)

There is a lot of ideas on how a project should be started, even literature gives numerous strategies and steps for the start of a project. Still according to the interviewees, the best way to start a commercialization project is to go directly to the potential customers. This is something that the university society seems to be dreadful of. The given theories tell us that everything from product tailoring to pricing should be analyzed in an early phase as is also supported by an interviewee (2): "Especially in the beginning we did a lot of product tailoring for our customers. At least some parts were always modified according to the needs of the customer. We usually do what the customer wants." Still in the end even researchers just have to pick up the phone and call the customer to really know what they want as is later on emphasized by the same interviewee (2): "In the beginning we were working a lot with product developers, but usually you should really focus on the customers in the beginning."

"The best way to find customers by far is to visit fairs, exhibitions and meet potential customer's personnel over there. There usually is at least some sales officer or even a CEO standing over there. So that is how we started out. Usually we won't have our own stand though, so we'll just go walk around. Also just doing basic research by internet, you can find most big players." (Interviewee 2&3)

This study has not analyzed the ways in how or where customers should be contacted. Still according to the interviewees some basic forms of meeting new people are trough fairs, exhibitions and internet searches. The reason why this has not been addressed further in this work is that these methods are already well used in LUT and thus do not need further attention.

Markets are full of different uncertainty factors, but in general they can be divided into three main categories (Jalonen, 2011):

1) Customers and the uncertainty related to them
2) Uncertainty of competitors actions
3) Pricing development of the competitors' product (or service)

The uncertainty factor related to *customers* is one of the most significant factors when calculating the market potential. It originates from the uncertainty related to the customers' needs, the actual demand

for a product or service, and the buying behavior of the customer. Harris & Wooley (2009) state that the prediction of future needs of the customers are rather difficult to predict even as the current needs are fully understood. This is why a research project before entering any given market is highly beneficial for the commercialization team, as it gives adequate time to study the target markets before entry. Thus providing a larger understanding of the customer behavior and the possible reaction to a new products.

The uncertainty created by competitors' actions is the second largest uncertainty factor. Usually a start-up company's market logic is based on the assumption that it is acting differently than its competitors or other actors in the target markets. From the viewpoint of the customer it does not always seem so, as it can be extremely difficult to truly stand out. This is most commonly the result of unawareness of the customer, maybe understandably so. The situation becomes even more difficult when the globalization of economics and world politics change the behavior of a given market (e.g. fluctuation of oil prices in the mid 2010's). Usually when considering a commercialization project while under the control of the university, it is suggested that a comprehensive competitor analyzes is done to fully understand the focus markets.

The pricing development of the competitors' product (or service) is stated as the third major factor in bringing uncertainty to markets. It includes the development of products as well as the entry of completely new products which can unbalance the markets. For example the changes in pricing of a competing or replacing product's raw materials can have a decisive effect on success or failure to sell a product. Thus it becomes highly relevant to build a working supply chain while building or developing a prototype in the research phase.

A fourth uncertainty factor is also suggested by literature. According to Lowe (1995) an ambiguous legislation can have a dramatic effect on how the markets react to a new product. The same law can be interpreted diversely in different countries or even inside the same country. In a smaller scale this phenomenon can be seen in pricing policy in different counties or cities. Generally this can be seen in the way the given technology is protected (by patents and other IPR). Usually the more radical a company's product is the greater the uncertainty level is. Fortunately for LUT, the level of know-how involving IPR is high and patenting is one of the first things a research group involved with high-tech development will have to deal with.

"The commercialization aspect of the project was working in perfect alignment, but the prototype just was not working. I think that the biggest problem we had with commercializing the project was the proper lack of resources [human and financial resources]. They got depleted totally." "Don't focus too much on releasing articles, but focus on doing business." (Interviewee 1 & 3)

The uncertainties mentioned previously can be seen also in the comments of the interviewees as some of the biggest problems for getting to the markets have been: *product related problems*, *resource related problems* and *focus related problems*. Also the belief that customers will just come to you is a ludicrous idea and still a common acceptance. This is also stressed by an interviewee (2): "We had the idea, well we will just wait for the deal. And the truth is that it won't always come. We should have had a bigger sales force."

In Table 4, this study will show the results of uncertainties and factors related to *Market potential and competitiveness*. This will better help to understand the main points and causes behind a successful fulfilment of market potential and competitiveness. This factor in itself can be considered as the second most important factor when commercializing a research project, as will be shown later on in the conclusion section. The main reason why market potential and competitiveness is considered to be more important than e.g. *The product and technology* is the fact that an idea has to have a verified market or customer bases before the actual concept of commercializing a product or a technology can be started. Also the target customers' needs and wants will influence the development direction of a product or technology tremendously, thus making it a priority in the commercialization process.

Table 4. The market potential and competitiveness -factor

Market potential and competitiveness	A well experienced business expert should be in charge of the commercialization
	The contacts that a business expert taken from outside the academic working environment can be a great boost to the potential business
	It is important to contact the potential customers in an early stage to develop the product in the right direction as well as understand the markets better
	Best way to find customers is to visit fairs and exhibitions
	The more people in general know about your project, product or company the better
	The first deal gives the biggest feeling for success, aim for it as early as possible!
	Contacting potential customers during the research phase can lead to longtime customer relationships
	The deals (customers) won't come to you, you have to go to the customers.
	The research group should not deplete their resources in an early stage, but rather divide them to the full extent of the project.
	Understanding the differences between customers gives you a better chance of getting a deal
	The commercialization has to go hand in hand with the product development
	Product tailoring is one of the best ways to attract new customers
	The marketing material should involve only the benefits of the product and reflect those on the customers' needs
	It is easy to say when too little effort has been put in contacting customers, it is difficult to say when too much has been done
	As a university project you should not focus too much on releasing articles but focus on doing business
	You should always benchmark projects that have done things right!

4.3 The product and technology

When considering what kind of a product one should create, it is most important to understand the attributes the customers' need from the product or technology. In commercialization, an idea in itself is not yet a product but once the idea get its physical form it can be called a product or at least a prototype of that product. What is relevant in the productization of an idea is to understand the problem the product intends to solve. What really makes the difference is the size of the problem. In other words is the problem big (have to) or small (nice to have). It is also important to understand the uniqueness of the product.

The fact that should be remembered in research projects' technical development phase is that the earlier the product development is done the less it will cost when the actual production begins. This is because the level of know-how is larger and the suppliers are well recognized. The stage of the product or technology is also a matter to be recognized. For this the FVCA (2006) has created an evaluation questionnaire to better understand the product or technology:

- What operations have been done to develop the product or technology and what has to be done before it is ready?
- Has the research and development operations been outsourced at any time?
- What are the trouble points of the product planning and how can they be solved?
- How is the testing of the product or technology executed?
- What is the lifecycle of the product or technology and what are the risks involved?

> "We have built already around 30 working prototypes and we know it is only through this that you can show that this idea really works! To those who really have the money, and who really want to invest, and who want that investment to actually produce something. So if it's only on paper, then it will not work out, not in any way."
>
> (Interviewee 1)

In most cases building a working prototype is the only way to really present the proof of concept to the customer. Sometimes simulation models and idea crafting is shown to potential customers, but to fully gain their trust a working prototype is needed. Simulations can be of course a cheap and easy way to show how the product or technology would work, but from experience in this case a customer or a partner is needed with previous understanding of what can be expected from simulations. As is typical for a product or technology oriented research project, product tailoring is used to attract customers and further develop existing relationships. The willingness to do product tailoring for individual customers gives an image of commitment and trust which will help in getting critical customer references. Later on ones the amount of customers has reached a sustainable level the

company can change the direction to a more standardized production. This is verified by a statement from the interviewee:

"Especially in the beginning we did a lot of product tailoring for our customers. At least some parts were always modified according to the needs of the customer. Even now we still do tailoring, we only have a few standard products. So what we do is use a lot of basic modules that we build our products upon, to save in material costs. We usually do what the customer wants. We try to modify our product really little today, so the products that we have are rather good and we can focus more in sales." (Interviewee 2)

In principle the risk of using a new technology is always greater than that of the old solutions, which means that the benefits gained from the new solution have to be well presented. A product or technology oriented company, as start-ups from university high-tech research tend to be, has to provide a solution that is new, cheaper, more unique and more essential than any other product or technology that a competitor possess. Even then it may not be enough.

"You have to have some offering that will attract the bigger customers, which is needed by that company because if the customer has a different supplier that supplies a similar product, then you don't have any chance. So what you can do is just make your product cheaper than the competitors. It really takes a lot of time and effort to attract the customers, and you have to show your face actively." (Interviewee 2)

Even though literature gives us numerous ways in how to attract customers with different attributes or marketing tricks, sometimes the price is the only thing a customer looks at. This can be a sad truth in B2B –markets as well, where companies are highly price oriented and want to reach for an optimal profit margin. This is something that should be remembered in product development during the research project.

Even as there are numerous ways to protect a new technology, all agree that at least some IP – protection has to be used. This can be more difficult than it would first appear as almost 70 percent of today's growth businesses are based on service innovations or that at least the product sold includes some level of service (TEM, 2013). Still, when talking about university research patenting and other IPR should be done in as early phase as possibly, if only because of the long period of time it takes to process a patent application.

Jalonen (2011) defines a product as: "a technical solution with the operations and services involved in its process". In many ways technology is the base where a business is build or a research project is focused upon. Harris & Wooley (2009) state that the uncertainties in products come from the technical details and the possibilities a new technology brings as well as the whole life cycle of that product.

The technology's level of newness is a considerable factor when measuring uncertainty as there are no or little previous knowledge of the products suitability, functionality or usability. When considering the whole product process that involves the operations, technologies and know-how needed to create a new product or service, it should be noted that without the actual business model to commercialize the product with the product itself would be useless.

Thus uncertainty in technologies can be divided into different levels. As Shenhar, Dvir and Shulman (1995) suggest:

1) Uncertainty of low-level technologies
2) Uncertainty of mid-level technologies
3) Uncertainty of high-level technologies
4) Uncertainty of extra high-level technologies

According to many researchers the uncertainty connected with the technology originates from the quandary that people and organizations have about the level of information and skills needed to operate the technology. So what should be remembered while the product is being developed in the research phase is that the technology can only be developed in accordance with to the expertise of the team members and their ability to utilize that technology. On the other hand, the development of technology is random and that the uncertainty related to the technology is not temporary but permanent. This means that not all of the organizations using a new technology will be able to utilize that technology even if they have succeeded on doing so with previous technologies.

In Table 5, this study will show the results of uncertainties and factors related to *The product and technology*. This will better help to understand the main points and causes behind a successful fulfilment of this particular factor. As is presented in this section, the product and technology can be seen as a tangible embodiment of an idea. This phase of materialization provides concrete proof of the concept, thus giving it validity. A prototype, as explained previously, is one of the best way to provide real evidence of the functionalities of an idea in practice. This in turn will help to gain the trust of customers, investors and other stakeholders.

Table 5. The product and technology -factor

The Product and Technology	Building a prototype is one of the best ways to test the concept (Proof of Concept), because it will show the possible technical problems in the technology
	It is imperative that the prototype is working during the research project to convince potential customers
	Building a prototype also allows the team to build a preliminary supply chain
	It is important to focus on how the prototype is presented to the world
	Patenting and IP protection are important when developing a new technology
	Cost effieciency is important to keep in mind when developing a new technology
	Doing product tailoring for potential customers will help you to develop the technology further and gain lasting relationships with the customers
	From product tailoring a standardization direction should be taken in product development
	New innovations and R&D are vital to the future of a company

4.4 Funding

"Getting start-up capital is always the most important and difficult thing to do." (Interviewee 4)

The main idea behind funding is to gain monetary resources needed to take a project to an actual business. There are many steps and stages for gaining founding, which have in common the need to proof the business concept to outside investors. The believability and accuracy of financial, growth and development forecasts provided by the project team is a good way to signal the team's know-how of a given industry to outsiders. Cash flow forecasts are the most common way to illustrate the strengths of a strong and reliable entrepreneurial team. One thing a research group should remember is that after the public funding is spent usually more funding is needed before the business can support itself. As is shown in the statements below, funding can be a matter of life and death for a start-up company as the cash flow and operation costs have to be covered. Also the fact that funding provides legitimacy in the eyes of customers can be a big boost to a start-up.

"I think the most important things one should remember when you start a business is to remember the cash flow, so you just have to have enough investments. It helps us tremendously when working with big customers, when you have some venture capitalist working with you as it really gives legitimacy to our business." (Interviewee 2 & 4)

The financial statement of a company is one of the first things outside investors will look at. When talking about a research project, the budgeting and the actualization of that budget gives a crystal idea of how and where financing is needed. By reflecting the financial statement or a project budget it is possible to build a forecast model of the sustainability and profitability of the to-be business. Forecasts based on the history of a project or the early years of a company do not, of course, predict the changes or new competitors in markets. This is why it is necessary to compare different earning models before entering the markets, as it can have a significant effect on the company's cost and financial structure.

"As I look it from the technical side, I wish we would have ideas that could been developed through this funding stages. I would say that all these ideas would have been long time ago in commercial use, even without the help of TEKES. It really is hard for me to believe that we really have those kind of ideas that you just give it a little bit of money and that would be all it needs." (Interviewee 1)

The technical development is in all aspects a concreate way of showing that the technology works. Thus a working prototype also gives legitimacy for investors as they can see that the funding has not gone in vain. As is stated by an interviewee above; funding in itself is the key for successful commercialization. Even though forecasting the investment and financial needs of the first years of a new high-tech oriented company is highly relevant, as also are the uncertainties related to the subject significant. As an investor you can only trust in the accuracy of the forecasts of sales amounts, pricing policy, predicted problems in markets, needed employees and other cost factors. This is why in general terms like 'risk investments' or 'risk investors' are used.

"Just with our own money and public money you just won't get far enough, you really need the capital investors. Personally I have been really satisfied by the business angels we have, they have even give us some support, and could give more because of their experience." (Interviewee 2)

A good example is given to us by the interviewee, who states that capital investors can also give more than financial help. Capital investors are known to not steer the actual project or start-up company because of the general believe and good-will commitment towards the entrepreneurs. Still it could be beneficial to ask for the advice of these capital investors as they in general have previous experience on how young, high-tech oriented, companies should be managed. This is helpful when trying to avoid the general risks and uncertainties commonly seen in similar start-ups. All in all, investors in

general are a resource whose' interests should be provoked. The summary of the findings can be seen below in Table 6.

Table 6. The funding -factor

Funding	Most high-tech oriented start-up companies need a lot of funding
	Cash flow calculations are one of the most important things to have when talking to possible investors
	There are many forms of risk investments: public investors, venture capitalists, business angels ext. The terms of getting funding vary depending on the form of the investment
	Having venture capitalist behind you brings reliability to the company
	Getting one investor onboard usually leads to more investors
	Funding leads to the possibility of further technical development
	Investors want to see results
	The reaction of risks investors can vary a lot, go talk to many people to get a better idea of your situation
	Funding is only one part of the problem, you have to have everything else in order before you try to get money

4.5 Steering group

A steering group can be defined as an entity of people with different roles that provide guidance and support to the actual research group or team working on a given project. Its aim is to steer the research project in a direction that will allow it to become successfully commercialized. This is mainly due to the previous experience and knowledge the steering group members bring. A steering group has three distinct roles in the governance of a research project that are:

- Communication and consolidation role
- Negotiation role
- Decision making role

From experience it can be said that the members of a given steering group can bring important links to potential customers as well as other partners needed to successfully commercialize a product or technology. These people can come from other public institutions like TEKES or partly government owned companies related to the given technology, which could work as possible customers or benefactors of the project results. Other steering group members can come from the private sector, providing important information of a target market or the trends dominating the markets. Also possible investors and university stakeholders are commonly working in steering groups of commercialization projects.

There are three different kind of people in a steering group that all are necessary and that influence the execution and success of research projects. The three managerial offices are:

- Coordinators
    - That steer the strategic direction of a research project and;
    - Facilitate cross-projects and cross-department coordination
- Controllers
    - That establish, update and provide the information base for decision making and;
    - Deliver corrective measures in supporting for top management (project supervisors)
- Supporters
    - That provide services to project managers and;
    - Cultivate standards within university project portfolios

These statements are also in line with the findings of Beringer, Jonas and Kock (2013) whom have provided evidence of the behaviors of internal stakeholders in projects and the way they are managed. According to these researchers the diversity of people in the steering group can bring a lot of new and important ideas and contacts to the project team that would otherwise be unnoticed. The only risk related to this is the lack of interest or time that the steering group members provide for the executive team. In similar lines is a statement from one of the interviewees:

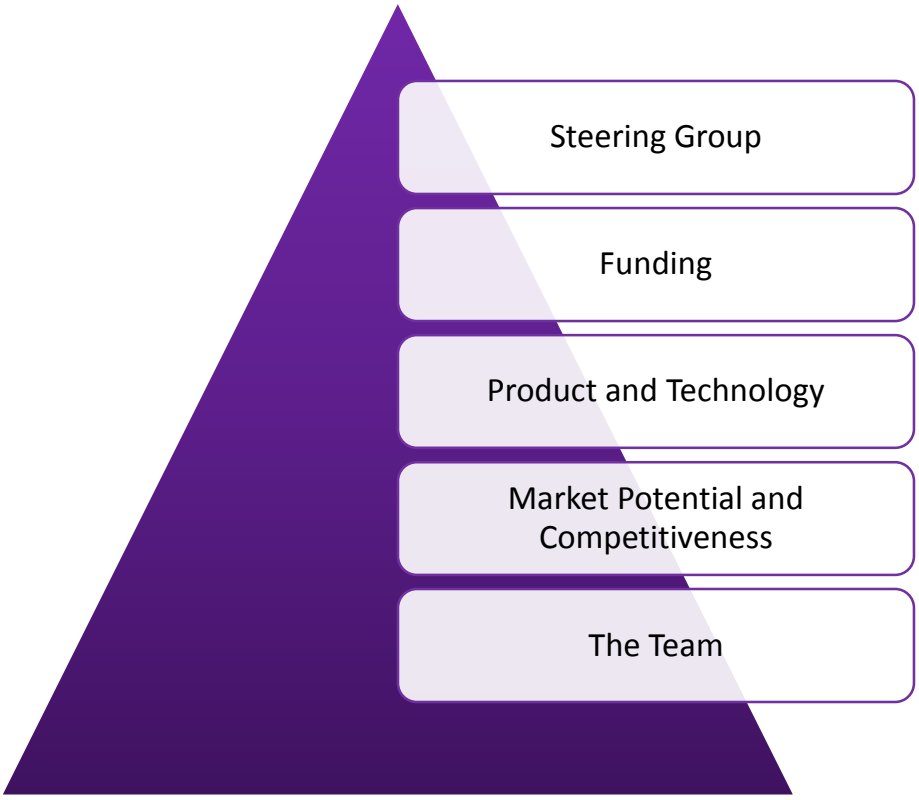
"Our advisory board was rather diverse, so we had people from public organizations, business life, technology, so that was something that was done really nicely. Unfortunately they all did not have time to come to the meetings"
(Interviewee 1)

4.6 Summary

Now this study has provided tangible evidence of the five main factors and the uncertainties related to them when considering the potential of success of commercializing research projects. The five main factors were: *The Team, Market Potential and Competitiveness, Product and Technology, Funding* and *Steering Group*. As can be seen from the hierarchy below, in Table 7, the factors have been put into order of importance. This does not, however, mean that a previous factor has to be completely covered in order to continues to the next step, but rather that they provide the possibility and bases for furthering the research process.

The hierarchy of the different factors are based on the general focus that has been found during the literature review as well as the statements provided by the interviewees. It is not, on the other hand, a hierarchy that is determined strictly, but rather a hierarchical process of actions in the order they should be taken due to the fact that the previous determines the possibility of the accomplishing the next step. As has been stated before, these different factors are not directly connected to each other, but rather provided a bases on where the next step is built upon. This provides the possibility to work on several steps during the same time or even come back to an earlier step after another one is completed. In other words the hierarchy states the different guidelines found to effect the successfulness of commercialization research projects.

Table 7. Bebek's hierarchy model for high-tech commercialization research projects.



The first step is *The Team*. It is the cornerstone that the whole project will be built upon. The team is generally responsible of creating, developing and pitching the idea from where the project will start. As has been stated earlier the team should consist of a variety of experts that have the necessary skill set and will to take the idea to a project. Also it is important that the team members are relatively close to each other and keep in frequent contact with other team members, especially if they are working in a different area of the project. All in all, the team will be the executive group that will be responsible for doing the actual work and also they will be the members best suited for the possible spin-off company that could be created from a successfully commercialized research project.

The next layer of the hierarchy is the *Market Potential and Competitiveness.* As has been stated earlier the main reason why this has been classified as more important than the next step *The Product and Technology* is it's important to first test the concept or idea to the potential customers (markets) before building a product or a prototype. The product or technology should be done according to the needs and wants of the customers, thus enhancing the need to verify first the markets. Also as the projects in question are commercially oriented the focus will be firstly on the verification of the markets and only after this will the focus be in the development of the technology. As has also been stated earlier, an outside agent can be highly beneficial for a research group if the know-how is not found inside the team. This also provides an excellent example of how the co-operation between faculties can drastically enhance the possibility of success of research projects, when know-how is lend or gained from other researchers.

The Product and Technology is the third layer in the hierarchy and one of the most important aspects of the whole process. This section provides details on how an idea is made tangible and how it will affect the team, customers, investors and other stakeholders by providing proof of concept. The possible prototype recommended to be built is in the core of this layer as it will be the bases on which production, product development, marketing and image will be based upon. As was stated by one of the interviewees the prototype is probably the only tangible evidence of the idea working in practice, thus the importance of it is well placed.

The fourth layer is *Funding*. Even though it may seem like a logical step even before the other layers, it is actually only a booster to the commercialization project. A lot of great inventions and even implementations have been done with minimal or no funding. Never the less, when talking about high-technology research projects, funding is usually needed to develop, build and commercialize the technology. Thus, as stated earlier, it is important to address the need for funding in an early stage. As a public research project it is logical that the actual project will firstly be funded by a public institution like TEKES and later on by private or half-governmental venture capitalist or individual

angle investors. Nevertheless, the amount of funding needed should always be known and calculated precisely to bring credibility to the project.

The last layer, as a cherry on top, is the *Steering Group*. This Group consists of a variety of experts that bring direction and general steering to the project. It is commonly generated from people from the public sector as well as the private sector so that potential customers, partners, investors and other stakeholders are well represented in the steering group. The importance and impact to the projects of steering groups is something that should be research more to fully understand the potential gained from an effective and diverse group. In any case, it has been shown that the steering group can have a significant boost in commercializing high-tech research projects by brining experience, guidance, contacts and investments to the project and the executive team.

Now this study has explained in detail the hierarchy shown this conclusion section, which will be the base for commercialization projects now and in the future done in the university. As an additional note, this hierarchy has already been successfully used as a framework in several commercialization projects done in LUT and Saimia by the commercialization team that the author is also a part of. There is no doubt that because of the successfulness of these projects in question, this particular framework will also be used in projects to come. It is of course after several years of work that one will have tangible data of the overall successfulness of the projects using this framework. Still it is the wish of the author that as many research projects would benefit from these findings.

As a conclusion, Table 8 provides ten most important aspects that should remembered when commercializing a research project. Theses ‘commandments’ are directly related to the hierarchy of commercialization factors that has been presented earlier and are gathered from the findings previously explained in this chapter. These ten aspects are meant to work as a short list or guideline for starting commercialization projects to remember the ten most important aspects. Still for a complete and fully understandable commercialization guideline, one should asses all of the aspects provided previously in the analyzation of the different factors related to commercialization.

Table 8. The ten aspects of commercialization

The ten aspects of commercialization
Find team members from out of your usual working surrounding
The best team dynamic comes from the mutual respect and trust for those working in different fields of the projects
People working in the same project should be working physically close to each other
It is highly important to contact the potential customers in an early stage to develop the product or technology in the right direction as well as to fully understand the target markets
The customers wont come to you, you have to go to the customers
You should benchmark projects that have done things right
Building a prototype is one of the best ways to test the concept (Proof of Concept)
Product tailoring for potential customers will help to develop the technology futher
High-tech oriented research projects need a lot of funding, get it early
An experienced and active steering group will provide guidance and direction for the research project

5 A PRAGMATIC VIEW OF THE STEPS FOR EXECUTING A COMMERCIALIZATION RESEACH PROJECT

In this chapter the study will analyze what steps should be taken in different parts of a research project to enhance to success rate of a commercialization project. The chapter has been divided into three different categories in a chronological order. The first section focuses on the period prior to the research project, where the first ideas only begin to take shape, before the actual funding is granted to the project. The second section coverages the first half or usually a year of a commercialization project where the initial steps are taken towards an effective commercialization project. It also states what characteristics a period report should include incase it is required from the funding organization, e.g. TEKES. The third section addresses the importance of the different work packages and the typical goals set for this stage of the project. Also it gives an idea of what an end report should look like, which also in most cases is presented to the funding organization.

5.1 Steps to take before the start

First there is always the idea. An idea can be formulated as an individual, a group of people or as a collective mind. There is no right or wrong way to get an idea, there are only the right and wrong ways to develop that idea. In the university community that this study is analyzing, an open environment is most commonly the best booster for developing an idea. Most likely the actual development of an idea is done inside a predefined research group or a social group, most commonly consisting of people having similar academic backgrounds. Still the most important thing to do once one has had an idea is to “open your mouth”.

If an idea gains interest and believe from one’s peers, then it most usually becomes an entity of interest to that particular group of people which allows them to commit to that idea. At this point, before taking the idea any further there are some basic tests done to give proof the concept even if it is still done in an intangible level as is also recommended by Kotler and others (2003) earlier in the theory section. Further on the idea is pitched to higher level officers at the given organization to see if it has any chance of giving birth to an actual project. This phase usually takes a lot of time in public organizations such as a university, but it also gives more validity to the idea as it is assessed by more experienced confidants with a mainly objective point of view.

Ones the idea has been accepted by the appropriate personnel in the organization and gain the trust and interest of those people then the actual planning for a project truly begins. Most commonly there are supporting branches in the organization itself which will help through the process of making an idea into a project. Still, this being the case, the actual group of people or ‘the team’ whom have been

in charge of developing the idea will also be the main people working for the development of the project. This also enhances the previously explained importance of a dynamically working team. Now that the team has had a green light for the further development of the idea the actual steps towards become the focus for gaining funding and thus creating an actual research project.

The steps for gaining public funding are determined into different sections which are combined from different research funding applications, previous experience through participatory action research and the cumulative framework of a company based in Lappeenranta focusing on conduction funding applications for projects done in LUT as well as Saimaa Applied Science. The approval of these funding applications is the single most important milestone in determining if the idea becomes a project or not.

The funding application starts as most academic works would start; by giving an overview and backgrounds of the to-be project. In these sections it is important to attract the reader's interest and to shortly but accurately describe the fundamental idea behind the desired project. Also all information and previous achievements on the particular field should be mentioned in this section; e.g. previous research or know how of the group members or suitable components created inside the research faculty. The second section should focus on the goals of the project ones funding is granted. The goals should be clear but also give room for improvement or even change in case the project takes an unexpected direction during the actual project work. Most commonly a commercialization project's goal include the successful business build from the project where a spin-off company is in the core of the project goal. The individual goals of people involved should also be mentioned, but for this a separate work packages should be identified as will be shown later in this chapter. An example of how project goals with sub tasks can be categorized is:

1) A strong knowledge of the market environment
    - Understanding customer needs
    - Geographical viewpoint; environment awareness or the situation in the markets
    - Size, role, culture and innovativeness of potential customers and partners
    - Machine suitability and requirements
    - Contacting potential customers and partners
2) Identifying the channels for a profitable business model
    - Supply and support partners, can be described by Porter's Five Force –model
    - Licensing
    - Place in the value chain; a solution or a component

- Assisting functions; simulation models
- Charting the subcontractors and other partners for technological and business development

3) Verifying the functionality of the key-technology or service, Proof of Concept
    - Simulation environment and development of the overall process
    - Authentication through CASE –examples

The third section consists of the NABC –analyzes which is vastly used in the academic work and especially LUT. The NABC –analyzes four main areas of a business model which are also commonly used in the demonstrations of the project itself. Porter's Fife Force –model is also an extremely convenient way to provide detailed data to the NABC- model. Underneath in figure 7 is shown the NABC-wheel provided by TEKES. The four areas are: (TEKES, 2012)

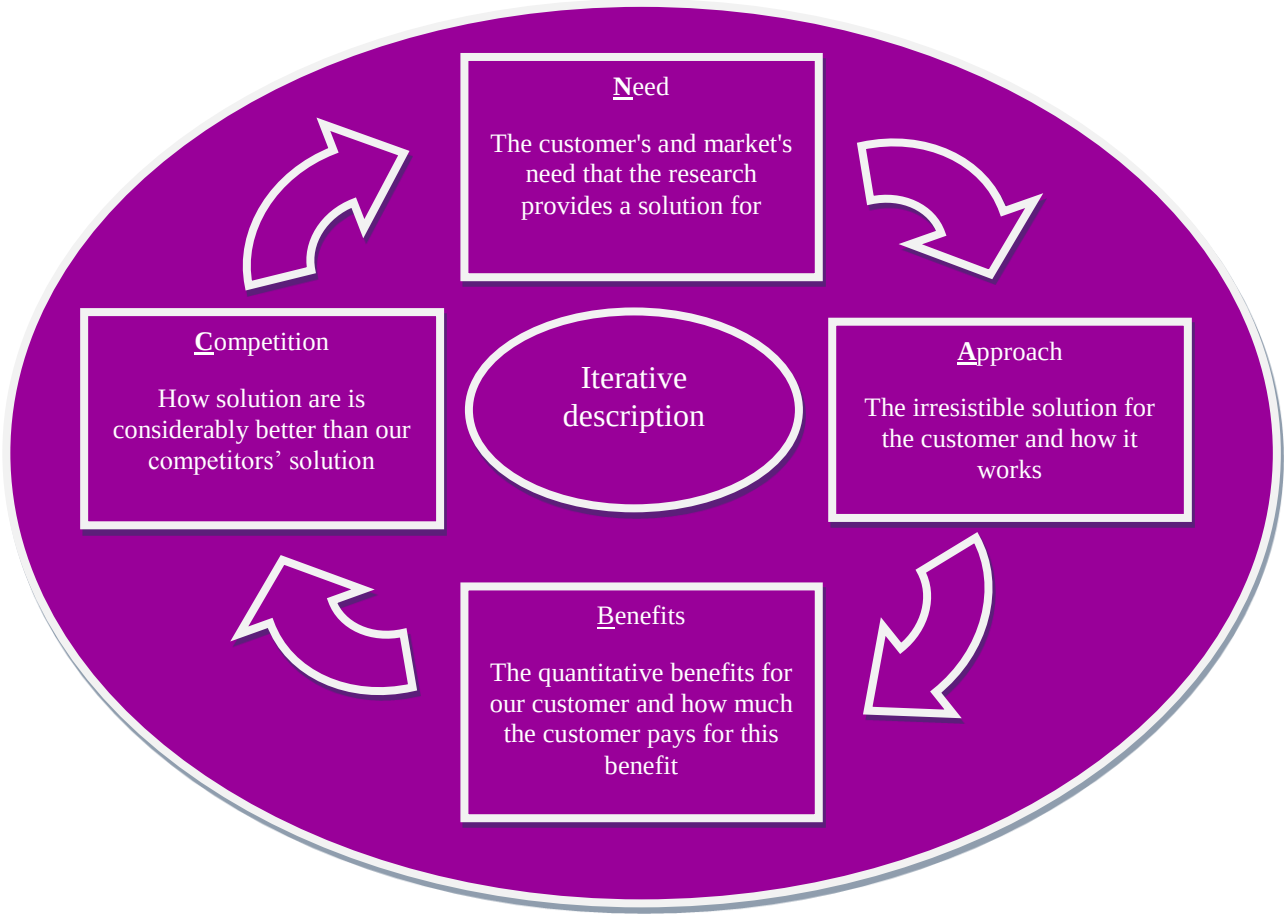


Figure 7. The NABC –model (TEKES, 2012)

1) Need, which indicates the need's for the product or services most commonly coming from the needs of the customers. It is said that needs are generated from only two sources, a necessity or excess money.
2) Approach, which provides details of the solutions or technology behind the idea that allows the fulfillment of a given need. The Proof of Concept is a typical indication of approach.
3) Benefits, which specifies the detailed differences of the new solution or technology compared to that of an existing or an older model. Also new technologies can arouse new benefits.
4) Competition, which naturally explains the current market conditions and the other players in the given markets that can oppose a threat or possible an opportunity to the project.

Fourth section is designed to give examples of different *scenarios for business development*. This means the different ways of creating a market with a given product or technology. The study has found that there are three main ways for a company to develop their business. The most inclusive scenario is *solution business* where the product or technology is implemented into other components related to the solution making it a fully functional system that the customer can install in its own products or use right away. Also the installation, maintenance and after sales work is included in this business model. The second scenario is *component business* where the spin-off company concentration its sales to the individual component it creates, thus focusing only in their core know-how. The last and least of the scenarios is licensing where the business comes from the usage of the patent by which the product or technology is protected by.

The fifth section consists of an execution timetable with detailed definitions of the work packages included in the planed project. The work packages should be divided according to the expertise or focus areas of the project such as: *Market potential and environment*, *Development of technical specifications for manufacturing*, *Business concept and gained customer value* and *Proof of Concept*. An example of the first work package is shown in Table 9 where the focus area of the work packages are indicated, with the subtasks listed with their intended moment of execution. Similar timetables should be provided from all work packages intended for the project.

Table 9. An execution timetable for a commercialization research project

Execution timetable	201x		201x					201x	
	Q3	Q4	Q1	Q2		Q3	Q4	Q1	Q2
WP1: Market potential and environment									
Defining the market environment									
Mapping and contacting customers									
Defining customer needs and requirements									
Value network - analyzes									
Product family and scalability									
Partners included in the business generation									
Managing the financial needs for starting a business									
Exhibitions and fairs	Exhibition or fair 1.					Exhibition or fair 2. and 3.			

The sixth section comprises of the actions required for starting a business. In other words it shortly describes the possible first customers which will also act as references, the people involved in the team and the project manager as well as the project supervisors and finally the financial indicators and the possible business outcomes. The seventh and last section gives a finalizing overview on the steps of the project with indicators divided into four main categories which will also be the proposition given to the public funding organization:

1) Budget and the timetable for using the budget
2) Expenses, funding and resources
3) Risks
4) Management team

In total this seven step process which is also shown in Attachment 3, as an example of an table of content for a funding application, is a way to determine if the idea should really be turned into a project lasting for around two years and having funding for up to a million euros. The funding application length is usually around 30 pages and should be compiled by the whole team. The example of funding application table of content is provided and the property of the company Clover Factory Oy.

5.2 Steps to take during the first year

After the first funding has successfully been approved for the project the actual work can begin. It is natural that the work packages will be the main focus of the first year so that the different team members assigned to those work packages are responsible for the execution of the work. Also it is vital to state, as previously shown, the importance of co-operation and communication between different team members in the project. Also the work packages should be executed in a fashion that provide support to the other work packages. In other words they should be done simultaneously so that no one package is done earlier than others and that none of them are left undone.

In a situation where a funding gateway is set, usually a year from the start of a project, the goal is to develop the project as far as is necessary to gain the rest of the funding after the first year has gone. If one is to look at the funding application and in specific those of the *Scenarios for business development*, *Work packages* and *Launch of the business* one can easily determine what the main goals for the first year are. Probably the simplest way for us to explain the goals of the first year is by explaining what a gateway report has to have in order to insure the funding for the second half of the commercialization project.

A gateway report would start as a funding report dose, by an introduction. This time the introduction should focus more the general actions done during the first year whereas the previous report's introduction was an outlay of the general idea. This is typically done by explaining shortly the highlights of the overall report. Also new technical features as well as changes in the project plan should be already notified in this particular section.

The second section, *Customer mapping and initial contacting* will provide a detailed set on what companies have been mapped as potential customers and why have some companies been categorized as not potential. Also it should be clearly explained that how the product or technology can be used in the potential customers' products or solutions. Also a conclusion on how the initial contacting has worked out should be added with the main findings of the reaction of potential customers towards the new product or technology. Generally an information package including a separate information set about the actual project and the technology developed with technical features should be presented to the potential customers. This will also help the potential customer to understand the aim of the overall project.

The third section, *Case companies*, should include the achievements being made in customer mapping and customer contacting. These steps have been found to be useful and in line with previous commercialization projects. The idea is to give a general idea of the process needed to be done in the

first year. Depending on the product or technology being commercialized the weight and time needed to accomplish each step can vary. Still it is important to understand that the process is in all ways similar in all commercialization projects. A general process that should be done in customer contacting is:

1) Mapping potential customers
2) Categorizing the potential customers by geographical location or by the products they produce
3) Creating an information package and other marketing material for the customers
4) Contacting the potential customers by phone and e-mail
5) Going for a company visit to the possible customers factory site
6) Inviting the possible customer to your project execution site for testing the prototype
7) Agreeing on future co-operation

As this step of mapping and contacting potential customers has been done successfully it is logical to explain in-depth about the individual company relationships that have been generated during the project. This can easily be done by providing examples of company cases that will be done during the project with pilot customers or other partners. One of the best ways to give validity to a new business are the cases done with customers. In other words this section should be comprised of different possibilities of entering a market. The cases themselves should include a general background of the target company, the steps taken towards creating the relationship, what concrete actions have been done and what future tasks should be performed. All and all, in a commercialization project this is the most important part as it will show if the product or technology truly has the potential to be commercialized.

Also a new section including the competitor analyzes should be done during the first year. Competitors generally bring validity to the markets as it is easier to proof the benefits of a given product or technology. While analyzing your main competitors it is important to assess the whole value chain, meaning their suppliers, manufacturing, R&D, marketing & sales as well as other partners involved in their business. Also by comparing competitors with each other will give a better idea on how your product or technology is better or worse than those of the competitors'. Also by analyzing the earning models they use, one can chose the most profitable version for the long-run.

The *Main achievements* section will provided detailed information of the state that each work package is in. It is also important to reflect the achievements of each work package to each other as they should work to benefit from each other. A simple way to present the state of each work package is an updated version of the timetable shown in Table 10 where the current state is reflected on those to come. Also

if there are any additions, deletions or changes in the timetable, this would be the place to provide that information.

The last to sections *Conclusion* and *Action plan for the next year* are meant to show the main findings and actions done during the first year and reflect those to the actions planned to be made during the second year. In this part it is common to benchmark the successful actions of the first year to the second. An example of this is a successful case with a potential customer that could work as a pilot company. The same methods used in contacting and creating relationships with that company can be used with other companies outside the main market zone, e.g. local markets vs. European markets. All and all the steps shown previously in the Table 9 should now have been completed in order to provide trust to the Steering Group and other members involved in evaluating the successfulness of the given project. The example table of content for the gateway report is provided in as Attachment 4.

5.3 Steps to take during the second year

After the tasks of the first year have been successfully executed and the trust and believe of the funders have been kept high, it is time to focus on the objectives of the second and most critical year of a commercially oriented research project. Generally it could be roughly said that the first half or year a research project that aims to commercialize a product or technology should mainly focus on the building of team, market potential and the product itself. In other words it is understandable that finding the proper team members, the potential customers and the channels of marketing the product or technology to those customers, as well as the development of a prototype can take easily a year's time. Still, all of these activities, be it difficult or not, should be accomplished during the first year in order to start successfully implementing the entry strategy during the second year. So, if one is to presume that the vital steps, explained more deeply in the previous chapter, are all achieved to a satisfying degree, one should focus on the tasks and goals to be done during the second year.

As argued before, the second year of a commercialization project will determine if the product or technology developed will ever have the chance of entering its determined markets. This study have provided an execution timetable, Table 10, for the third and fourth quarter of the X + 1 year, where X is the year the project has started and also for the first and second quarter of the X + 2 year, meaning the last half a year of the research project. It should be noted that the tasks and goals of the second year do vary according to the tasks and goals accomplished during the first year, but still this will give a general idea of what should be done during the second year.

When tasks and goals of the second year are compared to the execution timetable of the first year, shown in Table 9, one can immediately see that the focus has shifted from *defining the markets, mapping the customers, defining customer needs and requirements* and *value network analyzes*, which can be categorized generally as market research, to more sales oriented actions as *contacting customers, creating a product family, getting partners* and going to *exhibitions and fairs.* This is a very logical continuum when thinking about university research projects in general, which tend to be rather academically oriented at first, but later on become more implementation oriented.

Table 10. An execution timetable for the second year of a research project

Execution timetable	**201x +1**		**201x +2**	
	Q3	**Q4**	**Q1**	**Q2**
WP1: Market potential and environment				
Defining the market environment				
Mapping and contacting customers				
Defining customer needs and requirements				
Value network -analyzes				
Product family and scalability				
Partners included in the business generation				
Managing the financial needs for starting a business				
Exhibitions and fairs				

At this point the *contacting of customers* should be already done in a regular bases as the potential customers and partners have been mapped out during the first year. It is also important to keep in contact with those potential customers that have already shown some level of interest towards the product or technology in order to keep the relationship active. Also new contacts can be found through the first contacts as players in a specific market are best known to those companies generally involved in them. In other words contacts can proof to generate new contacts. It is also important to widen the focus area, which is commonly done by contacting potential customers from different geographical areas keeping in mind the famous Uppsala model provided by Blomstermo and Sharma (2003).

The way that the actions related to: *Defining the customer needs and requirements* change from the first year to the second is that during the first year the focus is on understanding and mapping the needs and requirements universally found in customers or companies in a specific market, whereas during the second year the focus is more in determining the individual needs and requirements of

specific customers or companies that could turn out to become the pilot- or reference customers of the project. This section goes hand in hand with the product tailoring explained in earlier chapters, as it is important to understand how, where and why the customer wants to use the product or technology provided to them.

Once a working prototype has been build and it can be shown to different stakeholders and partners, it also time to evaluate the possibility of developing a *product family* and the *scalability* of the given product or technology. The reason why these tasks are also defined under the Market potential and environment work package is that the development of the product or technology should be driven by the needs and requirements of the customer and not of the general desire of the developers. As is emphasized earlier, cost efficiency is key when thinking about taking the product or technology to mass production. In other words, you want to develop a product that will work without problems and with full efficiency, but only as long as the core product is set to last. As a practical example, there is no point in developing an electrical motor which lifespan is 25 years to a hybrid working machine which is intended to be used only 15 years, unless the point is to business out of the used components.

Starting a spin-off company from a high-technology research project is not easy, and nearly impossible without the help and support of partners from different fields. This is why a strong emphasis has been put into the section of *partners included in the business generation*. These partners range throughout the whole value chain, involving companies from the supplier side to funding organizations and organizations that provided a given part of the overall solution to the actual customers that will work as first references for the spin-off company. There is direct answer to what is the appropriate amount of partners needed to successfully commercialize a product or technology, especially as the aim of the commercialization projects can vary tremendously. Still it should be said that by co-operation with different organizations and companies the rate of success grows tremendously as the amount and the quality of partners bring validity and trust to the product or technology being commercialized.

The last section focuses on the *financial needs* of the possible spin-off company. Even though the project is still in its research phase where no actual business or revenue is allowed, it becomes even more important to map the possible investors that could help the spin-off to grow and allow it to further develop its technology. This is especially vital to spin-offs coming from high-technology research projects, as the financial needs of developing high-tech products is commonly high, as has been explained in previous chapters. Thankfully at LUT the risk-investment company Green Campus innovations is focused on funding and supporting spin-off companies coming from its parent university.

6 CONCLUSIONS

The focus of university research projects has been moving towards technologies that can be implemented and used by the general public. Boosted by this focus, commercialization research projects have become even more interesting and important for universities as they provide a channel for entering to markets with a given technology or product.

As was found during the literature review, previous studies concerning academic entrepreneurship and commercialization research projects tend to focus on analyzing the meaning of these keywords as well as providing extensive arguments for the need for these projects. On the other hand, the previous literature concerning these themes do not state *how* these projects should be executed. This problem is also brought up by scholars such as: Shane (2004), Wright et al. (2004) and Powers (2003).

What makes the need for a pragmatic study of the steps of successfully executing a commercialization research project in Lappeenranta University of Technology is the aim of the new strategy of creating 100 new companies by the year 2020. Thus, this study focuses on providing a practical framework of the different factors related to the overall theme, as well as to highlight the different uncertainties and reasons behind these individual factors, provide a guideline of executive steps to be taken in a commercialization research project, and provide an example of how to gain funding for these projects.

All in all, this chapter presents the answers to the research questions presented in the introduction and evaluates the results with respect to the limitations of the study. First the theoretical implications are discussed. In addition, limitations of the study and future research opportunities are identified.

6.1 The key results

The main results provided in this study are based on the analyses of previous literature focusing on the pragmatic side of creating innovations and commercialization of products and technologies in general. The main themes provided in the first empirical section, Chapter 4, are gathered from the findings done during the interviews. Also the information gathered during the literature review have shown that the focus of previous studies tend to focus on these particular factors. The actual results, as provided in the empirical chapters, Chapter 4 and 5, are the sum of findings done during the interviews, study of the final reports related to the cases as well as individual findings. These findings are explained in detail also in this chapter.

Earlier studies related to academic entrepreneurship have been mainly focused on the importance and general aspects of commercializing university high-technology research, with the exclusion of *how* this research should be commercialized in practice. Thus, this study aims to create understanding and find concrete steps to execute a commercialization research project, which has mainly not been the focus of previous studies. The aim of the study becomes even more important when keeping in mind that the commercialization projects in the university society, mainly funded by TEKES, have started in 2012 making them rather new as a phenomenon, making them an even more interesting target for research. Also the successfulness of the projects thus far have shown little results, making a universal commercialization framework, as is the aim of this study, a necessity.

This study has been executed by conducting a literature review on the subject of commercialization projects and academic entrepreneurships in general. As has been stated earlier, the focus of these previous studies have been on the importance and general meaning of commercialization research projects, leaving the guidelines for execution in the dark. Thus, the main literature used in the theory section focuses on general innovations and commercialization to gain a deeper view on the practical side of the subject. For gaining further qualitative data, four in-depth semi-structured interviews were conducted on experts from previous commercialization research projects. These cases where chosen by their level of commercialization, meaning mainly the stage that they are in after the actual research projects have ended. The data gathered was found to be highly beneficial and sufficient for the findings provided in the empirical section. As the data was gathered from the interviews and from the final reports, provided by TEKES, a cross analyzes was done to find similarities in the themes, later known as factors, to create an understandable framework from the data. In order to reach the set targets, the following questions were formed:

1) *What kind of factors, and uncertainties related to those factors can be found in the high-tech commercialization research projects?*
2) *How can a high-tech commercialization research project be successfully executed and what are the steps involved in the commercialization process?*

The first research question is answered in the first empirical section, Chapter 4, where the results of the literature review and the analyzing of the interviewees have provided. It was found that there are five major factors involved in the successfulness of commercialization research projects and that these five factors involve at least some levels of uncertainties. The five factors found are:

1) The Team
    - Which is focused on the composition and expertise of the team members, as well as the actual working methods involved in the team's working dynamics
2) Market potential and competitiveness
    - Describes the company's possibility and probability for growth and value increase
3) The product and technology
    - Analyzes what kind of a product or technologies one should create and that can be commercialized
4) Funding
    - Focus on the ways to gain monetary resources needed to take a project to an actual business
5) Steering group
    - An entity of people with different roles that provide guidance and support to the actual research group or team working on a given project

From these findings, ten most important aspects have been gathered, as is shown in Table 8, which should guide the commercialization research project from the early beginning and which should be kept in mind during the whole commercialization process. Also a hierarchical model has been created from these factors to better present the connectedness of the different factors. The aim of the hierarchical model is not as much to present the factors in different values as it is to show that they are part of a larger entity and that the different factors are dependent on each other.

The second research question is answered in the second empirical section, Chapter 5, which focuses on the executive steps that should be taken during a commercialization research project. Similar instructions cannot be found in previous literature and are in many ways desperately needed in guiding the research projects towards a new business. The findings show that during first steps of commercialization projects the focus should be on:

1) Idea generation and development
2) Setting the goals for the commercialization project
3) Developing a NABC –analyzes, following the TEKES instructions
4) Identifying different scenarios for business development, also known as the entry channels
5) Creating an execution timetable for the different work packages
6) Assessing the overall structure of lunching a business out of the research project
7) Fixing the budget, overall timetable and management group for the project

The specific actions related to each step have been provided in detail in Chapter 5. What should be remembered that the funding application for a commercially oriented research project follows these seven steps, shown in detail in attachment 3. What should be remembered is that these steps precede and overlap the actual start of the project as the first steps have to be identified in the in the funding application phase. These steps are extremely important to follow for all commercially oriented research project as they provide a baseline for keeping the project goal oriented and maintain the balance between technical development and sales work. This framework is also strongly related to the core competences of the company Clover Factory, which has provided the possibility to field test these findings in several commercially oriented research projects within the LUT and Saimia.

As the project moves onwards the actions intended for the project move from a more academic focus to an even more business oriented direction, this is also a major failure step for many commercially oriented projects, as has been explained by the statements provided by the interviewees. During the end of the first research year and the start of the second year the idea development should be at its peak. The format of execution has changed to focus the individual cases of product development and testing done with potential pilot and reference customers. These cases provide validity to the project and enhance their possibility to start a new business. Also a competitor analyzes is expected, as the market entry should be the projects first priority. As has been shown in the example timetable, Table 10, the overall process has become rather customer oriented with the goal to gain reference customers.

All and all, these findings provide detailed explanations on *why* and *how* commercially oriented research projects should be executed. When comparing the findings to the known literature, the findings themselves are highly practical and can be implemented to any commercially oriented research projects, regardless of the technology or product developed. These findings have been able to be put into practice during the actual writing process of this study, by the help of Clover Factory. Thus far these findings have been successfully used in four commercially oriented projects in LUT and Saimia: *Vmax, HS-Eden, Drive!* and *Kooler*, with two more projects scheduled to start during Fall 2015.

6.2 Limitations and future research opportunities

This study focused on finding practical steps for executing a commercially oriented research project. In most cases studies related to academic entrepreneurship focus on creating understanding on *what* academic entrepreneurship is and how it can be defined. Also many of the previous studies, unlike this study, aim to argue *why* academic entrepreneurship is important. The importance of academic

entrepreneurship has not fully been addressed in this study in relations to the host university, Lappeenranta University of Technology. The focus has been in providing a framework that can be used to reach the university's goals of generating 100 new companies before the year 2020, still further research should be made on the possible impact of these companies to the university, to the campus and to Lappeenranta.

As a limitation of this study, the focus on the pragmatic side of creating, funding and executing commercialization research projects has come on the cost of lacking major academic contribution. This has been a known choice, as the acknowledgement on the previous studies of *what* and *why* academic entrepreneurship is and how important it is to the surrounding society. This lack of academic contribution can be corrected by further studies of the subject, where, for example, the study of the effects of successful commercialization projects to the parent university as well as the surrounding environment should be measured. This is an excellent example of a quantitative study that could be created in LUT by analyzing the different impact factors related to successful creation of spin-offs from research. These themes can include the study of the financial impact, job creation impact, image impact and educational impact.

Also the validity of the findings can in some aspect be questionable, mainly to the lack of previous research. Still, it can be argued that by the statements gained from the interviewees and the boost that individual projects inside LUT and Saimia have gained from these findings are measurable. In any case, it is only by analyzing these cases that these findings have been and will be implemented in, the successfulness and correctness of the findings them self's. Thus, time is needed. Even as the direction and goals so far achieve via these projects are showing excellent potential, they cannot directly validate this study, although as a discussion is this not the case with all new ideas.

As further research, this study does not analyze the financial impact that these commercially oriented research projects have on the university. The amount of funding gained from other institutions, as TEKES, is measurable, but does this have any effect on other focus areas, such as article releases or education? A study should be made on the ways of optimizing the profitability of the universities of conducting commercially oriented research projects. Still it can be noted that according to the evidence provided from the projects that Clover Factory is involved in, is that these commercially oriented projects bring outside funding to the university, as is intended, provide project work for students and have the possibility to create new businesses and work around the campus or in Finland.

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ATTACHMENTS

Attachment 1. Presentation of the interviewees

Jari Backman

The person interviewed from the ORC –project was the project vice-supervisor Professor Jari Backman. Prof. Backman holds master's, licentiate's and doctor's degrees from LUT in energy technology. He has a 30 year experience for working at the university in various research projects. Two of these projects have been the newly launched TUTLI –projects, which were funded by TEKES. The ORC –project was set to be a project to benefit the local area of Northern-Savonia. Thus from this limitation Prof. Backman could work only as the vice-supervisor, where the actual supervisor for the project had to also come from the region of Northen-Savonia. On the other hand Prof. Backman was the project supervisor on the HEX.COM –project, which was the continuum of the ORC –project. In both cases he was working with the projects from the funding stage onwards.

Asko Parviainen

Mr. Asko Parviainen is a founding member and the managing director of Axco Motors. He graduated from Lappeenranta University of Technology in 2005 as a doctor of science in energy machinery. Mr. Parviainen also has research and teaching experience from LUT, beginning as a research assistant during his 3th year in the university. His experience from research projects originates from around five different project he has been involved in during his years at LUT.

Mr. Parviainen ended up becoming one of three founding members of Axco Motors. He personally got involved during the same time as he was finishing his doctoral dissertation, straight from the university as was. He was recruited to the project by another founding member. The idea of becoming an entrepreneur in the field of permanent magnet generators came easily because of his strong knowledge in this particular field. Mr. Pyrhönen states: "It was easy to join the team as the vision the three of us had were in line with each other."

Jouni Ikonen

Associate Professor Jouni Ikonen is a doctor's graduate in information technology from Lappeenranta University of Technology. During his 20 year career in the university he has been working in several research projects as well as supervising countless master's and doctor's theses. He himself describes: "one of my most important responsibilities is to see that students get work." This can be seen also in the amount of students involved in his research projects. By late he has been working in two different commercialization project funded by TEKES. One of these is the Game Cloud project, which this study has used as a case study in this theses work. In the Game Cloud project Assoc. Prof. Ikonen was working as the supervisor during the full two year span of the project. At the moment he is working in the department of innovation and software in Lappeenranta University of Technology.

Matti Malkamäki

Matti Malkamäki is a master's graduate in industrial engineering and management from University of Oulu. Since his studies he has worked in companies like: IVO Service Power or later Fortum Service and VDSL Systems. In 2002 Mr. Malkamäki was a co-founder and managing director of a company named Greenvironment, which was responsible for the technical developments of small biogas power plants. His experience in developing and working with power stations stretches from 1995 which makes him one of the leading experts in the micro gas turbine industry.

Mr. Malkamäki moved to Berlin, Germany in 2007 with the expansion of Greenvironment. His work abroad rewarded him with countless contacts in the micro turbine industry, which would prove to be implacable in his ventures to come. In 2010 Greenvironment was listed to the stock exchange which boosted the company even further. Unfortunately for the company, in 2012 the government in Germany set a new energy agenda for the next decade which turned out to be ruinous for the company. This only gave new boost for Mr. Malkamäki's entrepreneurial mindset, as in 2013 he founded the company Aurelia Turbines, which is also one of the focus cases of this theses.

Attachment 2. Interview questions for experts involved in target cases.

Diplomityön haastattelu kysymykset (Yrityksen nimi**)**

1) Minkä alan koulutus teillä on?
2) Oletteko aikaisemmin työskennelleet LUT:lla, jos kyllä niin kuinka pitkään?
3) Oletteko olleet mukana useammassa yliopiston tutkimushankkeessa?
    - Kuinka monta näistä hankkeista on ollut TUTLI – hankkeita?
4) Kerrotko lyhyesti *Yrityksen/projektin*:n ydinliiketoiminnasta?
5) Kerrotko tutkimushankkeesta ja omasta roolistasi hankkeessa? (Oliko hankkeella jokin toinen nimi tutkimusvaiheessa?)
    - Kuinka kauan hanke kesti? (milloin alkoi?)
    - Kuinka suuri budjetti hankkeella oli?
    - Ketä projektin tiimiin kuului tutkimusvaiheessa?
6) Minkälaisia vaikeuksia tai ongelmakohtia projektin edetessä tuli vastaan?
    - Erityisesti kaupallistamiseen liittyviä ongelmakohtia
    - Kuinka selvisitte näistä ongelmista?
    - Toimivatko tiimin väliset synergiat?
7) Saitteko tarpeeksi tukea sidosryhmiltä, kuten TEKES:ltä?
    - Oliko teillä tarpeeksi tietoa yrityksen perustamiseen?
8) Teidän näkökulmasta, mitkä asiat projektissa menivät oikein ja mitkä olisi pitänyt tehdä toisin?

Miltä teistä tuntuu olla haastateltavana tämän tapaisesta aiheesta?

Attachment 3. Table of content for a funding application of a commercialization research project.

xx.xx.20xx

Introduction

1. The overview and background of the project
2. The goals of the project
3. Business model, the NABC -analyzes
    1. Need
    2. Approach
    3. Benefits
    4. Competition
4. Scenarios for business development
    1. Scenario case 1
    2. Scenario case 2
    3. Scenario case N
5. Execution timetable of the project:
    1. Work package 1: *Market potential and environment*
    2. Work package 2: *Development of technical specifications for manufacturing*
    3. Work package 3: *Business concept and gained customer value*
    4. Work package 4: *Proof of Concept*
6. Launch of the business
    1. First customers and references
    2. Team and roles
    3. Financial plan and business model
7. Overview of the project
    1. Budget and timetable
    2. Expenses, funding and resources
    3. Risks
    4. Management group

Attachment 4. Table of content for a gateway report of a commercialization research project.

xx.xx.20xx

Introduction

1. The overview and main events during the first year
2. Customer mapping and initial contacting
3. Case companies
    1. Case A
    2. Case B
    3. Case N
4. Competitor analyzes
    1. Competitor A
    2. Competitor B
    3. Competitor N
5. Main achievements of the work packages
    1. Work package 1: *Market potential and environment*
    2. Work package 2: *Development of technical specifications for manufacturing*
    3. Work package 3: *Business concept and gained customer value*
    4. Work package 4: *Proof of Concept*
6. Conclusion
7. Action plan for the next year