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HOW UNIVERSITY TECHNOLOGY TRANSFER OFFICES FACILITATE THE CREATION OF SPINOUTS FROM ACADEMIC LIFE SCIENCE RESEARCH

Perspective on dynamic capabilities

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Table of Contents

List of Figures

List of Tables

1 INTRODUCTION

1.1 Background

It is generally recognised that the outputs of university research contribute to economic growth (Roessner, Bond, Okubo & Planting 2013, 23). Such outputs include the education of new R&D personnel, the development of novel technologies, the creation of new technological prototypes and the formation of spinout companies that utilise these novel technologies. Aside from the outputs listed above, information is shared through publications, consulting and joint research, as well as by hiring the educated R&D personnel. (Roessner et al. 2013, 24.) The formation of these outputs is managed in universities on many layers. Managerial tasks may include the transfer of the created knowledge to a company, the collection of knowledge on research activities, the obtaining of financial resources, the formulation of strategy, and many others. Krauser (2003, 2–5) has recommended that the management of personnel should follow servant-leader ideology, where serving includes offering required services, such as aid in research funding applications and aid through legislation. Serving also includes the ability of the management structure to change according to the needs of those who require the services. Krauser (2003, 2–5) has further concluded that with the offer of aid to the research community in its various procedures and administrative tasks, the community is better able to focus on their main task: to perform novel research. Derrick and Alicen (2014, 26) have performed a systematic review of the research management literature, from 2003–2013, and concluded that no consensus yet exists on the definition of research management. Derrick and Alicen (2014, 26) propose that the definition given by Kirkland (2008) describes well how research management activities relate to the different processes in the university context. This definition is used in this work:

"…an activity instituted at the level of the institution, which seeks to add value to the research activity of academic staff, without being part of the research process itself."
(Kirkland, 2008, 718)

Derrick and Alicen (2014, 12) further propose that there is no one general structure that determines how research management should be organised in order to achieve highest organisational efficiency. Although discussion continues on how research should be managed, there is a consensus that establishing technology transfer operations, often under the title of a technology transfer office (TTO), is beneficial for research commercialisation (Bigliardi, Galati, Marolla & Verbano 2015, 364). Before further discussion, it is therefore beneficial to both define and limit the meanings of TTO and technology transfer.

Regarding the TTO, in this study we limit the definition according to Bigliardi et al. (2015, 362):

"TTO is a dedicated transfer unit that provides specialized support services, partner searches, the management of intellectual property (IP) and business development."
(Bigliardi et al. 2015, 362)

In the above definition, "transfer unit" refers to technology transfer activities. In this study, we further limit these activities according to business dictionary (www.business-dictionary.com):

"1st: Assignment of technological intellectual property, developed and generated in one place, to another through legal means such as technology licensing or franchising.
2nd: Process of converting scientific and technological advances into marketable goods or services."
(http://www.businessdictionary.com/definition/technology-transfer.html, retrieved 5.10.2016)

A TTO can therefore be seen as a university's instrument for the above defined commercialisation and technology transfer activities. Most of the research focussing on TTOs activities and research commercialisation has been conducted in the United States (US). United States universities started to create their own TTOs especially after the Bayh-Dole Act was established in 1980. This act allowed universities to own the intellectual property rights (IPRs) that emerged from federally funded research. (Siegel, Waldman, Atwater & Link 2003a, 112.) An act with a similar purpose was also legislated in Finland (Act on the Right in Inventions made at Higher Education Institutions (369/2006)), but the outcome has not been as widely researched. Aside from ownership, the Bayh-Dole Act cleared the patenting and licensing practices. A combination of the ownership of IPRs and increasing pressures for increased research output from the surrounding economy strengthened the importance of well operating TTOs. (Siegel, Waldman & Link 2003b, 28.) However, the results of the Bayh-Dole Act on the performance of commercialisation activities remains mixed. For instance, Mowery, Nelson, Sampat and Ziedonis (2001, 116–118) found a positive impact on commercialisation activities when studying the University of California and Stanford University. However, Coupe (2003, 16) has studied US universities' patenting activities and found that while the Bayh-Dole Act did not increase the patenting activities of the universities in general, the act did increase patenting activities in universities that had established TTOs. In addition, a comprehensive review from Rothaermel, Agung and Jing (2007, 739) concludes that while the Bayh-Dole Act may have increased the number of patents, the overall quality of the patents may have been

also altered. However, the author further states that some research has shown that patent quality has decreased, while other research indicates the opposite. Shane (2004, 148–149) has concluded that the act gave incentives for commercialisation activities in fields where licensing was already an efficient strategy. In summary, both the Bayh-Dole Act in the US and Act on the Right in Inventions made at Higher Education Institutions in Finland have now given universities the ability to own and decide on commercialisation activities on their own.

The academic community has a keen interest in technology transfer to commercial entities, since the interaction gives access to relevant contacts in the field and aids in securing further financial resources for research. Recruitment has also been observed as a motive for universities to participate in technology transfer. (Decter, Bennet & Leseure 2007, 147–149.) Companies are interested in technology transfer from academic research, since the transferred technologies and expertise may give companies a competitive advantage over competitors operating in the same industry. In addition, companies are able to gather complementary assets, (i.e. assets that company did not own before). (Bell, 1993, according to Rothaelmer et al. 2007, 711.) Furthermore, Decter et al. (2007, 147–149) adds that the technology transfer gives companies access to novel technologies and ideas, allows them to quickly utilise novel technologies and reduces their R&D expenses.

As discussed above, the role of the TTO is to facilitate this technology transfer from university research to benefit a wider community (Bigliardi et al. 2015, 362). Muscio (2010, 199) states that one means of facilitation is to support university personnel to create spinout companies that use and commercialise the inventions produced by academic research. Zucker, Darby and Brewer (1998, 302) mention that especially the biotechnology industry in the US has seen growing demand for the novel innovations, and this need has facilitated the creation of spinout companies commercialising university research. Moreover, according to Zucker et al. (1998, 302), the university has been seen as a key provider of novel knowledge to this industry. Since this study focusses on the TTOs activities relating to spinout formation, the definition of spinout adopted here follows the Lockett and Wright (2005, 1045) who state:

> "We narrowly define university spin-outs as new ventures that are dependent upon licensing or assignment of the institution's intellectual property for initiation."
> (Lockett & Wright 2005, 1045)

These above definitions, including for research management, TTO, technology transfer and spinout, are presented in Figure 1 to illustrate their connections.

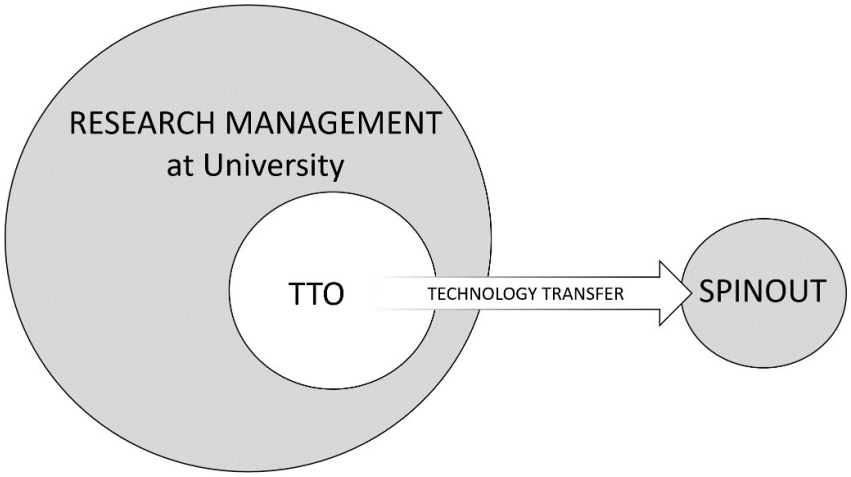

Figure 1. Technology transfer office (TTO) in university management.

The TTO has been seen as a "formal gateway between the university and industry" (Rothaelmer et al. 2007, 740), and it can be argued that the TTO plays the role of a facilitator in the technology transfer process, where inventions are commercialised through the establishment of new companies. This gateway function serves also as an intermediary between different stakeholder views in the technology transfer process (Siegel, Waldman, Atwater & Link 2004, 121). Siegel et al. (2004, 118) have stated that universities' scientists, the personnel who create the inventions, are primarily motivated by the recognition of the scientific community, by scientific articles in journals and conference presentations, and only secondarily by the additional funds. Regarding the funds, both personal financial gains and resources for the purpose of future research are seen as motives. The TTO's primary motives are focussed on the marketing and protection of the disclosed inventions. Finally, the primary motives of the company that utilises the license are financial gains obtained through to the licensed technology. Often, companies are eager to obtain exclusive licenses, restricting possible competitors from obtaining the rights to use same technology. (Siegel et al. 2004, 121.) Aside from the differing motives that individuals have while participating in shared technology transfer process, organisational cultures also differ dramatically. Researchers are steeped in a scientific organisational culture, while TTOs can be seen as bureaucratic, and companies are used to entrepreneurial organisational cultures. (Siegel et al. 2003a, 31–32.) An outline of parties participating in the technology-commercialisation process are viewed in Figure 2.

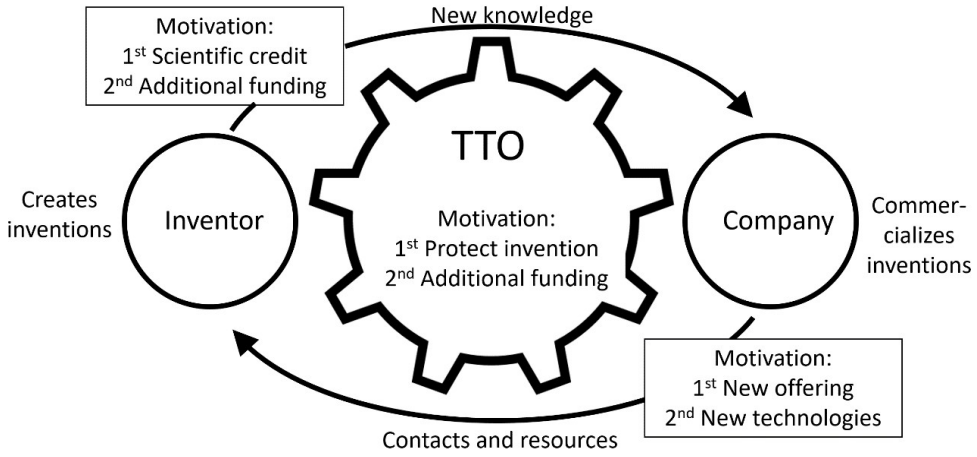

Figure 2. Different motives of inventor, technology transfer office (TTO) and company during commercialization process. Adapted from a table by Siegel et al. (2003, 31).

To manage the intermediary role, universities offer incentives to the personnel of the TTO and scientists aiming to increase the collaboration between participating stakeholders and to facilitate the commercialisation of inventions emerging from research. These incentives can be financial or non-financial, and incentives in general have been shown to benefit the commercialisation process. In turn, a lack of incentives has been shown to decrease commercialisation efforts. (Siegel et al. 2003, 27–46.)

Since the focus of this research study is on the spinout formation process from life-science-related academic research, the characteristics of the life science field are briefly summarised below. The field differs drastically from fields such as IT-development in terms of development time (often 5–7 years, depending on the novelty of the potential technology), and high infrastructure costs that often arise from expensive instruments and the requirements laboratories. Furthermore, the labour is also specialised, with a high percentage of researchers having PhD's, and lastly, the business field is subjected to high legislation, especially when focussing on human diagnostics and health applications. All these factors, combined with complex value chains, create a need for efficient TTO capabilities to secure the critical resources for successful spinout creation. (Shimasaki, 2009.)

The commercialisation of university research, the activity that is performed by TTO, can come with multiple challenges: research and technology development is often performed by people who are evaluated with academic success. Academic success is often indicated by the number of peer-reviewed articles published by the researcher and the researcher's success in applying for funding and creating consortiums. In contrast, the investors of possible commercialisation activities are mainly interested in the commercial potential of the invention combined with IPRs. Since establishing IPRs takes additional

time and effort, the inventors of a technology are not often motivated when their work is prolonged by year(s) of possible IPRs protection before publishing the results, since publicity through peer-reviewed journals is often the metric by which scholars are measured within academia. The TTOs are in the organisation to close this gap. They utilise different types of processes to aid the commercialisation of potential technologies. (Shimasaki, 2009.)

As discussed at the beginning of this chapter, no single dominant management structure for TTO operations exists. However, Markman, Phan, Balkin and Gianiodis (2005a, 247–249) have performed thorough analysis of 128 different TTOs and concluded that three organisational structures emerge: the traditional university structure, non-profit research foundations, and for-profit private extension. These structures are presented in Figure 3.

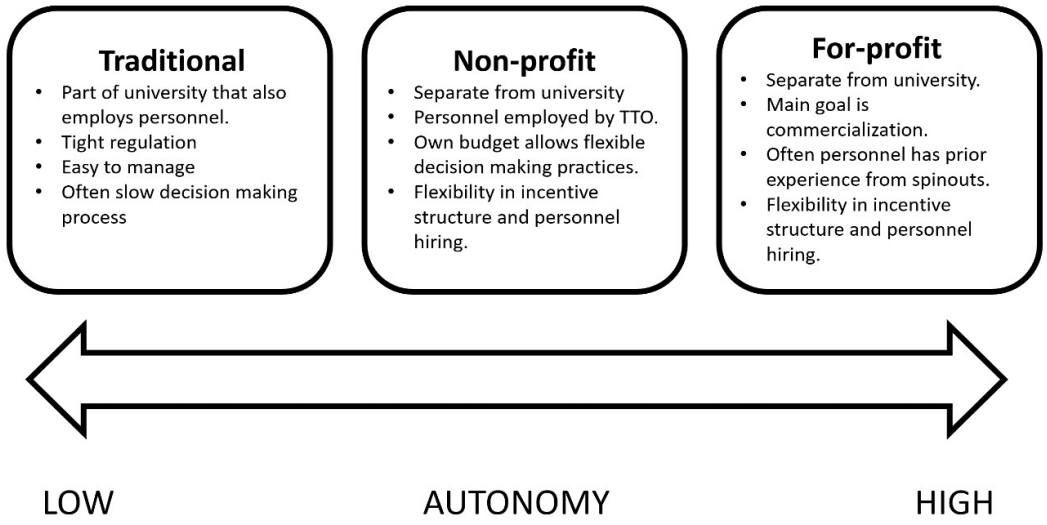

Figure 3. Different structures of technology transfer offices (TTOs). Adapted from a table by Markman et al. (2005a, 247–248).

Out of these three structures, the traditional and non-profit models are often dominant. The traditional structure can be seen as an extension of university policy, where the TTO is managed by university administration. Often, this structure is restricted in terms of incentives. On the contrary, the for-profit structure is managed by personnel with entrepreneurial experience and offers the highest degree of freedom in terms of incentives and general operations. (Markman et al. 2005a, 246–255.) Aside from different organisational structures, Markman et al. (2005a, 250) also classify inventions in four different stages, as seen in Figure 4.

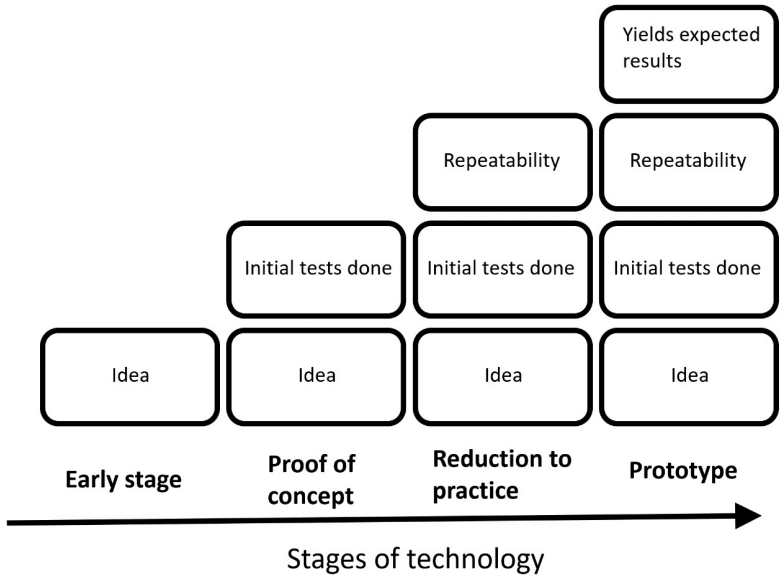

Figure 4. Stages of technology. Adapted from a table by Markman et al. (2005a, 250).

The TTO can facilitate the commercialisation of technologies from each of the above stages, but the preferred routes for commercialisation differ accordingly. With early-stage inventions, the feasibility of the invention can still be unknown, and future research is needed for the invention to become usable in the target market. Therefore these inventions are often commercialised to existing companies. In turn, the university obtains fees for further development of the patented technology. However, this collaborative research can lead to future intellectual property (IP) disputes over the ownership of the developed technologies. Furthermore, licensing companies are unwilling to agree on long licensing contracts and the high costs associated with license compensation, due to uncertainties regarding the feasibility of the technology. For these reasons, TTOs often view licensing for sponsored research as the least favourable alternative for the commercialisation of the patented technology. (Markman et al. 2005a, 251.)

Also, technologies already at the prototype stage are also often commercialised to existing companies. The markets for these technologies have been identified, and clear estimates of the value of the invention are known by TTOs. Since the value is known, TTOs are able to reliably calculate the fees of the license and offer it to the established companies in the selected field. Companies that license the technologies in prototype phase are often large and have established viable operations in their target market. In addition, the companies often have a clear focus on applying the licensed technology as soon as possible. For TTOs, the licensing of the technology to an established large company also brings security in IP disputes, since large companies are often eager to protect their licensed technology and aid in pursuing possible IP violations that might emerge from the competition. (Markman et al. 2005a, 253–255.)

However, technologies that have been developed beyond their early stages but are not yet prototypes are often commercialised by establishing new spinout companies. For these technologies, the value is still partially unknown. When new company is formed to commercialise the technology, the TTO often receives equity from the established company in compensation for the granted technology. By obtaining equity, TTOs obtain revenues from the spinouts through dividends and royalties from company sales. In addition, revenues are obtained by selling equity, for example, in an initial public offering. By engaging with the company as an equity owner, the TTO takes more active role in company development, setting common goals and aligning company strategy to university strategy, along with aiding in managerial tasks and further development of the technology. In addition, the ownership by TTO gives legitimacy to the company that can, in turn, aid in further financial acquisition. If the new venture applying the patented technology does not succeed, often the licensing contract states that the license is returned to TTO for future use. Finally, by taking equity from the new venture, the TTO secures future revenues in a situation where the company is not applying the licensed technology (e.g. due to the difficulties in technology development or if a more viable alternative technology emerges through a company's development). (Markman et al. 2005a, 251–252.)

As discussed above, multiple routes to the commercialisation of technologies exist. Among these, the most frequently applied by TTOs are licensing the technology to existing companies or spinout formation to commercialise the developed technology (Siegel, Veugelers & Wright 2007, 641). However, it must be noted that commercialisation approach is not limited to only the stage of the technology, but the mission and traditions of the TTO also have significant impact on the decision making of TTO (Markman et al. 2005a, 250). In addition, Feldman, Feller, Bercovitz and Burton (2002, 118–120) have found that the experience and traditions of TTOs also have an effect; high levels of prior experience in licensing may encourage TTOs to search alternative strategy, for example. Finally, Feldman et al. (2002, 118–120) discovered that increased autonomy, as in the case of for-profit a TTO structure, increases the use of spinout formation as a commercialisation route.

1.2 Purpose and research gap

There exists increasing pressure to successfully commercialise university-based research, and universities have established TTOs to manage operations for this goal. The purpose of this study is to contribute to the research on TTO activities. The majority of the existing literature has focussed on the process analyses of TTO activities and discussion of different activities TTOs undertake during the commercialisation process, as will be viewed in chapter 2. Moreover, most of the studies are performed either in the US or UK, probably

because of these countries' long history with TTO activities. In addition, studies analysing TTO's capabilities during commercialisation are somewhat lacking. Since novel inventions are able to meet and solve varying challenges, it is expected that each commercialisation event is unique and that no single general structure could be applied to all commercialisation events. From this follows that assumption in this study is that there must exist some level of adjustment of current resources and capabilities of TTOs to facilitate spinout formation from these various inventions. Therefore, the main aim of this study is to evaluate how Finnish TTOs facilitate spinout formation from academic research. To achieve this goal, three sub-questions are used:

1: How autonomous are TTOs in their decision making?
2: What are the stages in the commercialisation process leading to spinout formation by TTOs?
3: How have TTOs developed their commercialisation process activities?

Since this study examines multiple cases of TTOs, it is important to first discover what the autonomy and general aim of these TTOs regarding commercialisation is. This analysis is achieved by answering the first sub-question. As seen already in the introduction chapter, how the TTO is integrated into the university setting may have a clear effect on the preferred commercialisation routes applied. The first research question therefore provides a foundation and clarifies the setting in which the latter research questions are built upon. In addition, the TTOs' level of autonomy is important, as the third research question focusses on how TTOs have developed their own commercialisation processes. The first sub-question is answered through the literature review and through collection of research data from case organisations.

The second research question focusses on the stages taken by TTOs in the commercialisation of invention towards establishing a spinout company. Here, the research becomes more focussed on the sequential process taken by TTOs in facilitating spinout formation. It is essential to understand the order of this process, since the third research question is based upon it. The literature review in chapters 2.1–2.2 offers introduction of this process gathered from existing literature. However, most of this literature is performed either in the context of the US or the UK. Also, the process in chapters 2.1–2.2 is not unique to any research field, such as life sciences research, the focus of this research. Therefore the second question is applied to discover whether similar processes exist in case offices in Finland and in life-science-related commercialisation activities. To answer this question, data is gathered from the existing literature and through the collection of research data from the case organisations.

Finally, the third research question will answer how the TTOs have developed their commercialisation process aiming towards spinout formation. To answer this question,

the theory of dynamic capabilities is applied and elements of the dynamic capabilities are sought in the behaviour of the case TTOs. Dynamic capabilities have been previously applied in the context of TTO activities e.g. by Weckowska (2015) who studied the activities of six different TTOs and evaluated how TTOs learned during their licensing activities. Moreover, Weckowska (2015, 62) has stated that, in general, the way TTOs develop and adjust their abilities for commercialisation purposes remains "under-researched". It can be also generally argued that not many empirical dynamic capability studies have been conducted, as discussed by Ambrosini and Bowman (2009, 37). The reasons for this are discussed more thoroughly in chapter 2.3.2. The aim of the third research question is therefore to amend to this gap by analysing what dynamic capabilities are present in the case TTOs' activities, more precisely, in the context of life science commercialisation through spinout company formation.

2 THE COMMERCIALISATION OF INVENTIONS THROUGH THE FORMATION OF SPINOUTS

Chapter 2.1 focusses on the core topic of this research: the process of the commercialisation of inventions, starting from invention disclosure and ending with the establishment of a spinout company that utilises the invention for commercial purposes. In chapter 2.1 the activities of TTOs are discussed in chronological order to offer a thorough understanding of a TTO's tasks relating to spinout formation, while chapter 2.2 discusses same processes from the perspective of an emerging spinout company focussing on two dominant spinout formation models: the stage model and the evolutionary model. Chapter 2.3 discusses the dynamic capabilities of an organisation. Finally, initial framework that is the synthesis of the chapters 2.1–2.3 will be drawn in chapter 2.4.

2.1 The activities of a technology transfer office

Wallmar (1997, 135–138) found that patents obtained and further commercialised have a significant impact on the surrounding economy. The university's technology transfer process that starts from the scientist's discovery and invention disclosure, and which eventually leads to the licensing of the patented technology to an existing entity or to a newly formed company, is presented below in Figure 5. In the following chapters 2.1.1–2.1.6, each of these stages are discussed in chronological order.

Figure 5. Technology transfer process from invention disclosure to spinout formation. Adapted from Bradley, Hayter and Link (2013, 5)

2.1.1 Invention disclosure

In the first stage of the commercialisation process, researchers who have created novel inventions are subjected to disclose the invention to TTOs for further commercial evaluation. This invention disclosure has been argued to be "key input" in the technology transfer process. (Siegel et al. 2003b, 29.) Although the invention disclosure can be seen as

mandatory practice under Bayh-Dole Act, sometimes inventions are not disclosed (Siegel et al. 2003b, 30). As proposed by Lockett and Wright (2005, 1046), TTOs should increase the awareness of themselves among the scientific community of the university in order to increase the number of disclosed inventions. Similar observations have also been made by McAdam, Keogh, Galbraith and Laurie (2005, 1423). Jensen, Thursby and Thursby (2003, 2) suspect that only about half of inventions are disclosed to TTOs. Rothaermel et al. (2007, 739) have concluded in their review that disclosure number is effected by university's incentives, such as reward system for scientists and TTO personnel participating in the disclosure process.

2.1.2 Evaluation of invention for patenting

After an invention has been disclosed to a TTO, the TTO evaluates the commercial potential of the invention from multiple viewpoints, and this evaluation process requires both the technological understanding and understanding of the market (Vohora, Wright & Lockett 2004, 151–157). As proposed by Lockett, Wright and Franklin (2003, 118), evaluations performed only by academic personnel are often insufficient, and Lockett and Wright (2005, 1047) have mentioned that for this purpose TTOs also employ personnel with varying backgrounds. A TTO can also perform "business coaching" in the invention disclosure phase to promote entrepreneurial activity for the possible following spinout formation (Lockett & Wright 2005, 1047).

An extensive review from Bradley et al. (2013, 9–10) provides a classification of levels by which TTOs evaluate the potential of an invention. These include revenue and licensing potentials, characteristics of the field of the invention, competitiveness and extensibility. According to the review by Bradley et al. (2013, 9–10), in the evaluation of revenue and licensing potential, the aim of the TTO is to evaluate possible revenues generated by the patented technology. Litan, Mitchell and Reedy (2007, 60) have further argued that TTOs allocate most of their resources in the most promising disclosures in terms of probable rate and size of the returns.

In the characteristics of the field analyses, TTOs evaluate whether licensing is an efficient method of commercialisation in the given field (Bradley et al. 2013, 9–10). For example, Geuna and Nesta (2006, 793) have shown that the life science sector in the US constituted approximately half of the country's licensing revenue in 1998.

Bradley et al. (2013, 9–10) proposed that in competitiveness analysis, TTOs analyse the invention according to Goldhor and Lund (1983, 145–146) to evaluate whether the invention is revolutionary, has current competitors, or is it small added evolutionary in-

vention to the existing technology. Finally, TTOs evaluate whether the technological invention could be applied to multiple different fields, extending the usability, and potential profitability, of the invention (Bradley et al. 2013, 9–10).

Meseri and Maital (2001, 118–120) have studied the invention evaluation process in US and Israeli universities and discovered that universities apply similar processes for evaluation, such as estimation of potential market size and demand in the market. Simpler evaluations are also performed, as proposed by Siegel et al. (2004, 118), who have stated that often the demand and interest of the industry may be enough to proceed to the patenting phase. Finally, Lockett and Wright (2005, 1047) mention that the invention can be difficult to market and commercialise profitably if there is no patent to protect its use.

2.1.3 Acquiring a patent

After the decision has been made to proceed to invention protection, the patenting phase begins. Technology transfer offices must decide whether the patent is sought for global protection, or only in certain regions, since the former is more expensive. Patent application is often drafted together with attorneys specialised in the field, who may be employed by TTOs, or these expertise are outsourced from specialised companies. In addition, personnel with marketing background often participate in patent drafting to evaluate commercial probability. (Bradley et al. 2013, 10–13.) In the US, a drafted patent is then filed to United States Patent and Trademark Office, and in Finland to the Finnish Patent and Registration Office (PRH) for the evaluation.

The patent application is evaluated according to novelty, non-obviousness and utility. In novelty analysis, the originality of the invention is evaluated. Once it has been concluded that the invention is in fact novel, non-obviousness is examined. The invention should not be obvious to a person disciplined in the field. In addition, the invention should have a useful purpose. A granted patent is effective for 20 years. However, the patent itself is not an approval to use the patented invention, but to restrict others from applying it. (Shimasaki, 2009, 32–35.)

Although TTOs prefer radical inventions that have the potential to create novel technologies or even industries, the scope of patent protection in these instances can create challenges (Agarwal & Shah 2014, 1125). Agarwal and Shah (2014, 1125) have discussed how, in the patents that cover an emerging industry, the novelty of the industry creates difficulties on how to limit the claims in the patent, since the technologies are constantly evolving and since there may be no consensus even on the definitions of the technologies applied on the field. Agarwal and Shah (2014, 1125) further discuss that once the field has matured, also the scopes of new patents are easier to define. Similarly, Agarwal and Shah (2014, 1125) also discusses that if the industry is still in an emerging state, TTOs

may underestimate the patent's future profitability, since no beneficial applications yet exist.

2.1.4 Licensing to existing company

In the marketing phase, TTOs market the invention to the potential companies that would utilise the invention. A TTO's main role in the marketing phase is to be the intermediary between scientists and companies and to balance the different motives and views of participating shareholders (Bradley et al. 2013, 13–14). Licensed inventions often require substantial further development before they can be brought to market, and this development requires collaboration between inventors and the commercialising company (Jensen & Thursby 1998, 1). Markman, Gianiodis, Phan and Balkin (2005b, 1058) have analysed the revenue rate of the inventions and concluded that the faster the granted patents are licensed, the higher the revenues from royalties and licensing fees will be. These authors further mention that the normal time for commercialisation to occur is approximately four years, but this time varies significantly between different industries. (Markman et al. 2005b, 1068.) For example, regulatory approvals in medical field increase the time for commercialisation significantly.

Rothaermel et al. (2007) have proposed that factors that effect this rate are a TTO's resources and previous experience in licensing, and the participation of the inventors in the licensing process. Shane (2002, according to Rothaermel et al. 2007, 746) mentions that companies often commercialise inventions only after the patent has been issued, and Colyvas et al. (2002, 67) further propose that commercialisation would often not occur without intellectual protection. In addition, authors propose that the marketing activities of TTOs are especially important in fields connections of the industry are low to the university (Colyvas et al. 2002, 67).

2.1.5 Establishing a spinout company

Besides licensing the invention to an existing company, TTOs can aid in the formation of a spinout company that will utilise and commercialise an invention. The company can be seen as a continuum from the academic research with a focus shifting from basic research, carried out in universities, to applied research and commercialisation of the developed technology. (Agarwal & Shah 2014, 1119.) Also, spinout companies are utilizing novel technologies that may have an ability to create new industries (Agarwal & Shah 2014, 1127). Agarwal and Shah (2014, 1126–1128) have further classified academic spinout companies into product or process innovation companies. The authors have argued that

start-up companies emerging from mature industries (e.g. from a larger company's own R&D) are often focussed on process innovations. In contrast, spinout companies emerging from academia are often focussed on product innovation. (Agarwal & Shah 2014, 1126–1128.)

Lockett and Wright (2005, 1043–1044) have proposed that the most common commercialisation route followed by TTOs is to license the invention to an existing company. However, in situations where the licensing agreement is not expected to yield satisfactory revenue, the formation of a spinout is a viable alternative (Lockett & Wright 2005, 1044). Jensen and Thursby (1998, 23–24) have found that spinouts in which the university is equity owner, compared to situation in which a license is granted in exchange for cash for existing companies or spinouts, provide higher revenues for universities. Similar results have been reported by Bray and Lee (2000, 386), who have stated that spinout formation with equity ownership should be TTOs' main aim and that licensing for cash should be considered only if the invention is not applicable for equity strategy. Therefore it is surprising that none of the three stakeholders—scientists, TTO or companies—see spinout company formation as the most important outcome of the commercialisation process (Siegel et al. 2004, 130).

Vohora et al. (2004, see Agarwal & Shah 2014, 1117) have discovered that around half of the spinouts emerging from university research had collaborated with already established companies, and Agarwal and Shah (2014, 1118) stated that these academic companies collaborate with existing companies in same field. Agarwal and Shah (2014, 1119) also state that often spinouts do not sell their products directly to end-customers, but work as subcontractors in the value chain.

2.1.6 Challenges in the technology transfer offices' processes

Siegel et al. (2004, 139–140) mention that in some situations university scientists can see TTOs as too bureaucratic and inflexible in their processes, leading to situations in which the TTOs are avoided in the commercialisation process. Likewise, companies that license inventions may see TTOs as too aggressive in their licensing fees and royalty requirements, and this view can hinder their willingness to proceed with the licensing (Siegel et al. 2004, 133). Regarding incentives, scientists are often evaluated in the universities according to their outputs in peer-reviewed journals and by their ability to gather funding for research. This may lead to situations in which scientists have no incentives to perform disclosures and commercialisation efforts. (Siegel et al. 2004, 130.) In similar manner, a lack of incentives for TTO personnel can reduce commercialisation efforts (Siegel et al. 2003b, 42).

Besides challenges, Siegel et al. (2004, 137–140) also proposed a list of recommendations that should be performed by TTOs to increase their commercialisation success. These include better incentives in general, more finances for patenting and marketing activities, a better understanding of the cultures and motives of stakeholders, employees should be with varying backgrounds (in some TTOs there is overemphasis on lawyers) and they must have high experience in negotiations. Finally, the focus should not be only on maximising licensing royalties but also on increasing spinout company formation. (Siegel et al. 2004, 137–140.)

In similar manner, Siegel et al. (2003b, 43–45) have proposed that TTOs should increase their marketing efforts and have personnel with entrepreneurial backgrounds to facilitate spinout formation. In addition, McAdams et al. (2005, 1424) have recommended that more time should be allocated for scientists who target spinout formation.

2.2 Process models of spinout formation from academic research

While in the chapter 2.1 the focus has been on the discussions of TTOs' roles and activities in the commercialisation process, this chapter focusses on two dominant process models of university spinout formation. One of the aims of this research is to contribute to the framework of the TTO commercialisation process with a view of dynamic capabilities to analyse how the TTOs modify and extend their resource base and facilitate spinout formation. Therefore it is beneficial to first discuss the motors of change in the process before introducing the dominant process models.

2.2.1 'Motors' of change in the commercialisation process

Analysis of a process is often challenging. Processes proceed through events or phases, which are often difficult to distinguish from each other. In addition, each phase is effected by the individual's actions. (Langley 1999, 692.) To understand the dominant models of TTO processes described in chapter 2.2.2, as well as the dynamic capabilities viewed in chapter 2.3, this chapter introduces work from Van de Ven and Poole (1995), who have discussed progress and change occurring in a process. The authors introduced different elements that were life-cycle theory, teleological theory, dialectic theory and evolutionary theory. These theories have been described as the "motors" of progress and change in different contexts. (Van de Ven & Poole 1995, 510.) Each of these motors can be understood as different views of a single process. Different explanations for a process's evolution and change can be analysed by applying these different viewpoints. (Van de Ven &

Poole 1995, 510–512.) Four different motors were derived from 20 process theories (Van de Ven & Poole 1995, 512), and the authors propose that "all specific theories of organizational change and development can be built from one or more of the four basic types" (Van de Ven & Poole 1995, 511). As described by Van de Ven and Poole (1995, 528) different theories may contain a different mix of the discovered motors. Each of the four individual motors are next discussed, before an analysis is given of how they are present in two of the most dominant models of university spinout formation in chapter 2.2.2.

In the life-cycle motor, progress is seen as sequential and irreversible. Each of the future steps are continued from the latter stage, and the progress occurs according to an innate logic. Order of the steps is pre-set and each of the steps must be accomplished in pre-set order to allow progress to a later stage. In addition, the final stage is also known beforehand. According to Van de Ven and Poole (1995, 514), this theory is best described by the metaphor of "organic growth". (Van de Ven & Poole 1995, 513–515.)

With the teleological motor, the goal is known, but it is pre-set by the individuals or groups participating in the process. In contrast to life-cycle theory, progress of the stages in pre-set order is not required, and the main goals in each of the stages, and also a final goal, can be altered accordingly. Actions taken in each stage include planning, evaluation and process modification if they are seen as beneficial to progress. In teleological progress, the major limiting elements in progress are a lack of resources and a restricting environment. (Van de Ven & Poole 1995, 515–517.)

In dialectic motor, the progress occurs through conflicts of opposing sides. Dominant views are challenged by opposing views and the conflict emerges. The outcome of the conflict can be to retain the dominant view, which occurs in situations where the dominant view is powerful enough to withstand the opposing view. The second possible outcome is that a powerful opposing view surpasses the dominant one, replacing it as the current view. Finally, often the most desired outcome is the synthesis of the dominant and opposing views to form a merger that includes elements from both views. (Van de Ven & Poole 1995, 517.)

The final motor to be discusses is the evolutionary motor. This theory is constructed around a model of selection in which different organisational structures or processes evolve and the most suitable is selected. Competition between different structures and process variations occurs due to limited available resources. Once most suitable variant is selected, the model also includes retention aspect in which the selected variant attains the obtained position and tries to hinder the development of a new selection loop. (Van de Ven & Poole 1995, 517–519.)

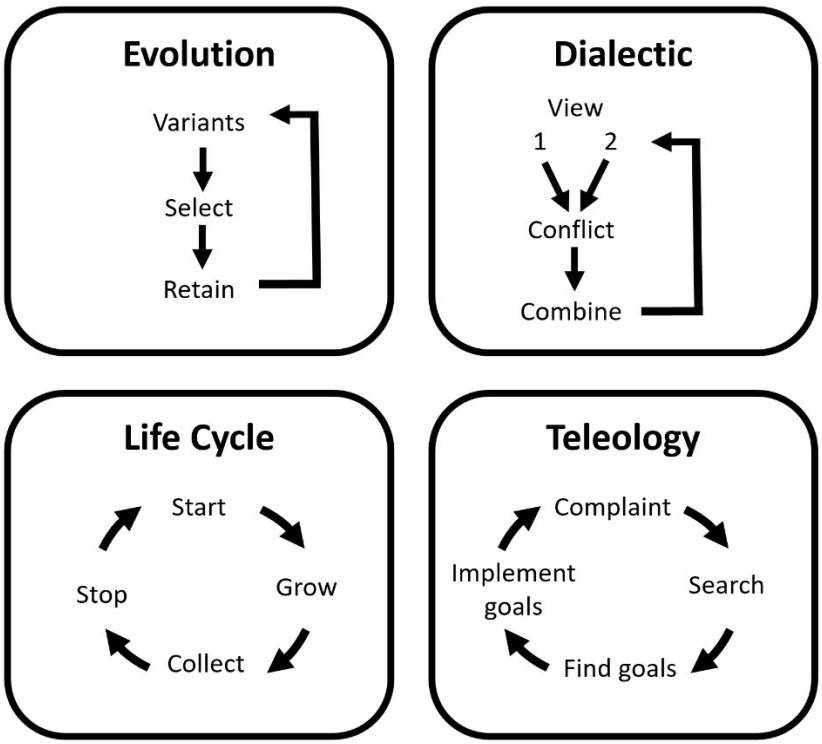

Figure 6. Motors of change. Adapted from a figure by Van de Ven and Poole (1995, 520)

Rasmussen (2006) has analysed how the motors described by Van de Ven and Poole (1995, 520) are present in university spinout process theories. The authors further argue that by evaluating the presence of these motors in the spinout formation process, researchers "can enhance the understanding of complex phenomena such as university spin-off formation" (Rasmussen 2006, 3). Rasmussen (2006, 6) categorises two of the dominant models, from Vohora et al. (2004) and from Ndonzuau, Pirnay and Surlemont (2002), both which are discussed in-depth in chapter 2.2.2, to have characteristics of life-cycle motor. While the life-cycle motor can efficiently describe the spinout formation process, this single motor lacks existence of "change and serendipity" (Rasmussen et al. 2006, 6) and is often unable to distinguish the reasons why the process moves forward (Rasmussen 2006, 10). However, in contrast to Ndonzuau et al. (2002) stage model, the model by Vohora et al. (2004) also includes elements from teleological motor that allows the evaluation of the process in terms of how the change occurs between different stages in relation to goal setting, action and evaluation (Rasmussen 2006, 7). The teleological factor was evaluated to be present in situations such as increasing change of motivation of inventors to commercialisation and how goals to meet this target were changed. (Rasmussen 2006, 16.)

Rasmussen (2006, 14–15) further discusses how opportunity recognition is viewed in terms of the life-cycle motor. The authors conclude that while the inventions emerged from years of academic research, opportunity recognition was a result of an individuals'

effort to evaluate the potential of the invention for the purpose of commercialisation. Prior networks and business contacts were seen as a valuable assets in this stage. Following opportunity recognition, the invention procedure was seen to utilise the life-cycle motor, as an invention is developed inside an institute in different stages, such as acquisition of funding and further technological research, while moving towards becoming a spinout venture. (Rasmussen 2006, 14–15.)

A dialectic motor can be also seen as a distinct motor in the spinout process. Participants in a spinout formation process have different motives for participation and come from different organisational cultures. (Rasmussen 2006, 8–9.) Rasmussen (2006, 8–9) has proposed that a dialectic motor can be found in these events of conflict and synthesis especially at the early phase of the spinout formation process. These events include situations where inventors take an active role in the spinout formation process and how to separate ongoing academic research activities from those. (Rasmussen 2006, 18.) One solution to overcome this is to apply sabbatical leaves for a period of commercialisation, as proposed by Rasmussen (2006, 18).

Finally, the evolutionary motor can be seen in the spinout process, especially in network collection. Spinout companies that have collected prior networks with financers, collaborating companies or access to additional resources have been found to be more efficient in further resource gathering and have a higher probability of establishing successful operations. (Rasmussen 2006, 10.)

Rasmussen (2006, 21) concludes that the university spinout process often begins with a teleological motor to drive opportunity recognition using existing networks and individual motives. After this initial phase, a dialectic motor is often observed. A lifecycle motor emerges only after the spinout formation process has been initiated in terms of resources gathering. (Rasmussen 2006, 21.) The life-cycle motor is the most widely used motor to describe spinout formation process in the university setting. However, it is recommended that this model be supplemented with additional motors and theories, since they are able to give insight into a complex process. (Rasmussen 2006, 21.) This recommendation is in line with the research focus of this work. The aim is to first analyse whether TTOs' processes regarding spinout formation are similar to the models introduced in chapters 1–2, after which the observed process is extended with a consideration the of dynamic capabilities introduced in chapter 2.3.

2.2.2 Dominant models of university spinout formation

In this chapter two different models relating to spinout formation from academic research, the stage model by Ndonzuau et al. (2002) and the evolutionary model by Vohora et al. (2004), are discussed in detail. The discussion of these model provides valuable insight

into a TTO's process, as presented in chapter 2.1, and introduces the context of the motors discussed in chapter 2.2.1. While chapter 2.1 introduced a linear, one-directional process of spinout formation centring on TTO activities, these models discuss the same events but from the perspective of a spinout company, examining the requirements and obstacles faced during the process of spinout formation.

In the first model, Ndonzuau et al. (2002) interviewed personnel from 15 different universities, of which 10 were from Europe and five from the US, the Finnish universities being Helsinki Technology University (currently Aalto University) and the University of Turku. On the basis of interviews, these authors constructed a stage model that represents the different stages through which a spinout proceeds before reaching the stage where sustainable economic returns are obtained. This process starts from idea generation and proceeds to finalisation, launch and strengthening the company –phases in chronological order. Since the focus in this research is between the discovery of an invention and spinout formation, the final strengthening phase is excluded from the below discussion.

In second model, Vohora et al. (2004) performed a case study in which the authors interviewed personnel from nine university spinout companies emerging from seven universities, all from the United Kingdom. Aside from company representatives, the authors also interviewed TTO members and university managers from corresponding universities. The key results were the discovery of four different stages, named "critical junctures" (Vohora et al. 2004, 147) that university spinout formation faces during the formation of a company from original research discovery. In addition, the authors argued that each of these junctures must be overcome in terms of gathering sufficient resources and capabilities before a company is able to proceed to next phase. In total, four different junctures were discovered: opportunity recognition, entrepreneurial commitment, threshold of credibility and threshold of sustainability, in chronological order. Similarly, as in the model by Ndonzuau et al. (2002), the final phase of the model focusses on strengthening the existing spinout company, and since this research focusses on the TTOs' activities between idea disclosure and spinout formation, the final juncture is excluded.

Figure 7 represents the model constructed by Ndonzuau et al. (2002), and the stages from idea generation to launch of the spinout are discussed further below. As noted above, the strengthening phase of the formed company from original model is excluded from the adapted figure due to the focus of this study.

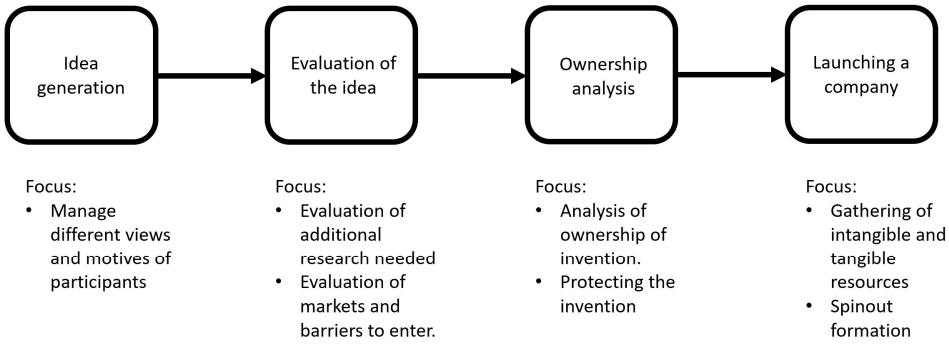

Figure 7. Stage model of spinout formation. Adapted from Ndonzuau et al. (2002, 283)

In the first phase, the authors identified two challenges in idea generation: academic culture and internal identification. Regarding to academic culture, Ndonzuau et al. (2002, 283) have found that a strong emphasis on publishing key findings from the performed research may hinder the possibility of further patenting and following commercialisation options. One of the reasons for the strong emphasis on publishing most likely arises from the career tracks in the university, where persons are evaluated according to their scientific outputs in peer-reviewed journals, as discussed previously in the introduction chapter. This further illustrates the importance of TTOs to have routines and means to manage these perspectives (Ndonzuau et al. 2002, 283–284.)

Aside from different cultures regarding publishing, the personnel in business and academia also have differing views of money. While researchers view money as funds to perform research, often applying their own grants to finance research group activities, people with business backgrounds view money as the output of the whole process and as a means to obtain further funding. These differing understandings may lead to a situation in which the lack of business-oriented goals in the applications results in the lack of economic value in the performed research. (Ndonzuau et al. 2002, 283–284.)

Besides contradicting views, Ndonzuau et al. (2002, 284) has classified the first idea phase to include internal identification, which is a way of both identifying the idea and further assessing its commercial potential. The authors state that idea identification is both one of the most important and most difficult steps for university personnel in the whole spinout formation process. However, the authors further note that inventors often do not see the benefits of external evaluation of their invention (e.g. by people with business background). For example, inventors may believe that a highly innovative solution from

technical perspective would be enough for commercialisation purposes, but persons with business backgrounds could observe the invention to be unsuitable for commercialisation. Authors emphasise that the institute should have ways of aiding this technical evaluation process, especially to observe whether further research should be conducted. Apart from technical evaluation, the commercial potential of the invention should be evaluated in this phase. The commercial evaluation should include market analysis regarding the size of the market, possible barriers for entry, a competitor's business model analysis, and finally, whether there exists a possibility to build a novel spinout company to commercialise the novel invention. If these initial market and idea analyses show that there is potential in the viable commercialisation of an idea, these evaluations should be continued also in second phase, while other aspects are also start to be considered. (Ndonzuau et al. 2002, 283–284.)

The second phase may often start by analysing the ownership of the invention. In some cases, ownership is clear, such as when a university-employed researcher creates an invention with an only federally granted project, in which ownership belongs to the university in the US. However, inventions can also be created in jointly funded projects where multiple persons are involved, each employed by different institutes and companies. In these situations the clarification of ownership may take additional effort. Once the ownership of the invention is clarified, the invention's protection should be evaluated. Participating members should consider how difficult the invention is to copy, representing imitability, and does it create for example barriers to enter to the market. (Ndonzuau et al. 2002, 284–286.) Often, however, additional legal protection is sought in the form of a patent (Lowe, 1993, according to Ndonzuau et al., 2002, 285). After knowledge about ownership and decisions on protection are clear, the invention's readiness should be analysed and evaluated to see whether additional technical developments are required before reaching the prototype stage. The prototype stage should reveal whether the invention is scalable and shows potential to participating stakeholders. Furthermore, also initial business plans should be sketched, including estimated operation costs, which can be used for promotional purposes. Additional financing should be sought as well. (Ndonzuau et al. 2002, 285–286.) However, Ndonzuau et al. (2002) point out that often, at this stage, the invention is still in an early phase, and invention would require additional finances for further development. Therefore the authors mention that gathering finances at this stage may be one of the most difficult tasks in the venture-creation process. By the end of the second phase, both technological and business plans should be at a stage where they can be implemented in third stage's spinout creation. (Ndonzuau et al. 2002, 285–286.)

The third stage, which is the final stage to be discussed in this work, relates to the phase in which a company is launched. According to Ndonzuau et al. (2002, 286–287), major focus should be on resource gathering for spinout formation and to clarify relationships to the university from where the original invention emerged. These authors have

recommended that the spinout should be both operated and advised by skilled people, noting that Timmons' (1994, according to Ndonzuau et al. 2002, 286) discovery that often the failure of a spinout is not due to technical challenges, but due to company management failures, remains valid in the university spinout context. In addition, the authors have suggested that discovering the right managers and advisors with valuable experience and connections can be a major challenge. Ndonzuau et al. (2002, 286) state that the major tangible resources that should be gathered for spinout formation are finances and materials. Investors often view university spinouts as high-risk investments and evaluate loan interest and equity prices accordingly. Material resources can include, for example, production and research instruments or premises. These resources are connected to the relationship between the university and a spinout company. Since the commercialisation of a life science invention may take years before a spinout is formed, people who participate in the invention process may have other obligations to the employing university or be otherwise unwilling to leave for a spinout company. One alternative for a company to maintain access to this knowledge and possible specific instruments is to outsource the research from the university. (Ndonzuau et al. 2002, 286–287.)

In turn, Figure 8 represents the evolutionary model by Vohora et al. (2004, 152). In total, five phases with four critical junctures between each phase were discovered. In this work, the focus will be on TTOs' activities to facilitate company formation, and therefore the final parts of the model, where the established company is re-oriented and focusses on sustainable operations, are excluded from the figure. The phases and junctures are discussed below in chronological order.

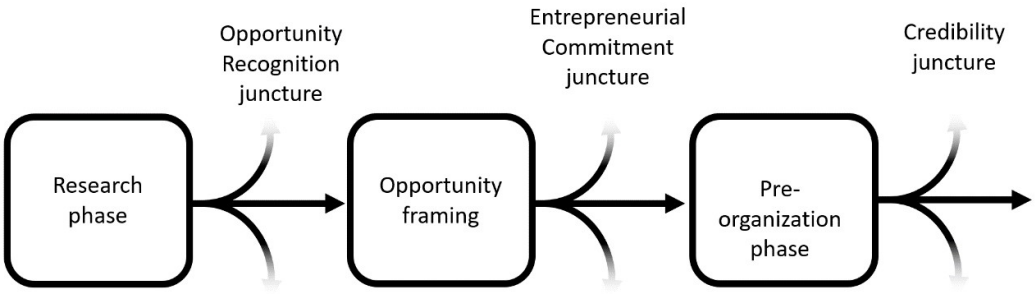

Figure 8. Evolutionary model of spinout formation. Adapted from Vohora et al. (2004, 152).

The first phase in the evolutionary model by Vohora et al. (2004) is a research phase. Since the work is carried out by university personnel and with an academic focus, the efforts are concentrated on the research and its subsequent publication, to serve the needs of academic community. (Vohora et al. 2004, 151.) This notion is in line with the earlier discussion from Ndonzuau et al. (2002, 283) and indicates the need for TTOs to act in an

intermediary role. Vohora et al. (2004, 151) have further stated that often the research leading to academic spinouts is conducted by leading experts in the given field, and not by young, unexperienced scientists.

After the research phase, spinout development faces its first critical juncture: opportunity recognition. The main focus here is to identify market need and to understand how the invention might meet this need. Often, this initial market evaluation is performed by the inventors who have high knowledge of its technical requirements, but lack business experience. This may lead to the over- or underestimation of the feasibility of the invention, possible profits, and an ability to form a company for commercialisation. (Vohora et al. 2004, 159–160.) Therefore it could be beneficial to seek additional resources from the networks outside the limited research environment to aid in opportunity recognition. (Vohora et al. 2004, 170.)

Once opportunity recognition junction has been achieved, the spinout formation process moves to the opportunity framing phase. In this phase, technology is evaluated further to observe whether it is ready for market, or whether additional developments are required. Different possibilities for commercialisation routes, markets and their barriers should also be evaluated at this point. In addition, authors found that often the initially recognised opportunities are not the most beneficial ones, and the ability to re-frame the technology and required resources to meet alternative opportunities becomes crucial. Since different markets and commercialisation routes may require different resources, such as human, physical, financial and technological, as classified by Vohora et al. (2004, 156), the evaluation is often an iterative process that may take years to complete. Inability to perform this framing may lead to difficulties in the later steps. Authors further found that the use of outside networks, such as potential customers and investors, in the re-framing phase may aid the company in the evaluating and discovering alternative opportunities. (Vohora et al. 2004, 151–156.)

After the target market and a way to commercialise the invention have been clarified, spinout company formation comes to entrepreneurial commitment –junction, where the major emphasis is to commit key personnel, mainly the leading management team and financing parties, to the spinout formation process. Major challenges often arise from the role of inventor and his or her role as a possible entrepreneur. While some finance providers are eager to see full-time commitment of the inventor as in an entrepreneurial role, the inventor may not have the incentives to act in this position, nor does the inventor always have the capabilities for the position. The challenges the inventor may face include a lack of role models who have prior experience in the successful university spinout creation, strong focus on research and lack of a motivation for a commercial development. In addition, the majority of the inventor's networks are often related to academic research, and the person may have no experience in managing a business operations. However, the

lack of business expertise may become a challenge also in a situation in which the inventor is eager to become and entrepreneur. Challenges may arise from the lack of manager capabilities, such as inability to delegate. To circumvent these challenges, one option is to appoint a surrogate entrepreneur, an individual with prior entrepreneurial experience who manages the spinout but is not the original inventor. However, challenges may arise due to the different views of the inventor and the surrogate entrepreneur about the focus and management of the company. In general, challenges in commitment junction can be a lack of incentives to participate and lack of networks to financers and personnel with market knowledge. These challenges may reduce the commitment of the participating stakeholders. (Vohora et al. 2004, 160–164.)

Once sufficient commitment is obtained from the entrepreneur and other stakeholders, spinout formation proceeds to pre-organisation phase. This phase can be classified as the most important, since these decisions form the strategy for the company's initial development. Moreover, Vohora et al. (2004, 157) emphasises that this phase "represents the steepest learning curve for the academic entrepreneur". The phase starts from the stage where a clear choice of the market and a spinout formation has been decided, and the aim is to gather the resources, capabilities, knowledge and managerial aid necessary to form a company. (Vohora et al. 2004, 156–157.)

Finally, a spinout faces an evaluation of credibility before it spinout is formed. Since the members of the possible company often lack prior business experience, and resources and capabilities are limited to know-how and IP ownerships, additional assets for venture creation must be gathered. A major focus in terms of credibility is therefore the ability to increase the credibility of the academic spinout company to attract funding for company formation. Difficulties in this task may arise from the lack of credibility in the spinouts entrepreneurial capabilities, such as prior experience running a company and its processes, and a lack of connections with existing networks. In addition, unsuccessful opportunity framing and pre-organisation phases resulting in modest strategic plans further reduce the credibility of the venture. Close connections to the university, such as establishing the company operations on university premises, may create additional challenges, since customers and investors may see the company as an extension of academic research without the desire to establish their own corporate identity. In order to increase the credibility of the venture and attain prior business experience, the use of a surrogate entrepreneur may be favourable. Furthermore, also prior experience of the university in successful spinout formation increases the credibility of the company emerging from the university. (Vohora et al. 2004, 164–171.)

2.3 Dynamic capabilities

Previous chapters have discussed the progress of an invention from initial discovery to spinout formation, first from a view of TTO operations (chapter 2.1) and then from a view of the emerging spinout (chapter 2.2). This chapter introduces the theory of dynamic capabilities, which will be used to assess the third research question relating TTO's capabilities, specifically in life-science-related spinout formation. Capability perspective can be seen to emerge from the research of resource-based view (RBV) (Eisenhardt & Martin 2000, 1106) and therefore the RBV is briefly discussed at the beginning of 2.3.1, before discussion on dynamic capabilities.

2.3.1 Emergence of dynamic capabilities

Lockett, Thompson and Morgenstern (2009, 9) indicate in their review that RBV has become one of the most applied theories in strategic research. Essentially, units in the analysis of RBV are resources of the company and capabilities how to utilise those resources in a given situation often aiming to achieve competitive advantage over competing companies (Lockett et al. 2009, 9–10). This combination has been evaluated as one of the core reasons for the differences between companies' performances on the market (Peteraf & Barney, 2003, 315). In addition, not all companies have the same set of resources available (Barney 1991, 112). Since there are differences in resources, Barney (1991, 112) has presented the VRIN framework to analyse the current resources of the company and to evaluate their characteristics. Author proposes that for the resource to become a competitive advantage, it must be valuable, rare, inimitable and non-substitutable (i.e. 'VRIN'). Still, although the VRIN framework is beneficial in evaluating existing units, the model is static and does not take into account the progress of the environment, nor does it discuss how a company is able to adapt to change (Barney 2001, 49–51). However, sustainable competitive advantage has been proposed to emerge from resources that have all VRIN characteristics (Peteraf 1993, 187–188). Although "resources are at the heart of the RBV" (Eisenhardt & Martin 2000, 1106), some scholars have further proposed that they are the combinations, uses and routines connected to these resources that can impart competitive advantage, not resources themselves. (Eisenhardt et al. 2000, 1107.)

Parmigiani and Howard-Grenville (2011) provide an excellent review of the empirical studies performed around routines. They divide these studies into the perspectives of capability and practice, where capability studies aim to answer what the "purpose or motivation"(Parmigiani & Howard-Grenville 2011, 414) of these routines is and how do they increase the performance of the organisation to meet their goals. In contrast, practice-oriented research aims to answer "how they [routines] operate and how they [routines]

are reproduced or changed as people enact them" (Parmigiani & Howard-Grenville 2011, 414). With a focus on capabilities, individuals are thought to possess self-interest over their actions, but a majority of them still operate as intended by the organisation. In practice perspective, individual self-interest has a greater effect on routines. This leads to a notion that in capability perspective the focus is in "what" and "why" questions, and while the practice perspective focusses on "how". (Parmigiani & Howard-Grenville 2011, 413.) To answer these questions, capability perspective uses routines as a whole in the unit of analysis. In contrast, practice perspective analyses routines in greater detail, taking account also the self-interest of the individual, so there is often a need to disassemble the routines before "how" questions can be answered. (Parmigiani & Howard-Grenville 2011, 413–417.)

Since the aim of this work is to examine processes of TTO and how capabilities are part of the facilitation of spinout creation, this study adopts a focus on capabilities perspective over practice. This decision allows attention to be drawn to the economic aspects of the TTO and the exclusion of analysis of self-interest of the participant's actions in routines in the TTO commercialisation process. Capability perspective is discussed more thoroughly below.

Since the focus on routines is adopted with an orientation to capability perspective, in this study the routines are defined accordingly. The definition follows the recommendation by Parmigiani and Howard-Grenville (2011, 419) who define them by quoting Dosi, Faillo and Marengo (2008, 1167): "the building blocks of capabilities, with a repetitive and context-dependent nature". Since there are vast number of these building blocks (for example, see Teece's 2007 discussion on microfoundations) not all formed capabilities are identical. Some capabilities are efficient at increasing the performance of the company by offering stability in operations, often classified as "ordinary" (Winter 2003, 991). In contrast, other capabilities are able to change the existing routines. These capabilities are called dynamic capabilities (Winter 2003, 992), and they are further discussed below.

Collis (1994, 145) divides capabilities into different categories. In the first category, there are capabilities that sustain the normal operations of the company's processes and practices. These can be classified as operational capabilities. In the second category, there exists capabilities that allow learning and changing the resource base and processes to suit environmental changes. A similar classification has been given by Winter (2003, 992), who divides the capabilities in different levels. Zero-level capabilities, also termed ordinary or operational capabilities, encompass activities that utilise current routines to perform tasks. One example would be "an organization that keeps earning its living by producing and selling the same product, on the same scale and to the same customer population over time" (Winter et al. 2003, 992). In turn, first-level capabilities are introduced as "capabilities that would change the product, the production process, the scale,

or the customers (markets)" (Winter 2003, 992). These, as with Collis's (1994) second category of capabilities, are dynamic capabilities (Ambriosi & Bowman 2009, 33–34).

However, there is no universal definition of dynamic capabilities. Parmigiani and Howard-Grenville (2011, 420) conclude that by 2011, already at least 10 different definitions had been used for this topic, each with their own distinct focusses and limitations. Similar results were found by Ambrosini and Bowman (2009) in their review regarding dynamic capabilities, as presented in Table 1.

Table 1. Varying definitions of dynamic capabilities. Adapted from Ambrosini and Bowman (2009, 32–33).

Definition	Author
"the firm's ability to integrate, build, and reconfigure internal and external competences to address rapidly changing environments"	Teece et al. (1997, 516)
"The firm's processes that use resources – specifically the processes to integrate, reconfigure, gain and release resources – to match or even create market change.	Eisenhardt and Martin (2000, 1107)
"A dynamic capability is a learned and stable pattern of collective activity through which the organization systematically generates and modifies its operating routines in pursuit of improved effectiveness"	Zollo and Winter (2002, 340)
"[Dynamic capabilities] are those that operate to extend, modify or create ordinary capabilities"	Winter (2003, 991)
"the abilities to reconfigure a firm's resources and routines in the manner envisioned and deemed appropriate by its principal decision-maker"	Zahra, Sapienza and Davidsson (2006, 918)
"a firm's behavioural orientation constantly to integrate, reconfigure, renew and recreate its resources and capabilities and, most importantly, upgrade and reconstruct its core capabilities in response to the changing environment to attain and sustain competitive advantage."	Wang and Ahmed (2007, 35)
"the capacity of an organization to purposefully create, extend or modify its resource base."	Helfat et al. (2007, 1)

Multiple definitions of dynamic capabilities highlight the still-evolving stage of the concept of dynamic capability (Barreto 2010, 257; Peteraf, Di Stefano & Verona 2013, 1389). However, out of these definitions, Teece, Pisano and Shuen (1997) and Eisenhardt

and Martin (2000) have become most dominant ones used to define dynamic capability research (Peteraf et al. 2013, 1389).

In this work, the definition will be limited as suggested both by Parmigiani and Howard-Grenville (2011, 420) and Helfat and Peteraf (2009, 94); who quote Helfat et al. (2007, 4), proposing that dynamic capabilities are

"the capacity of an organization to purposefully create, extend, or modify its resource base". (Helfat et al. 2007, 4)

Helfat and Peteraf (2009) further note that in this definition, the resource bases are "tangible, intangible, and human assets (or resources), as well as capabilities which the organization owns, controls, or has access to on a preferential basis" (Helfat & Peteraf 2009, 94), as described earlier by Helfat et al. (2007, 4). The "capacity" in the definition does not assume how efficient or inefficient the activity is, and the "purposefully" can be event smallest intentionality (Helfat & Peteraf 2009, 94).

There are four reasons this definition was chosen in this study. First, this definition is a synthesis from the definitions of the seminal works of dynamic capabilities research conducted by Teece et al. (1997) and Eisenhardt and Martin (2000). (Helfat et al. 2009, 94.) Second, the wide definition was selected because there exist multiple different types of dynamic capabilities that should suit the same definition (Helfat et al. 2009, 94). Third, dynamic capabilities can be difficult to observe, and only a few empirical research papers exist on the topic (Ambrosini & Bowman 2009, 37, Parmigiani & Howard-Grenville 2011, 424–430). Fourth and finally, while Teece (2007) classified Eisenhardt and Martin's (2000) research of dynamic capabilities partially "as important elements (microfoundations) of dynamic capabilities" (Teece 2007, 1322), the chosen definition recognises them as complete dynamic capabilities, since they fit the limitations of synthetized definition from both of the seminal works.

Now, since the dynamic capabilities have been detailed and a definition has been chosen that synthetises both Eisenhardt and Martin (2000) and Teece (2007), these two dynamic capability views are next discussed.

Eisenhardt and Martin (2000, 1107–1110) list multiple different processes that can be classified as dynamic capabilities. These include activities where resources are gathered, combined, allocated and utilised for various activities such as product development, knowledge creation and transfer. Similarly, dynamic capabilities can be seen as a "routines to learn routines" (Eisenhardt & Martin 2000, 1107) that can lead to formation of "best practices" (Eisenhardt & Martin 2000, 1108), such as accumulation of experience in company acquisitions, cross-cultural team formation to include altering views to the process, and feedback channel formation for customers. In short, the description given by Eisenhardt and Martin (2000) of dynamic capabilities can be seen to emerge from the

accumulation of tacit knowledge related to a given process that may in some instances form an explicit procedure. However, while dynamic capabilities may grant competitive advantage to a company, they cannot be the source of sustainable competitive advantage. This proposition is given by Eisenhardt and Martin (2000, 1110), who states that while resources and capabilities can have the characteristics of the VRIN framework, and therefore would allow sustainable competitive advantage, the dynamic capabilities are not inimitable. Different companies can have own procedures, best practices and routines for the utilisation of the resources they discover, hence imitating successfully the competitors. This observation leads to the notion that dynamic capabilities are not a source of sustainable competitive advantage, but can be a source of competitive advantage for a period of time, before practices are imitated. (Eisenhardt & Martin 2000, 1110.)

Another notion given offered by Eisenhardt and Martin (2000) relates to the form of dynamic capabilities related to the market dynamics between highly and moderately dynamic markets. In markets that have only modest dynamics, markets are predictable with known companies competing with clear boundaries. In those markets, dynamic capabilities mostly rely on existing knowledge. This knowledge can be written down to a specific routines that are followed, for example in product-development processes. Often these dynamic capabilities have accumulated from multiple previous experiences and have become a part of complicated and detailed structures. (Eisenhardt & Martin 2000, 1110–1113.)

However, in high-velocity markets dynamic capabilities have different forms. These markets do not have a predictable future, and often there does not exist dominant successful business model. In these markets, dynamic capabilities are not accumulated and transcribed in written complicated routines, but exist in ways of acquiring and applying new knowledge quickly. The lack of accumulated written routines often means that companies have only a few rules which they follow to seize an opportunity, the speed of which becomes essential in these situations. Dynamic capabilities can take forms that allow fast gathering of knowledge and following prototyping, often with various prototypes simultaneously, to gain knowledge of how competitive advantage can be best attained. However, high-velocity markets do not mean that the participating companies are required to decrease all routines. Often, companies apply strict routines, especially in situations where sequential progress is evident requirement, and they apply dynamic capabilities in this process as they see fit. (Eisenhardt & Martin 2000, 1110–1113.)

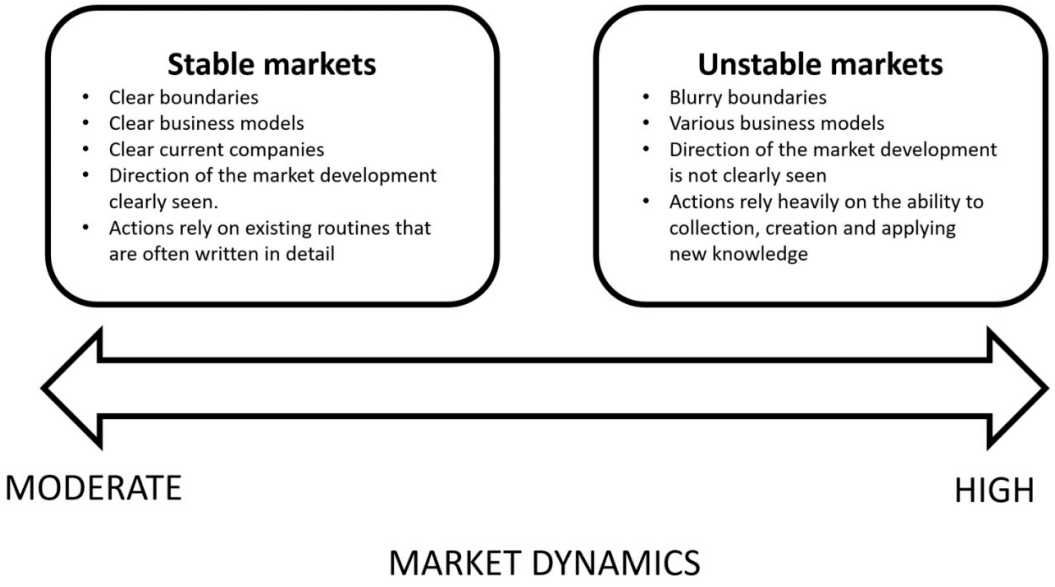

Figure 9. Different characteristics of stable and unstable markets. Adapted from a table by Eisenhardt and Martin (2000, 1115)

The differences in market dynamics lead Eisenhardt and Martin (2000, 1113–1114) to note that while in moderately dynamic markets, dynamic capabilities can have complicated forms and are therefore difficult to observe, in highly dynamic markets, the difficulty of observing dynamic capabilities is due to their simplicity.

Eisenhardt and Martin's (2000, 1114) suggestion that dynamic capabilities are accumulation of learning and not only accumulation of knowledge, as described by Teece et al. (1997), leads the authors to discuss what effects this learning process. They conclude that while small drawbacks are beneficial, as proposed by Sitkin (1992), too many failures can lead to blockage in the learning progress. In turn, multiple moderate successes where capabilities are altered slightly are best for acquiring knowledge. Finally, too much success in one event can result in a situation where a company evaluates its methods to fit all opportunities alike, creating false optimism. (Eisenhardt & Martin 2000, 1114–1116.) Eisenhardt and Martin (2000, 1117) conclude that while dynamic capabilities are not a source of sustainable competitive advantage, they are a source of temporary competitive advantage when companies apply them in learning and meeting market opportunities.

Teece (2007) discusses the elements of dynamic capabilities and proposes that dynamic capabilities can be divided into sensing, seizing and managing opportunities. Moreover, each of those steps are composed of multiple subunits, named microfoundations, as illustrated in Figure 10. Each of these sets and corresponding subsets are discussed below to create wider understanding of the content of dynamic capabilities.

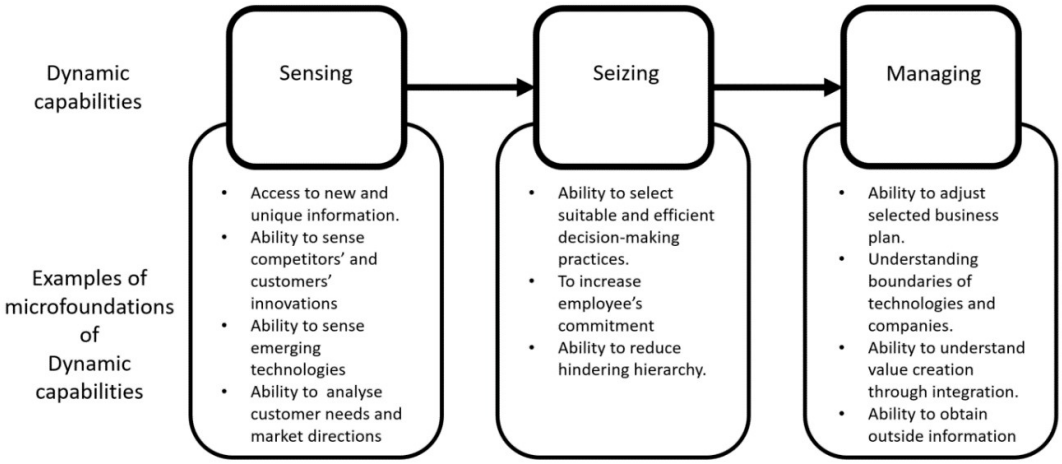

Figure 10. Dynamic capabilities and examples of microfoundations. Adapted from Teece (2007, 1342)

Companies can sense opportunities because they either have access to information no other company has, or they are able to create such information, for example through their own R&D activities. Observed information is, for example, connected to knowledge of market needs, trends, competitors and the potential of the new information. In short, a combination of new information of a market's current and predicted state allows estimation of opportunity potential. Microfoundations of sensing include a notion that companies sense both inside and outside activities, leading to the notion that observed events vary between companies. In addition, while companies sense outside events, they must connect them to the sensed information from inside the company to evaluate the usability of the sensed opportunity. Moreover, processes should allow the evaluation of external and internal opportunities arising, for example, from new technologies. This process should be organised inside the company so that it is not tasked to only a few individuals. Furthermore, a process should not have many layers of information transfer, since the content of the information can be altered. (Teece 2007, 1322–1325.)

Once an opportunity is sensed, it should be seized, which can occur by meeting the sensed opportunity with a suitable product or a service. Especially in emerging market conditions, without dominant business and product models, seizing may require multiple various resources. A combination of novel business plans and resources can in turn face restrictions by a company's bureaucracy, limiting the ability to seize the opportunity. An example of a limiting process is a too-strict decision-making hierarchy, which can be efficient in markets with slow dynamics, but restricts the use of a required business plan in novel market situations. Other challenges may arise when the sensed opportunities are evaluated too optimistically or when an opportunity is evaluated strictly with investment-returns calculations, with the former circumstance steering seizing to unprofitable actions and the latter relying too much on possibly unreliable metrics. (Teece 2007, 1326–1329.)

The microfoundations of seizing focus mostly on a business plan and its functions. A business plan dictates which technologies are developed to meet which opportunities, how they are commercialised and brought to a market and to which segment. Moreover, microfoundations focus on the ability to adjust an existing business plan when new information is collected and evaluated. In an ideal situation, multiple alternations to business plans are evaluated simultaneously against valid customer needs, and the decision-making process should be cleansed of pre-existing biases. Another microfoundation is the ability to understand the boundaries of the company and their technology to competitors. For example understanding a value chain and its most important assets, and the resources that should be outsourced. In addition, technical inventions have their own varying boundaries compared to alternatives. Another microfoundation is the understanding of platforms where value is created by incorporating products or services into pre-existing items. In addition, the ability to obtain neutral external and internal perspectives and information can be considered a microfoundation. (Teece 2007, 1329–1334.)

After an opportunity is sensed and how it should be seized is evaluated, managing this process becomes essential. A company's management routines are often efficient in minimally dynamic markets, but high-velocity markets require an ability to alter the processes and resources. It follows that in these situations, a company's management structure should be flexible to allow the alteration, and the company should have the means to both attain and use newly gathered knowledge. Microfoundations to complete these tasks include allowing decision making to occur not only at highest levels, granting autonomy also to managers. Other microfoundations include the understanding of developed invention and the benefits that can be achieved if supporting elements are included in the invention, or whether the invention creates higher value when integrated to alternative systems. Finally, processes to learn and secure learned information, as well as incentives structures that guide personnel to act towards set goals, can be classified as microfoundations. (Teece 2007, 1334–1341.)

2.3.2 Challenges in the observation of dynamic capabilities

The previous chapter introduced dynamic capabilities. While the selected definition of dynamic capabilities separates them clearly from operational capabilities, reliable identification of capabilities as dynamic during empirical research can be challenging. Where the differences between levels and categories are drawn depends on the studied organisation, which means that some capabilities that would be classified as dynamic in one organisation can be ordinary in second organisation. (Winter 2003, 992.) These challenges are briefly viewed.

Helfat and Winter (2011) list three different challenges in the assessment of dynamic capabilities and the separation of them from operational capabilities. First, when organisation and its processes are observed for only a short period of time, the change in resource base and operational actions, which often takes long period of time, can be difficult to observe. Therefore, often only operational capabilities are seen, while the presence of dynamic capabilities remains vague, although they may exist. Therefore it is recommended that the focus of dynamic-capability research, when performed over a short period of time, is not on the change of resource base or capabilities itself, but on how the capabilities allow fast change in resource base. The second challenge arises from the assumption that dynamic capabilities create radical change. This assumption is often associated with dynamic capability definitions given by Teece (2007), while Eisenhardt and Martin (2000) have discussed that companies utilise dynamic capabilities also in moderately dynamic markets. For example, Helfat and Winter (2011) have proposed that when oil-drilling companies operating in moderately stable markets seek new drilling locations (resources) that are subsequently included in their operations, they utilise dynamic capabilities. Thus, even processes that use same capabilities over and over can be dynamic capabilities if they increase the resource pool. However, often these activities are wrongly classified as operational capabilities due to the short timeframe, which hinders the ability to observe alterations in resource base. This insight leads also to third challenge for the separation of operational from dynamic capabilities. The same capabilities can be both operational and dynamic in use. In these situations, the perspective taken by researcher is important, since capabilities can have multiple classifications. These above-discussed challenges can be reduced by changing the observed timeframe to longer periods of time, allowing for easier identification of occurring change. (Helfat & Winter 2011, 1245–1249.)

2.4 Initial framework

Much research has been conducted relating TTOs' activities in commercialisation process. The literature review in chapters 2.1 and 2.2 explains in detail prior research relating to the sequential commercialisation of an invention, moving towards spinout formation. The prior research includes which parties perform commercialisation events, what resources are needed in each of the steps and what challenges might emerge. The initial framework is therefore drawn based on this sequential structure, and collected from work by Lockett and Wright (2005), Siegel et al. (2003a; 2003b & 2004), Bradley et al. (2013), Ndonzuau et al. (2002) and Vohora et al. (2004). In addition, the initial framework presents different activities of TTOs in each phase discussed in chapters 2.1–2.2.

The first phase in the sequential process is the research phase, in which the inventions are developed. The next phase is the evaluation of the invention, where the most promising inventions are assessed and chosen for further commercialisation activities. The next phase, where invention is protected, is performed by or with the TTO. Finally, TTOs gather and the secure resources for the inventions that are subjected to spinout formation.

While the first and second research questions of this study are connected to the autonomy of a TTO and to the stages of the commercialisation process on the path to creating spinouts, respectively, these research questions are used to build a context for the third research question, which focusses on the dynamic capabilities of TTOs. The studies related to dynamic capabilities in these stages are, however, lacking, as mentioned in chapter 1.2. Moreover, the classification of capabilities into either operational or dynamic is challenging (see chapter 2.3.2). For these reasons, the initial framework does not present the precise dynamic capabilities, but only their presence is indicated.

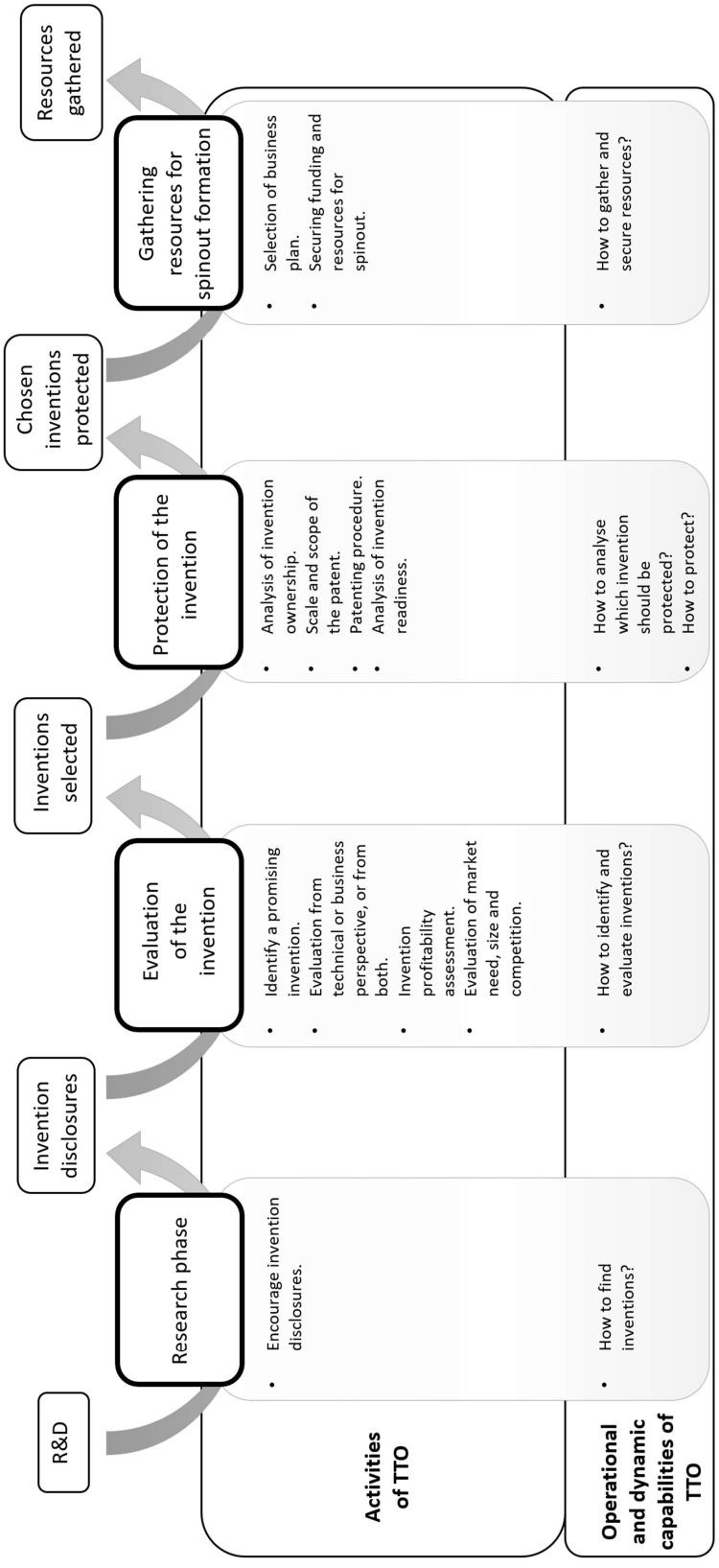

Figure 11. Initial framework of the study

3 RESEARCH DESIGN

3.1 Research approach

Universities are in an important position in providing research outputs to the wider community, in turn facilitating economic growth (Roessne et al. 2013, 23). As discussed in chapter 1.1, TTOs either reside within or in close connection to the university, and the commercialisation of university research outputs is often bestowed to them, making them an important element in the commercialisation process (Bigliardi et al. 2015, 364). Due to the increasing recognition of TTO's and their importance in this commercialisation process, the activities of TTOs have also been studied extensively in business literature (see chapters 1.1, 2.1 and 2.2). However, much of the research has focussed on the activities aspects of the TTOs, and research on the dynamic capabilities has been lacking. This study mainly centres on the dynamic capabilities of the TTOs in the commercialisation process towards spinout formation. However, while operational capabilities are often easier to distinguish, there are challenges in categorising capabilities as dynamic (see chapter 2.3.2)

In order to obtain answers to the research questions, multiple alternatives for both a research approach and applied research methods exist. Often, a research approach follows either a qualitative or quantitative method. (Creswell, 2007, 39–40.) In addition, a research approach may have elements from both, in which case it is termed mixed-methods research. In quantitative research, the aim is often "testing objective theories by examining the relationship among variables" (Creswell, 2009, 4). This aim, in turn, is often achieved by testing pre-set hypotheses in statistical means to obtain quantifiable results (Creswell, 2007, 16). On the other hand, a qualitative approach is often used when there is a need for a "complex, detailed understanding of the issue" (Creswell, 2007, 40), and this can be obtained only by talking to people to gain their insights. Moreover, a qualitative research approach is favoured when a complex situation or event cannot be revealed by quantitative methods. (Creswell, 2007, 39–40.)

Due to the high complexity of the phenomena pursued in this study, and their process-like structure, this study followed a qualitative approach. However, qualitative research is often seen as challenging method to perform research (Yin, 2003, 1). Multiple qualitative research approaches exists, such as ethnographic, case study, grounded theory, narrative and phenomenological. (Creswell, 2009, 78). The decision of which approach is recommended is to be decided upon answering questions: what types of questions are asked, and does the researcher have control over the studied events. (Rowley, 2002, 17.) While each of the above methods have their unique advantages, this research is performed with case study. Dul and Hak (2007, 4) discuss case study research as research in which

one or small number of case-study targets are selected and studied in their own context, and where the obtained data is analysed through qualitative methods. This approach allows researcher to gain deep understanding of a relevant topic, with an ability to ask *"*how" and *"*why" questions (Yin, 1994, 9, 2003, 6–8), as required in this study.

A case study approach has been argued to be an efficient way to analyse processes in their environment (Gummesson 1988, according to Meyer, 2001, 331). Also, a case study is effective when a researcher has no control over the studied events, so that the researcher cannot manipulate the behaviour of observed event. (Rowley, 2002, 17). Similarly, Yin (2003, 7–8) indicates that a qualitative case study is well suited for research situations in which studied events are occurring currently and over which researchers have no control. Rowley (2002, 18) also proposed that a case study approach is effective when events are studied in their context and where multiple data-collection approaches can be applied, such as interviews and documents. Furthermore, a case study approach is an efficient tool when there is a need for exploratory study concerning the topic (Rowley, 2002, 16), as it is in this study, where prior knowledge about dynamic capabilities of TTO's are lacking. Similar claims have also been made by Dul and Hak (2007). Moreover, Dul and Hak (2007, 24) emphasise that a case study is especially suited in complex topics lacking prior research.

The philosophical stand on knowledge and how it is viewed effects selection of study methods (Eriksson & Kovalainen, 2008, 29). This stand is the concern of epistemology and ontology, where ontology refers to "what is there in the world?" (Eriksson & Kovalainen, 2008, 14), and epistemology to "what is knowledge and what are the sources and limits of knowledge?" (Eriksson & Kovalainen, 2008, 14). This study follows the paradigm of critical realism, in which "reality is assumed to exist but to be only imperfectly apprehendable because of basically flawed human intellectual mechanisms and the fundamentally intractable nature of phenomena" (Guba & Lincoln, 1994, 110). This position, in turn, leads to an epistemological stance that excludes perfect dualism possibility and faces challenges in perfect replication (Guba & Lincoln, 1994, 110). Similar descriptions have been also given by Sayer (1992, see Easton 2010, 119). As critical realism accepts that observations of the world are imperfect, the aim of the studies that adopt the position of critical realism is to "collect further data that helps to distinguish among alternative explanations and on the community of researchers to debate them thoroughly" (Easton, 2010, 123). Moreover, critical realism is well suited when analysing complex situations and processes that have clear boundaries (Easton 2010, 123), as is the focus in this study. Critical realism is often applied in studying different events and their underlying causality, and is especially suited to support detailed case study research (Easton 2010, 120, 123).

The literature review was summarised into a theoretical framework synthetizing the current knowledge of the TTO's processes in life-science commercialisation. Likewise, an operationalisation table was constructed to illustrate how this study aims to extend the current understanding by examining the presence of dynamic capabilities existing in the process. Therefore the aim of this study can be argued to be to extend the current knowledge of the theory. Eisenhardt and Graebner (2007) discuss that such research is often termed theory-building research, and studies are often conducted with qualitative research approach utilising "why" and "how" questions (Eisenhardt & Graebner 2007, 26.) Given the above-discussed benefits, this study adapts a qualitative case study as its research approach.

3.2 Selection of cases

When multiple cases are selected, the aim in the selection can be that cases are selected either due to their similarities or opposites. If the former is sought, as in this study, the aim of the multiple case study is to analyse similar elements between the cases. (Meyer, 2001, 333.) Multiple case studies follow replication logic in which each single case can be seen as an independent experiment, and each serves as a replication in the cross-case selection (Yin 1994, see Eisenhardt and Graebner 2007, 25). In addition, Eisenhardt and Graebner (2007, 27) state that "theory building from multiple cases typically yields more robust, generalizable, and testable theory than single-case research."

With the aim of extending the current knowledge, the selected cases should also fit into the scope of the study aim. Therefore the cases are purposefully selected to fulfil the need of the study and not to represent the population of, for example, every organisation. (Eisenhardt & Graebner 2007, 27.) As this study focusses on the commercialisation of research results emerging from life-science research from Finnish universities, the population for the case selections was therefore limited to 14 different Finnish universities. The National Defence University of Finland was excluded from the population, since it does not have life-science related research activities. Of these 14 universities, the study chose to focus on the TTOs of Aalto, Helsinki and Turku universities. These three universities are largest universities in Finland in terms of number of students (http://tilastokeskus.fi/til/yop/2015/yop_2015_2016-05-10_tie_001_fi.html, retrieved 18.3.2017).

3.2.1 Aalto University—Innovation Services

Aalto University's TTO is located in Espoo. The purpose of the TTO "is to identify commercially potential innovations and turn them either into profitable startups or valuable licenses". (http://innovation.aalto.fi/about-us/, retrieved 17.3.2017.) Currently, the TTO employs eight people, and the TTO has responsibility in commercialising Aalto University's IPRs. Patent portfolio is divided to five categories: Medical device & life science, engineering & electronics, energy & cleantech, computer science & ICT and chemistry & materials. (http://innovation.aalto.fi/about-us/, retrieved 17.3.2017.)

3.2.2 Turku University—Innovation services

Turku University's technology transfer is located in Turku. The TTO describes its activities as follows: "To create and start new business, Innovation Services unit promotes and supports exploitation of the results originating from scientific research of the University of Turku. The unit offers innovation services for the personnel of the university." and "The aim is to develop these innovations into profitable businesses (start-ups, spin-offs or IP licensing)." (https://www.utu.fi/en/unit/university-services/innovation-services/Pages/home.aspx, retrieved 17.3.2017.) Currently the TTO employs 11 persons to perform such activities. The patent portfolio is divided into diagnostics and imaging, biotechnology and R&D tools, therapeutics and drug targets, electronics, Internet of things (IoT) and semiconductors, and therapeutics and diagnostics. (https://www.utu.fi/en/unit/university-services/innovation-services/Pages/home.aspx, retrieved 17.3.2017.)

3.2.3 Helsinki University—Innovation Services

Helsinki University's TTO is located in Helsinki. The TTO describes their objective in commercialisation as follows: "Our goal is to identify and evaluate commercially viable research results and to turn them into profitable startups or out-licensing opportunities." (http://www.his.fi/en/about, retrieved 17.3.2017.) Currently, the TTO employs 15 people. In 2015, the TTO facilitated the formation of five spinouts from the university's research results. (http://www.his.fi/en/investors, retrieved 17.3.2017.)

3.3 Collection of data

Qualitative research can be performed by collecting different types of research data such as press-releases, statistics, newspaper articles and interviews. When interviews are chosen as one of the data collection strategies, this interview process should be described in detail, since the event of interview data collection is important part of the qualitative research project. (Eriksson & Koistinen 2014, 30–31.) Interviews are often used in qualitative research as a data collection approach, and this approach was selected for this study. Interview can be further classified as open, structured or semi-structured. (Eskola & Suoranta 1998, 60–64.) This study was performed with semi-structured interviews, which allow the collection of wide answers by applying open-ended questions. Semi-structured interviews are also recommended when the interview is performed one time only. Since semi-structured interviews utilise open-ended questions, the answers can be broad and may can cover multiple different areas of interest of the study. To facilitate a thorough analysis process, recording of the interview is therefore recommended. (Cohen & Crabtree, 2006, 1.) In addition, the transcribed recording allows the review of interview dialogue by other persons (Wright, 2013, 79). The operationalisation table, including the interview questions, is shown in Figure 12. It is derived from the theoretical framework presented in Figure 11, which synthetises prior research from the area of focus of the study. Interviewees and their corresponding organisations are presented in Table 2.

Table 2. Conducted interviews

Interviewee			Interview	
Organization	Person	Position in the organization	Length	Date
Turku Innovation Services	Anne Marjamäki	Business Development Manager	59 min	2.2.2017
	Anssi Kähkönen	Innovation Manager	61 min	2.2.2017
Helsinki Innovation Services	Kari Sinivuori	Director, Physical Sciences	42 min	10.2.2017
	Pia Sundell	Senior Analyst	62 min	10.2.2017
Aalto Innovation Services	Matti Korpela	Head of Innovation Services	76 min	21.2.2017

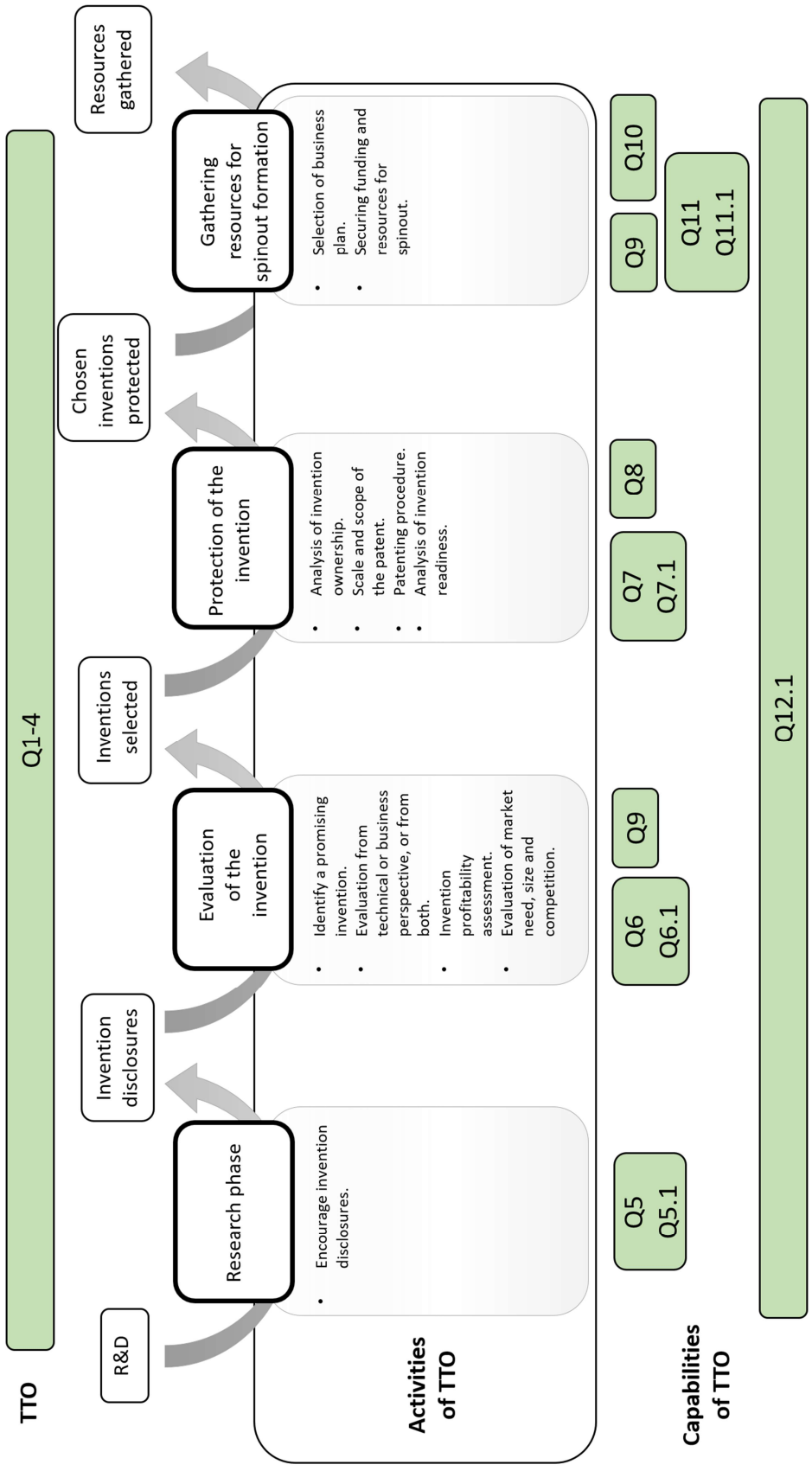

Figure 12. Operationalisation chart.

Semi-structured interview questions:
Q1: How would you describe the role of the TTO in university setting?
Q2: To what extent are the decisions related to commercialisation made inside the TTO?
Q3: What types of expertise do you value when hiring new personnel?
Q4: How would you describe the order of steps in the life-science commercialisation process from idea to spinout?
Q5: How do you find inventions for commercialisation?
Q5.1: And have you modified this discovery process in a the past few years? If yes, why and how?
Q6: How do you know which invention has commercial potential?
Q6.1: And have you modified this evaluation phase in the past few years? If yes, why and how?
Q7: How do you evaluate whether some invention should be protected?
Q7.1: And have you developed this evaluation phase in the past few years? If yes, why and how?
Q8: How is the idea protected in practice?
Q9: How do you know whether spinout should be formed around the invention?
Q10: What resources, in general, are needed for spinout formation? And do they vary between cases?
Q11: How do you gather and commit these resources?
Q11.1: And have you developed this resource gathering in the past few years? If yes, how and why?
Q12.1: How do you think the commercialisation process should be developed further?

The gathering of suitable interviewees began by studying the Internet pages of the chosen TTOs. Once suitable people were chosen by the interviewer, they were each called by the interviewer. It has been stated that trust between the interviewer and interviewee has an influence on the outcome of the interview (Eskola & Suoranta, 1998, 63). This trust was built by first explaining the reason for the interview in the first call. Also, all three case TTOs were given an opportunity to meet the interviewer before the actual recorded interview took place to discuss the purpose of this study and how the interview would be conducted in practice. Personnel from two of the three interviewed TTOs were met before the actual interview. Before the interview, a consent form (Appendix 1) was sent to the participants prior to the interview event. All the interviews were held on the premises of the TTOs. All the interviewees agreed for the interview to be recorded and for their names to be listed in the study. All the interviews were performed in Finnish, the native langue of both the interviewees and interviewer. The researcher aimed purposefully to avoid leading questions, as recommended by Yin (2003, 90). Once the recorded tapes were transcribed to text, the transcripts were sent to the corresponding interviewees.

The interviewees were able to review the transcript and exclude areas of their choosing. Data analysis was initiated after the transcripts were approved by the interviewees. Besides interviews, data was collected from other sources such as web pages and press releases.

3.4 Data analysis

In order to discover the process and activities of TTOs in the commercialisation of research, the collected research material must be arranged to facilitate the analysis of research material. There is not any pre-set strict rules for qualitative data analysis. However, a researcher must be able to explain the rationale of the choices in the study, as well as understand the limitations of selected methods, as discussed in this chapter. (Eskola & Suoranta, 1998, 54.)

The interviews produced 81 pages of transcribed text, in total, approved by the interviewees. Since the interviews were collected with open-ended questions that provided wide answers, the first objective in the data analysis was to find a pattern, which refers to the process of commercialization in this study, from the transcribed literature before cross-case analysis was initiated, as recommended by Eriksson and Koistinen (2014, 35).

There is much flexibility in how the analysis of a case study can be performed (Meyer 2001, 329). However, before conducting the analysis, it is important for one to familiarise oneself to the data thoroughly. (Eskola & Suoranta, 1998, 110.) Therefore collected research data was read multiple times before a single case analysis was performed. The arranging of the research material can be performed without any pre-assumptions regarding the issues that may emerge from the text. In this approach, the possible prior theoretical framework is ignored. However, challenges may arise when there is no prior knowledge sought from the collected data. (Eskola & Suoranta, 1998, 110–113.) In addition, if there is no pre-existing theoretical framework, there is a fear the results are discussed without connecting them into context (Meyer 2001, 331). An alternative approach, also followed in this study, is to utilise a pre-existing theoretical framework and operationalisation table in arranging the collected material. The selected strategy requires that the researcher must be familiar with the theory prior to the analysis. (Eriksson & Koistinen (2014, 35.) Issues emerging from the data can be classified according to theoretical framework, and this structure can be a valuable tool in arranging the data. Moreover, the use of a pre-existing framework often makes the analysis more reader-friendly. (Eskola & Suoranta, 1998, 110–113.) Similar recommendation have been given by Eriksson and Koistinen (2014, 33) who discuss that the arranging can be performed by organising the data with grounded theory or with the aid of a pre-existing framework. In addition, the pre-existing framework and knowledge in theory allows the researcher to spend less time

collecting basic information about the studied phenomenon, such as information about process (Gummesson 1988, according to Meyer, 2001, 331).

Arranging the research material according to themes, such as steps in the commercialisation process, also facilitates the analysis of theories, such as dynamic capabilities. Quotations from transcripts can be copied under each theme, or if there is a fear of losing sight of the context, as discussed by Eskola and Suoranta (1998, 109), the sentences can be rewritten in the researcher's own words. However, while the re-arranging is a powerful technique, especially with themes emerging from theoretical framework, it involves partial subjectivity, since the material is classified by the pre-existing themes. To overcome this challenge, Creswell (2007, 152) recommends that there should also be an additional theme, or code, for the material that shows significance but does not fit into the pre-arranged themes.

In this study the arranging of the material was performed by dividing the material into themes consisting of the stages of commercialisation activities, as presented in the theoretical framework (Figure 11). Once the pattern was identified, the material was then compared against theoretical framework, as proposed by Eriksson and Koistinen (2014, 36). Similar recommendations have also been given by Creswell (2007, 163), pointing out that found patterns should be compared to the theory. Each case was analysed before the study proceeded in its cross-case analysis, as recommended by Eisenhardt (1989, 540) and Yin (2003, 116). Cross-case analysis was performed by comparing emerging themes and patterns, which in this research are processes and dynamic capabilities of TTOs, and the research results were visualised when applicable, as recommended by Creswell (2007, 148–152). Eisenhardt and Graebner (2007, 29), in turn, recommend that a theory be built during data analysis, and the results be presented with images, tables and other illustrations to enhance the representation of the data.

Due to the requests from multiple interviewees, the names of the case organisations are not disclosed in the findings, ensuring that opinions shown in quotation marks cannot be connected to a specific individual. This approach allowed both for trust-building between interviewer and interviewees and for a sense of ease in each of the interview situations. As the cases organisations and names of the interviewed individuals are listed in chapter 3.2, the non-disclosure of the names in findings section does not reduce the trustworthiness of the research, since this study can be readily repeated by using same study material and questions.

3.5 Evaluation of the study

The evaluation of trustworthiness of this study follows the recommendations of Lincoln and Guba (1985). Lincoln and Guba (1985, according to Lincoln and Guba, 1994, 114) determine the trustworthiness of qualitative research to be comprised of credibility, transferability, dependability and confirmatory.

Shenton (2004) describes credibility to mean "to ensure that their study measures or tests what is actually intended." (Shenton, 2004, 64). The author further proposes that the credibility of a study can be increased by utilising similar research methods as applied earlier to similar studies, acquiring knowledge of the studied organisation prior to the research in order to familiarise, to apply triangulation, to ensure that the persons participating in the study are willing participants that feel secure enough to unveil details necessary for the research, and to ensure that the data is reliably collected and interpreted. (Shenton, 2004, 64–68.) Meyer (2001, 345) has proposed that interviews are an efficient method of ensuring that data represents the studied problem, since unclear answers can be probed further during the interview process. Eisenhardt and Graebner (2007, 28) have suggested that the collection of data from multiple sources, such as multiple interviewees or from other sources, increases the credibility of the research. A similar recommendation was also offered by Eskola and Suoranta (1998, 50) and Yin (2003, 97), who propose that a single data source may lead to biased view of the events, and triangulation therefore increases trustworthiness. In addition, credibility can be increased by interviewing multiple persons from single organisation. Credibility may also increase if similar themes and answers to questions emerge from multiple sources. (Meyer, 2001, 337.) Nummela, Saarenketo and Loane (2016) have proposed in their studies that interviewing "key decision makers as respondents increased the validity" (Nummela et al. 2016, 57). Similarly, Eskola and Suoranta, (1998, 155) mention that the collected material should be significant for the study, and saturation is one indicator that a sufficient quantity of data has been collected. However, the authors have further stated that case studies are often conducted from limited number of cases, hindering the possibility of wide transferability. (Eskola & Suoranta, 1998, 155.)

In this study, credibility was increased by utilising similar research methods as applied earlier for comparable studies. All the interviewees were willing participants, and it can be argued due to their positions in their organisation that they possessed vast knowledge in the process of this study. In addition, triangulation and the multiple case study approach were applied to reduce bias in the study. Finally, data analysis revealed that a certain level of saturation had been obtained, indicating that the quantity of collected study material was sufficient.

Transferability refers to the ability to apply the findings to other events or populations (Shenton, 2004, 69). Shenton (2004, 69–70) argues that since the qualitative case studies

are often detailed analyses of specific events, their transferability to other events can be challenging. Therefore the purpose of transferability in qualitative case studies should not focus on the analysis of how well the transferability can be achieved, but instead focus on the detailed descriptions on how the study was performed to allow the readers to evaluate how the transferable of the study findings are into other situations. Author further explains that such detailed descriptions relate to the information of participating cases and interviewed personnel, interview length and questions, and finally the details of the method of data collection and analysis. (Shenton 2004, 69–70.) Similar recommendations have also been given by Eskola and Suoranta (1998, 153), who propose that qualitative studies should also present the logic of data collection and analysis. Such presentation also connects to the reader's ability to evaluate the research (Eskola & Suoranta 1998, 155). Eriksson and Koistinen (2014) discuss that case studies have been criticised for the difficulties they have with the transferability of their findings. Authors further state that the aim of case studies is often not to achieve transferability, but to represent a case in detail in order to widen the understanding of certain events. This is in line with transferability in critical realism, as Eaton (2010) describes "If a defensible causal explanation has been produced in one case then the constituents of that explanation provide a basis for developing theory beyond that case." (Eaton, 2010, 127).

Dependability refers to the ability of other researchers to repeat the study with same interviewees and questions, and to draw similar conclusions. Therefore dependability is connected tightly to repeatability. To allow such dependability, the research design and findings should be discussed in detail. (Shenton, 2004, 71–72; Meyer, 2001, 348.)

In this study dependability was strengthened by giving information about the participating members, the applied research approach and the interview questions, as well as data analysis. Therefore, it can be argued that sufficient information has been given for other researchers to repeat the study. However, as critical realism suggests, perfect replication of studies is unlikely (Guba & Lincoln, 1994, 110).

Confirmability is often referred to as objectivity. The aim of the research is to conclude results that represent the studied situation correctly and do not emerge from the subjective opinions of the researcher. It can be therefore argued that confirmability connects to above-discussed reliability and dependability. Such confirmability can be facilitated by applying triangulation, describing an applied research approach, and also by admitting the researcher's own prior assumptions, if they exist. (Shenton, 2004, 73.) However, Eskola and Suoranta (1998, 151) state that subjectivity cannot be completely excluded in qualitative research. Authors therefore stated that the logic of the data collection and analysis should thus be presented to allow a reader to evaluate the study's objectivity (Eskola & Suoranta, 1998, 54). This study follows such recommendations. Meyer (2001, 344) further proposed that especially in interviews, the connection between interviewee and

researcher is essential, and is therefore prone to subjectivity. Meyer (2001, 344) has proposed that one way to reduce subjectivity is to purposefully exclude prior expectations and assumptions during the research, as performed in this study.

As discussed in chapter 3.1, this study applies a qualitative research design to study the commercialisation process carried out by TTOs. Three case organisations were selected, as described in 3.2 and data collected with semi-structured interview technique that was discussed in depth in chapter 3.3. Collected interview and data from secondary sources were analysed first within single cases following cross-case analysis of the selected cases, as discussed in 3.4. The findings from the single- and cross-case analyses are next discussed, in chapter 4, before concluding the study in chapters 5 and 6.

4 FINDINGS

Collected and analysed data from three different case organisations are presented in chapters 4.1–4.3. The results of each case organisation are presented separately and the analysis is arranged according to themes, as discussed in chapter 3.4. The synthesis of the three case analyses and the cross-case analysis presented by following research questions is discussed in chapter 4.4.

4.1 Technology transfer office 1

The purpose of the TTO is to commercialise inventions emerging from the research conducted by a university. Such activities include the managing of the university's IP, selling of specific research results and licensing negotiations, and support in spinout formation.

Our job is to commercialize the innovations and ideas emerging from the university. (Person from TTO 1).

In most cases, a TTO is able to make and implement its decisions related to its internal processes and commercialisation activities. In larger decisions relating, for example, to the patenting expenses and spinout formation, the approval is sought from the top managerial level from the university. However, in such instances, the TTO independently drafts the application for which the approval is sought. Autonomy is also seen in the decisions relating to hiring new personnel, as the TTO can freely decide the person whom they wish to hire. Preferred skills of employees include experience in private sector, extensive patenting courses and higher university degrees. Substantial knowledge and a PhD were seen as helpful especially in the patent-drafting of life-science-related patents. It can be therefore argued that the TTO has much autonomy in their own decision making.

A higher university degree is wished, but a PhD is preferred. In addition, private sector experience, which is more important than PhD, is sought. And every applicant should have extensive patenting courses conducted from X [University's name redacted]. (–) If it [patent course] is combined with a private sector experience, it would be an excellent package. (Person from TTO 1)

4.1.1 Arrival of invention disclosure

Commercialisation often begins when a TTO receives an invention disclosure from a university researcher. This invention disclosure may arrive without prior notice, or in some instances the researcher may have been in contact with the TTO to discuss whether the invention disclosure should be submitted.

Everything starts from invention disclosure that comes to us. And the first step is to evaluate who owns the invention. We help if university owns the rights, or if they can be transferred to university. And then the next step is that we evaluate if it can be patented. But patenting is not carried out if the invention cannot be commercialised some way. So we'll do a bit of freedom-to-operate, patentability and commerciality evaluation. (Person from TTO 1)

However, although the right to inventions made at higher education institutions act (19.5.2006/369, http://www.finlex.fi/fi/laki/ajantasa/2006/20060369, retrieved 5.5.2017) is such that invention disclosure should be submitted without delay to university, not all inventions are submitted as invention disclosures. In some instances, scientists may not recognise that they have created an invention, and subsequently do not realise the necessity of invention disclosure submission. Also, in a few cases, invention disclosure may be purposefully avoided by the inventors. Therefore a TTO evaluates that here may exist some presumptions which may hinder the researchers in submitting invention disclosures, such as not knowing what the commercialisation processes the TTO facilitates are and what the invention disclosure means in terms of publishing the results in academic journals, which can be seen as the main aim of the researcher.

The right in Inventions made at Higher Education Institutions act states that researchers have an obligation to submit invention disclosure without delay. But if the researcher does not recognise that he or she has made an invention, which is the typical case, that researcher seeks publication and does not think that there is an invention. Therefore the increase in the awareness [of invention disclosure requirement] is one of our spearheads which we must also further develop. (Person from TTO 1)

To overcome these challenges, TTOs have evaluated that the awareness of such requirements and commercialisation practices should be increased among university researchers. The TTO thus applied and obtained funding to perform this awareness building. Multiple different tools to increase the awareness were tested, and the most efficient ones were selected for use in common practice. The effective methods were educating researchers to identify inventions and to share the gained knowledge in their research

groups. In addition, lectures on the subject are given in university by TTO members, and TTO personnel circulate in official and un-official university events to share the information about the TTO and its function. The awareness-building has increased the number of received intention disclosures and reduced the number of inventions published without assessment of commercial potential. Thus, the TTO has emphasised that they have performed systematic development to increase the number of invention disclosures. Since the successful awareness-building resulted in an increase in the received invention disclosures, the workload of the TTO also increased. This increase necessitated additional personnel to be hired by TTO to manage the increased work load.

In addition, challenges may arise when a TTO is contacted just before submission of the article into public journal. In such instances, the patent application can be written in a couple of days not to delay the submission of journal manuscript. However, in such cases, the scope of the obtained protection can be sub-optimal and easily bypassed, reducing the value of the IPRs significantly. Therefore, the TTO has focussed on awareness'-building also to facilitate the submission of invention disclosure at earlier stages. While the increase in awareness has successfully increased the number of submitted invention disclosures, the TTO believes that there is still a need to increase the number further by giving lectures and courses and by visiting on different university premises and on various occasions, since the TTO believes that some inventions, which would benefit from patenting and commercialisation activities, are still not brought into the knowledge of TTO before publishing.

Once in a while I read the paper X (local newspaper, name redacted) and learn that this [invention] has been created. And then it cannot be protected anymore after that. (Person from TTO 1)

Aside from the increase in the awareness for novel inventions, the TTO also believes that such actions would facilitate the recognition of researchers and teams that would like to proceed into spinout strategy. The TTO believes that if it could find such an individuals and teams early on, they would be more effectively aided to acquire TUTL funding (New business from research funding, discussed further in chapter 4.4) and to support their interaction with the external ecosystem. In addition, the TTO has also formatted the invention disclosure and other internal forms in a simple structures towards the NABC (need, approach, benefits, competition) model that forces the inventors' perspective to be included in the application.

It [NABC] forces the researchers to think always through the end payer that who would need this and who would be willing to pay for this if this would be taken further. (Person from TTO 1)

With this strategy, the TTO aims to lower the bureaucratic burden that inventors may see in the commercialisation process. The ease of the invention disclosure submission and earlier participation in the commercialisation activities, especially if they were commercialised, are believed to make future invention disclosure and commercialisation participation easier. Therefore, the TTO believes that the first time in the commercialisation process is the most challenging, and therefore focusses their activities on increasing awareness of the invention disclosure submission.

... but when the inventors or researchers have been in the process [of commercialisation] one time, then they understand it and what it is all about. So the first time is the most difficult. (Person from TTO 1)

4.1.2 Evaluation of commercial potential

The TTO states that one of the key aspects in investigating invention disclosure is to evaluate who the owner of the invention is, as the ownership of the invention differs according to the contracts of the project funding under which the invention is generated. If it is concluded that university has rights to the ownership and takes ownership, or if an invention owned by researcher is transferred to university, the TTO continues the commercialisation of the invention. The university has a six-month period in which it must take or decline ownership. However, ownership can also be transferred in a shorter time period if necessary.

The TTO evaluates the commercial potential of the invention by analysing target markets and possible positions in them. These are often performed by conducting internal market studies and technical level analyses. Internal technical level analysis is performed especially in the areas where there is an expert of such a field in the TTO. These fields are the ones from which the TTO receives majority of their invention disclosure, and such internal capabilities allow fast evaluation of invention disclosures. All this is performed in order to evaluate whether there are markets for the invention and to identify possible customers for patent-licensing or selling. However, in some instances, the outcome can be that current underdeveloped markets do not have customers for the highly developed technology, but markets could nevertheless become viable in five to 10 years. In those instances the commercial potential analysis does not start from the stage of current market, but focusses on the possible future markets.

The ability to protect the invention can be seen as essential element in the analysis of commercial potential. Such analysis is performed by evaluating novelty and inventive steps in the invention, as well as technical level compared to other approaches on the

field. Analyses relating to patenting are also acquired from external service providers, such as the PRH, which conducts especially novelty searches. The TTO states that as the PRH is an expert in such evaluations, outsourcing is more efficient than conducting evaluations internally. In addition, the TTO evaluates freedom-to-operate and the scope of the possible patent, as well as the patent landscape in the field of the invention.

When invention disclosure is performed at the early stage of journal-manuscript writing, the evaluations, such as novelty searches, also serve the manuscript-writing process, as writers gain new material for the manuscript. In addition, patenting offices and external consultants are used for various tasks in the evaluation, and acquired services may vary between the inventions. Also, synergy effects from the sought IPRs to currently university-owned IPRs are analysed. In some situations, the evaluation and commercialisation requires material transfer agreements (MTAs) and non-disclosure agreements (NDAs) from research partners. Commercialisation is evaluated by analysis of possible users of the invention in the current market, as well as the international potential of the invention.

Often the TTO must evaluate the commercial potential of the invention rapidly, to avoid prolonging the publication of work in academic research journals. Such need is evident especially when invention disclosure is received just before submission of the work in an academic journal. The above-mentioned awareness-building has also reduced the number of invention disclosures that arrive to the TTO at this late stage. The TTO has furthermore changed the commercialisation process to include the invention description in terms of NABC, as discussed in chapter 4.1.1. With this, inventors are forced to evaluate their invention in terms of commercial need and how their approach solves the challenge, as well as who are the current competitors and who would pay for the invention. Such a format also aids the TTO in the evaluation of commercial potential.

The increase in invention disclosures, as well as the managing of granted patents, have also increased the workload of the TTO, so the TTO has begun to outsource more evaluation-related tasks to external, specialised organisations and individual experts. Also, the TTO has observed that outsourcing of certain elements in the evaluation is also faster compared to a situation where evaluation would be conducted by the TTO's own personnel. Such outsourcing includes, for example, novelty and patentability evaluation outsourced to PRH. In addition, the TTO has hired more personnel to manage the evaluation stage of the process. These alterations were made to balance the increased workload in the invention evaluation stage. To facilitate a fast-evaluation process for inventions, the TTO also believes that they must have personnel with knowledge, such as research experience, from the field from which most of the invention disclosures are submitted.

4.1.3 Protection of invention

The evaluation of intellectual protection can be seen as a continuum in commercial value analysis. If commercial potential is found, the TTO proceeds with the protection of the invention. The TTO's main protection route for life-science-related inventions is patenting, if the invention meets the patenting requirements. Trademarks are also utilised, but in minor numbers. The TTO believes that invention should have commercial potential, markets, and meet the requirements of patenting. Only in exceptional cases does the TTO continue commercialisation if the invention is not patentable, since the commercialisation negotiations and other activities would require multiple NDAs and are often difficult without legal protection over the ownership of the invention.

In addition, a patent is seen as an essential requirement for future spinout, since spinout faces considerable challenges in raising equity when they lack IPRs. The TTO emphasises that a possible spinout should have exclusive rights to sell the products of the invention. In addition, companies are unwilling to invest in a spinout if there is uncertainty about whether the core technology can be patented or not, and if potential customers for the patented invention have already been identified, it increases the probability of invention patenting. In practice, the patenting is performed together with specialised patent officers.

We do not patent just for the sake of patenting, so there should be always some utilizer. (–) It [patenting] is such an expensive thing. (Person from TTO 1)

Start-up will not get any funding without a patent. That is clear. (Person from TTO 1)

In general the protection of the patent should be as wide as possible. The TTO sees that if the patent can be circulated with a minor modification, then the commercialisation of the patent is challenging.

The survivability of the patent must be seen so that it grants enough protection and that it will not generate extra costs because all interesting (but nonessential) features are included in there. (Person from TTO 1)

The TTO outsources patent writing to external patenting agents who are best in their specific field, regardless of who is the current employer of the patent agent. However, if prior patent family exists already in one patent office, it may be preferred that also new patents relating to these prior inventions are conducted in same office. The knowledge of which patent agent to utilise for a given patenting case has accumulated from the TTO's prior experiences in such work. The TTO emphasised that only through experience does it know which agent is most suitable for writing a patent application for a given invention.

...we find the best patent agent for the specific case. (–) For us the office [patent office] is minor point. (Person from TTO 1)

Furthermore, the TTO argues that if such patent outsourcing were given to a single patent office, there may exist a risk that patent office personnel may not have an expertise for the specific invention. Therefore patent officers are selected on a case-by-basis, case when the inventions are evaluated and proceed to patenting stage in the TTO's commercialisation process. This activity is also well understood by patenting offices, as they inform the TTO when they experience changes in their expertise.

Recently, one top expert retired from one of the [patent office] companies, and the company told us very openly that they do not have substitutive expert. (Person from TTO 1)

The TTO has also developed their practices in the patenting over the years. The TTO successfully promoted the knowledge of invention disclosure requirements, as well as their commercialisation routes to the university personnel. This resulted in an increase in the invention disclosures. This increase and the management of growing patent family led to the situation in which the office did not have sufficient resources to perform all the actions they wanted to.

We had time to check whether it is patentable and then patent it, and not how wide scope we would get in terms of the protection. (Person from TTO 1)

To overcome this, TTO hired more personnel with extensive patenting experience who, in turn, also managed their own responsible patenting office contacts. This increase in resources also reduced the workload, leading to faster evaluation and a better ability to evaluate not only the patentability, but also the scope of the patent, resulting in better protected IPRs. In addition, some aspects of the invention analyses are outsourced more frequently; for example, PRH performs novelty research and patentability evaluations for the inventions. Additionally, the TTO has hired more personnel with knowledge of patenting.

4.1.4 Gathering resources for spinout formation

Once the commercial potential and patenting have been evaluated, funding alternatives for commercialisation development are reviewed. In general, the TTO aims to find most

fitting commercialisation strategy for each invention, and therefore commercialisation strategies may vary significantly case by case. The choice of which commercialisation strategy is chosen is effected by the field of the invention, commercial potential, scope of the patent protection and whether the invention is sellable to a few or many customers, if needed. The TTO has no internal key performance indicators that might favour the selection of certain strategy.

We always try to find the right or most fitting way of commercialisation, so that it [invention] would end up to the market and not on the shelf of some company with half the price. (Person from TTO 1)

The TTO can facilitate the inventors to acquire funding from different funding elements, such as the TEKES (Finnish Funding Agency for Technology and Innovation) TUTL program or other TEKES funding instruments through which companies join to a project due to their direct interest in the developed technology. In addition, the TTO may contact established companies, for example to sell or license the invention. Repeated experience with spinout commercialisation strategies has resulted in the TTO's belief that TUTL funding from TEKES is the most important funding applied by teams to facilitate spinout strategy commercialisation. If obtained, researchers can utilise the funding for further technology development, as well as for business development tasks to evaluate different commercialisation alternatives. If TUTL funding is not obtained, the university also has a means to grant internal funding support for spinout formation, but in limited quantities compared to TUTL funding. In some instances where TUTL funding is rejected, and even if there is no customer currently in sight, a spinout strategy is still sought if the inventor places high emphasis on it. The TTO does not have any preference about which commercialisation route is sought, but emphasises that over a longer time period, more commercialisation activities have been performed through spinout formation compared to licensing or selling the IPR.

Life science commercialization might lean more towards start ups in longer time period. (Person from TTO 1)

The aim is that either we see that the idea can be brought forward with TUTL-project, or we have identified bunch of companies that we can start to contact right after the patent application has been filed. (Person from TTO 1)

TUTL is definitely the most important [grant] at the moment. Through it the commercialisation is most likely. (Person from TTO 1)

The TTO believes this funding to be the most important funding element targeted for spinout formation and has therefore dedicated a person to handle TUTL application management. The TTO has created a simple application sheet for TUTL-funding for inventors to fill, again reducing the felt bureaucracy. Simple application also allows efficient and fast evaluation of TUTL-applicable inventions. The TTO then interviews all participating projects to search for the most suitable inventions for TUTL-funding applications. In the next phase, the TTO teaches selected inventors to pitch their invention in NABC format, focussing on the problems the invention solves, current competition and possible customers. The first pitch is given to the evaluation board of the university, consisting also of the members from various companies. The TTO has established this evaluation board to aid the applicants to efficiently include views on commercialisation into the sought application. Approval is then granted for the selected few to apply for TUTL-funding from TEKES. TUTL-funding also utilises similar presentation of the invention to TEKES members. The TTO states that often already at this stage individuals in the project teams have used substantial time and resources for the TUTL-funding, locking them tightly both to the application period and the possible future TUTL-project. With the above process, the TTO believes itself to have increased the efficiency in the TUTL-application period. In addition, although a TUTL-funded project has the highest probability of ending up in a spinout, the spinout strategy can be felt as a considerable risk by the inventors.

During the TUTL-funded project, multiple business strategies can be evaluated. The spinout strategy often emerges, and the viability of business model alternatives are clarified during TUTL-funded project. However, spinout cannot be legally established during the TUTL project, nor is the final business plan written. In addition, invented technology can be further developed to increase its value and to test its applicability in a given challenge. Therefore, there is a need to lock in key resources, such as inventors, to the possible future spinout strategy, so that such human resources are available and willing to join a possible future spinout after the TUTL-funded project ends. The TTO indicated that such locking occurs often during TUTL-funded project where participants, inventors included, work towards common goal such as to develop technology to a stage that spinout could be formed around it. In addition, the inventor often acts as responsible researcher in a TUTL project. Such activities motivate the inventors to pursue the spinout strategy. Key resources can also be locked into a possible spinout strategy by forming preliminary agreements.

It [knowledge of whether the spinout is selected as a business strategy] often comes during TUTL process. If we get a team to work one-and-a-half to two years with an attitude that this could be spinout, licensing, selling or something else, then quite quickly are those groups spotted who say that we are not going to join any company. (Person from TTO 1)

Although spinout strategy has been its dominant commercialisation strategy, the TTO believes that it could be utilised more often. The TTO has experienced that multiple inventions would benefit from the spinout strategy as commercialisation over licensing. However, the TTO believes that one of the major obstacles that hinder spinout-strategy selection is the unwillingness of key inventors to join the spinout company. This unwillingness can arise from uncertainty about how a spinout company is operated and what circumstances must be taken into account, compared to working as a researcher in the university. Since the participation of the inventors in the spinout is seen as essential resource, the TTO has developed different ways to both motivate and reduce the boundaries of researchers to join spinout commercialisation. For example, the TTO has developed and applied internal funding that research teams can apply. With the funding, teams can act as a company inside the university to learn and gain experience about daily operations and spinout management. In addition, the TTO emphasised that inventors may participate in the company as technology experts in situations where company is joined by an experienced surrogate entrepreneur acting as a CEO. The TTO emphasised that if no one from the core inventor team of the invention is willing to proceed to the spinout route, then the commercialisation strategy of licensing or selling the patented invention is sought.

Spinout should be done from quite a many [inventions], but whether there is anybody who would go and lead it is the bigger bottleneck. (Person from TTO 1)

If no one from the team is willing to take the spinout risk, then we as a university will lean heavily towards a licensing and selling strategy. (–) But if the project has a clear champion and we can guide them to obtain money, and they have viable business plan, then definitely the spinout strategy. (Person from TTO 1)

In addition, the TTO has evaluated whether it should establish its own funding element targeted to project teams emerging from TUTL and concluded that it would not be efficient. Instead, the TTO focused on the development an external ecosystem to meet the needs of the project team after a TUTL has ended.

4.1.5 Transfer to external ecosystem

As the TUTL funding ends, the project team is guided into the external ecosystem by the TTO. This transition is an active process in which TTO combines the gained knowledge from the TUTL funding and prior knowledge from the external ecosystem and guides the spinout process to most suitable place. Such a place is often found from the local, external

ecosystem, and the TTO sees that these ecosystems are especially important after a TUTL-funded project has ended, and transfer into the external ecosystem can be seen as a next stage in the spinout formation process. The TTO has been actively participating, in the development of the surrounding start-up ecosystems, and some of them were initiated by the TTO, as they felt that such support is important for the teams aiming for spinout formation after TUTL-funded project has ended. In the ecosystem project team obtains investor contacts, mentoring and networks; has the ability to obtain surrogate entrepreneurs if needed; and constructs final business plan. In addition, the project team obtains support for the actual spinout formation.

Basically the process is inside [the TTO] to the end of TUTL and after that it is forwarded to external ecosystem. (Person from TTO 1)

... and when the researcher leaves [from university] we'll try to point the right route to external ecosystem where they can go. (Person from TTO 1)

... and search commercialization experts and consults that could be of help and support the (spinout) project. (Person from TTO 1)

The TTO also evaluates the resources that are needed for the spinout to form case by case. Sometimes, external aid is required, such as IT or a similar second foundation of technology to strengthen the company. However, the TTO does emphasise that inventors should participate in the spinout, stating that commercialisation in general can be challenging without the support of the inventor(s), as discussed in chapter 4.1.4. Similar challenges are also seen if the licensing of IPRs is selected as commercialisation strategy, since patented technology would require further development, which can be challenging without the participation of the original inventor(s). The TTO also lists other features required for spinout formation, such as business expertise, as well as access to lawyers for contracts and financing. Because the TTO experienced that motivation of the key inventors to take the spinout risk can be challenging, in some instances the TTO may recommend the key inventors to join the spinout company not as its champions, taking the CEO position, but to focus on managing the R&D operations. The importance of the surrounding ecosystem becomes important in such occasions as surrogate entrepreneurs, who may have prior entrepreneurial experience, are often sought from there to join the venture establishing. The TTO evaluates that surrogate entrepreneurs might lower the risk felt by the inventors in joining the spinout venture.

Quite often it is the case that the researcher who is clearly a biologist does not see that he or she could lead a company in which a second foundation would be IT. But the serial

entrepreneur is accustomed to this and views the company from different perspective as a whole, and the researchers can be then something else [in the company. e.g. to have some other position than CEO]. (Person from TTO 1)

When the commercialisation has reached to a stage in which spinout is formed, also the IPRs of the invention are transferred to the spinout. The TTO has evaluated different ways in which the IPRs could be transferred to the company and how a university seeks returns. The decision of the way that the IPRs are transferred to a spinout is made case-by-case.

[We have] systematically tested multiple different models and ways [to transfer the IPR]… so that it would not kill the company from the start, but so that university will obtain fair compensation, because university cannot perform subvention to a company. (Person from TTO 1).

This TTO also believes that, in general, life-science-based commercialisation faces challenges in terms of gaining sufficient funding. The TTO indicates that inventions from other disciplines, such as IT, can be developed further than life-science-based inventions with equal funding. The TTO also believes that commercialisation would benefit from added value of the invention. Quite often the inventions, even when they have proceeded through TUTL-funding, are at an immature stage and carry considerable risk for investors. The TTO is constantly developing and extending its own investor networks and utilises them to aid the project team in gathering funding in the spinout commercialisation strategy. The TTO has collected all the known funding instruments of which they are aware into a portal through which research groups can find funding for their projects. However, many of these funding instruments are given by companies and agreements state that developed IPRs are owned by the funder. Such funds are therefore not easily applicable for inventions targeted for spinout formation, as the university would not have rights for the developed technology. To overcome this obstacle, together with university the TTO is considering forming its own funding element to increase the value of the selected inventions. Such funding could be applied when necessary, for example after TUTL-funding, to attract investors.

…because life science is a cost-intensive field. Our electronic or digital commercialisation is able to make greater leaps forward with less of money, and that is often the bottleneck in our biological innovations, that more money is needed before it can be sold, licensed, or to establish start up. (–)With quite a small amount of money, an IT project can be developed into version 2.0. (–) Life-science [based inventions] are often suffering from the fact that customers, or investors, want the invention to be validated and that the

invention where they are investing their money has lower risk. Our projects are often one step too early at this. (Person from TTO 1)

Thus, the TTO facilitates spinout formation by gathering above-mentioned resources, managing TUTL funding and guiding the project team in the most fitting direction in the external ecosystem. However, the TTO does not in general participate in financing negotiations but gives guidance where such funding could be obtained. This is because they see that the company will be mostly owned by founding partners, and they should have the ability to negotiate decisions over financing.

4.2 Technology transfer office 2

TTO can be seen to be tightly integrated into the university, although they operate as independent units. In addition, the TTO has tight collaboration with other services, such as the legal and financial departments of university management, and is able to both individually and together with other units support the university's commercialisation activities. This support allows high flexibility in managing and facilitating commercialisation activities, granting a high level of autonomy to the TTO in decision making.

We have a good collaboration with the research field. There is also legal and financial services and company collaboration in which we actively participate. And through them we share the research field, and we can support each other in various tasks. (Person from TTO 2)

Although we are under university control, perhaps the inflexibility is sometimes missing. (–) I would say that we have good relationship both to management and to research layer. We do work for the university and advance its projects. (Person from TTO 2)

The preference for the backgrounds of recruits has also changed in recent years. Earlier, most of the people working in the TTO had an education in a research field, such as life science. Currently, however, the preference for hiring has shifted towards business-related experience and education.

It [the preferred experience] always depends on the situation that what type of experience is needed. When the TTO was established many of us had research experience. (–) Now when the organisation has grown and there have been organisational changes, we have hired more personnel purely with business experience. So we have a combination of people with research and business backgrounds. But then for us, who had more of this

research background, this has offered good education to learn also business expertise. (Person from TTO 2)

Preferably, business experience and not mainly research background. Because researchers are our customers, so we need to operate between researchers and investors. As versatile as possible. We have here personnel from various backgrounds. (Person from TTO 2)

Commercialisation of the invention can be performed with multiple different strategies, spinout being only one of them. Regardless of which commercialisation option is sought, the TTO is actively participating in the selected strategy, since it has the responsibility to manage the university's IPRs.

We always have a role in them [commercialisation activities] because we must manage the IP and patent portfolio of the university. (Person from TTO 2)

4.2.1 Arrival of invention disclosure

The process of commercialisation can be considered to start from the arrival of invention disclosure to TTO. According to the current legislation, when a researcher notices that an invention has been made, the inventor must submit an invention disclosure to university. Often, the TTO becomes aware of the invention when it arrives to TTO. In some instances, inventors have been in contact with the TTO to discuss whether invention disclosure should be submitted. However, although legislation mandates the necessity of submission, the TTO believes that some of the inventions are not submitted to TTO.

When the invention is made, then invention disclosure should be done. And the same law is for all of the universities. And then the invention disclosure comes to us. (Person from TTO 2)

But if you think that we have X [number retracted] researchers … then it means everyone would invent something once in 50 years. So there must be lots of hidden potential. (–) Legislation mandates that they should be disclosed, but when the figures are like this, then it is clear that not everybody is reached. (Person from TTO 2)

In addition, the TTO states that also earlier TTOs received a surprisingly low number of invention disclosures and evaluated that the awareness of the invention disclosure re-

quirement should be raised to reach the current level. This awareness-raising was performed by systematically conducting multiple different ways of increasing the awareness of the TTO's activities and commercialisation process among researchers. Such activities included the marketing events in university campuses and participation in university meetings. In those events, the TTO discusses the commercialisation process, requirements and also promotes the success stories of the university's research commercialisation in order to motivate the researchers to increase the invention disclosure submission rate. The TTO also emphasises that those researchers who earlier submitted invention disclosures often see the submission as an easy task, indicating that the first submission is considered the most difficult from the researcher's point of view. The aid provided for invention-disclosure submissions may also include evaluation of the invention prior to the invention disclosure submission to determine whether the invention disclosure should be submitted. Also, the TTO believes that by building awareness about commercialisation and the invention disclosure requirement to senior researchers, the information would be circulated also at the junior-researcher level. Still, the TTO believes that is should increase the awareness further, so that inventions would not be published without the evaluation of potential commercialisation. However, if such an instance occurs, the TTO actively contacts the inventors and encourages the researcher that in the future invention disclosure would be beneficial to submit.

We do these marketing activities on campus and participate in meetings where we talk about these things [commercialisation activities], what we do and what kinds of success stories we have had. And we try to increase excitement. (Person from TTO 2)

We have evaluated that at least once a year is a good frequency to promote our existence. (Person from TTO 2)

We just had the customer satisfaction survey, and from it the weakest link was communication. It was quite expected because we have so large a university, and not everybody can be reached. (Person from TTO 2)

Sometimes it can be that we either hear from somewhere else or read from newspaper that this has been invented. Then it is a bit too late. (–) But then on the other hand, in such instances we also need to be in contact with the researchers and tell them that (–) "next time, let's evaluate the invention disclosure together." Because law states that if a researcher has made an invention, it should be submitted as invention disclosure. But of course not all researchers know this. And then it is our task to raise awareness. (Person from TTO 2)

In addition to awareness-building, the TTO has also changed the invention disclosure sheet to be as simple as possible for researchers to complete. This simplicity also serves TTOs' purpose, since they are able to focus on the most important elements of the invention at the beginning of the commercialisation path. In addition, simplified process also allows efficient awareness-building for researchers in terms of what activities are conducted for a given invention disclosure, increasing the openness to TTO activities in the research field. The simplified invention disclosure also aids TTOs' own process by allowing efficient evaluation of the core elements in the disclosure.

We tried to make it as simple as possible in a way that it would be easy for researchers and also easy for us so that it would contain necessary information from which to start [the commercialisation evaluation], because legislation dictates that ownership of the invention depends on funding element. So, for example, these kinds of things we need to know. (Person from TTO 2)

I think it started that we had to think how we are able to reach the researchers and how we are able to make the process as easy as possible for all participants. And often it is the process that we make it as open as possible for researchers so that when they submit an invention disclosure they also know what is going to happen to it. (–) Very many said [in a customer satisfaction survey] that it is easy or relatively easy. But then there are also those who think it is difficult. Perhaps in life science it is easier to know what is an invention. (Person from TTO 2)

As the TTO has systematically promoted the submission of invention disclosures, the TTO also estimates that the output limit for the current size of the TTO may be close to the number of currently received invention disclosures that the TTO can efficiently commercialise. In addition, further increases could result in a tighter screening process in order to identify most suitable inventions for commercialisation.

Then does it come as a limit that currently there is enough invention disclosures for this size TTO. (–) [if the rate increases further] then we just have to use tighter screening that which are brought forward [in commercialisation]. (Person from TTO 2)

In addition, TTO has emphasised that researchers should be in contact with the TTO as early as possible to avoid the situations in which invention disclosure arrives a day before the submission of the work into a public academic journal. Such journal submission would exclude the possibility of IPRs generation for the invention, and in some instances researchers may fear that the submission would be postponed due to the commercialisation activities. Therefore, the TTO promotes that researchers should be in contact

with the TTO already when the writing of the journal manuscript begins. In such instances, the commercialisation activities, including novelty searches, support the manuscript-writing process.

We try to encourage researchers to be in contact as early as possible so that there wouldn't be those that say that they are submitting it [manuscript] tomorrow [into public journal]. Quite often we say that "please be in contact" when they start to write the manuscript or think about starting to write it, because researchers fear that they would not be able to publish it [if invention disclosure is submitted]. But actually, it is so that the patenting and journal publishing support each other. (–) Then we can do both: protect and think of the commercialisation, and publish. (Person form TTO 2)

The TTO also indicated that in some situations the submitted inventions are at too early stage. Invention disclosures may arrive at the idea stage, without any laboratory tests being done. In such instances, the TTO may recommend further research prior to the initialisation of commercialisation. In other instances, the invention has been developed and preliminary tests performed, but further development would be required prior to commercialisation activities. In such instances, the TTO often recommends further development before commercialisation activities are initiated, and it emphasises that the protection of the invention is also more efficient when laboratory tests have been performed to confirm the invention. For some of such inventions, TUTL-funding can be applied for, and the TTO actively participates in the gathering and managing of TUTL-projects.

One of the challenges in life-science projects is that often the invention disclosures arrive to us at quite an early stage. It can be ground breaking invention, but it should be developed further before commercialisation. For that, for example, the TUTL is an excellent alternative (as funding). And it can be that the market is not ready for it, meaning that the timing is really critical. And sometimes invention disclosures arrive at the idea stage, and there may not be much proof that the idea works. Often, we may then suggest that it could be developed further, do a bit more tests and obtain results. Protection is also easier to secure when it can be demonstrated to work properly and there are examples. (Person from TTO 2)

4.2.2 Evaluation of commercial potential

After invention disclosure has arrived at the TTO, it evaluates the invention from multiple viewpoints. Often, the ownership of the invention is evaluated before other evaluations are initiated. Since the source of the funding dictates which party, such as inventors,

the university or funding suppliers, owns the rights to the invention, the analysis of the funding contracts is performed when the invention disclosure first arrives at the TTO. If the invention is owned by the university, or if inventors wish to transfer the rights to the university, the TTO manages the commercialisation activities. Once the ownership analysis has been performed, the TTO evaluates novelty, patentability, commercial interest and existing markets for the invention. The TTO performs internal commercial potential analysis by collecting information from market reports and databases in order to gain a general view of the field. Once this view has been obtained, the TTO discusses with the inventor thoroughly to clarify the concept of the invention and to discuss further the potential users of the invention. The TTO emphasises that by utilising the knowledge of the inventors who have years of experience gained from research in their disciplines, faster and more efficient evaluations can be obtained. In addition, such knowledge is difficult to surpass with just a few days of market research.

We check who owns it [invention]. (–) If it belongs to the university or researchers want to transfer the rights to us and are interested in commercialisation through us, then we check if the invention is truly new and perform our own background research for the invention. But we discuss quite a lot with the inventor who has years of experience in the field. I don't think that we can with a few days of research work surpass the level that researcher has reached. And then we discuss with the researcher if he/she has seen comparable [inventions]. Then, if it is really new and novel and it seems that researcher is interested in taking it further and there are markets, then we start to protect it, often with a patent. (Person from TTO 2)

We perform preliminary analysis to see whether it is patentable, whether it is commercially interesting and whether there are markets. Then, depending on the invention, we think of the next steps. For example, is it at early stage and would it require proof-of-concept funding? Then we could recommend the TEKES TUTL instrument, which is specifically targeted for these kinds of commercialisation activities emerging from research institutes. (Person from TTO 2)

But the TTO also emphasises that in some situations the market analysis can be challenging, due to the characteristics and stage of development of the invention. For instance, the researcher may have submitted an invention disclosure describing an invention without naming potential customers or customer fields. On such occasions, the TTO often performs also a thorough customer analysis to see whether there would be users for the invention. The TTO furthermore emphasises the need for existing markets and highlights that inventions targeted for the markets that may emerge after 50 years are challenging to commercialise at the moment. The evaluation of the current market, and especially the

analysis of whether there is a need for the invention, requires specific skills. As the invention has not yet been patented, the gathering of knowledge about market need is a balancing act in terms of the information given to the potential customers and information that must be withheld to avoid revealing patentable information.

... the researcher comes with a nice new key [invention] and then we start to think about whether there is a lock [need] where the new key fits. When there is an invention based on a phenomenon, it can be that there is not any market emerging for it for the next 20 years. (–) But when there is down-to-earth invention, then we see the current competition and form an educated guess of the potential [of the invention]. If it is, for example, an electric solar wind sail and the evaluation is that it could become huge thing, but it won't occur in the next 50 years, then there just isn't that type of a market. (–) So the ones for which we see there is market here and now we proceed further with. (Person from TTO 2)

But then there are jewels from which can be seen that there is a problem; the solution is needed and markets are large and attractive. And the market does not need to be big if only there is a specific need. (Person from TTO 2)

...but often it requires deeper analysis to see whether there are markets. We must be in contact with potential customers, who they are and do they need this [invention]. (Person from TTO 2)

Potential customers can be contacted during the evaluation, but there is a high risk that, because these are new inventions, that patentable elements are revealed. (Person from TTO 2)

The TTO also emphasises that the analysis of commercial potential is tightly connected to the core team of inventors and their willingness and motivation to seek commercialisation. Once the key inventors are participating in the commercialisation, the patentability of the invention is evaluated.

Even if there is a good market, it is the team that matters if it is going to make it. (–) Basically, it must be that the researchers are interested in proceeding like this [commercialisation]. If they are not, then it won't become anything. So it is a team thing. But after that comes the protection question. (Person from TTO 2)

The TTO performs internal novelty analysis for the invention by evaluating the patents in the field of the invention and further highlights that other TTOs often prefer outsourcing this task. However, the TTO performs the evaluation internally by utilising patent databases, as well as other sources of information. This evaluation is often carried out in parallel to the commercial potential analyses described above, and the two analyses are tightly connected. Analysis of commercial potential, in turn, is often performed in parallel to the patentability analysis.

I would say that protectability should be checked first. Or, I don't know first, but together [with commercial potential analysis]. (Person from TTO 2)

When the TTO encounters interesting and relevant prior patents, it contacts the inventors to discuss whether the existing patent is an obstacle for patentability. Such communication allows the use of prior knowledge gathered by the inventors and fosters an efficient process to identify whether the invention provides a unique benefit. After internal evaluation of the novelty and patentability has been carried out, the TTO contacts specialised patent agents to draft a patent application to protect the invention (as discussed further in chapter 4.2.3).

As the number of invention disclosures has increased, the TTO emphasises that the importance of market analysis has likewise increased. The TTO has increased its focus on the evaluation of the current market, as well as on the analysis of emerging, future trends in the market in considering whether to commercialise an invention. In addition, the TTO states that there exists a need to increase the resources, namely by hiring new employees both to perform the current market analysis and to focus on predictions about the market and demand trends. Such actions would allow the TTO to give more efficient evaluations of future needs. The increase in invention disclosures has also resulted in a high workload, and the TTO has focussed on the selection of the most suitable candidates for the TUTL application process. Likewise, the increase in the TUTL-funded projects has increased work in granted projects.

Now when the number of invention disclosures has increased we must be more precise in the evaluation of whether there is a market. Sometimes it may be long way ahead, but we must evaluate how fast it can emerge. So although at the moment it seems that the market is immature, we will proceed with protection because we see that in a few years there is big markets and need emerging. (–) with the current resources we cannot take part in everything [commercialisation], and perhaps the balance has shifted towards TUTL. To it, we try to direct the most fitting projects where there is a market, and take them further. (Person from TTO 2)

I think there could be more people who would be closer to the market. It connects to the resources. (–) A couple pairs of hands more who would evaluate the market and predict future markets. I think the prediction should be done more in order to stay connected to the market and to see what it looks like in the future. (Person from TTO 2)

4.2.3 Protection of invention

After the evaluation of patentability and commercial value has been performed, the TTO proceeds to the protection of invention phase. The TTO emphasises that often the protection is sought with a patent, as the trademarks and other protection instruments do not grant similar scope and protection. In addition, the TTO also experiences that the alternative to keep the invention as a trade secret is challenging, as inventors have preference for publishing the results.

I would say that first of all it should be protectable. Those inventions that we take further to commercialisation must be protected so that no one else copies them. (–) I would say that all the inventions we try to commercialise we also try to protect with a patent. (Person from TTO 2)

We have some of the things [inventions] that cannot be patented and then we think other alternatives such as trademarks or that it would be kept as a trade secrets, which is challenging in research cases where the publication is the resource for funding. (Person from TTO 2)

Prior to the patent application-writing phase, the TTO performs an internal analysis of the patentability of the invention by analysing different patent databases. If it is seen that the commercially valuable invention has potential for gaining IPRs in the form of a patent, the TTO proceeds to the patent-application writing phase. Similarly, as in the evaluation of the commercial-potential phase, the TTO utilises the accumulated knowledge of the key inventors in the patentability analysis phase. Such practice is seen to increase efficiency in the evaluation.

We check that there is room [for invention by performing patent landscapes]. (Person from TTO 2)

There [in the protection analysis] some [TTOs] use outsourcing. (–) But we usually search these databases for how much and what patents are found in the field of the invention. And in our opinion if it looks like that there is something that comes close [to the

invention] then we forward it to the inventor to ask their opinion. (–) About how it [the invention] is new and what the researcher has suggested. And then comes the patent agents. (Person from TTO 2)

As the patent writing and ability to obtain maximal scope in the patent requires specific skills in the writing process, the TTO has outsourced the patent writing to specialised patent agents. In the patent-writing process, the external patent agents write the patent. The inventor participates in the patent-writing by contributing technical details and descriptions of the invention. In addition, the TTO actively participates in the patent-application-writing process by including market and commercial views. The selection of the patent agent who writes the patent application is made according to the specific need. The knowledge of which patent agent has the most fitting experience to draft the patent application in the field of the invention comes from prior experience from TTOs. The ability to select the most suitable patent agent may increase the speed of patent drafting, as well as increase the scope of the obtained patent, leading to an increase in the value of the obtained IPRs. The importance of this outsourcing task is evident, since the TTO has a dedicated internal IPRs manager to handle such matters.

We know quite well the persons in Finland who write the patents. And from the basis on our experience we choose the one that will be taking care of it [invention]. (–) We have done so much collaboration in the past years, and we have an IPR manager who handles this area quite well. (Person from TTO 2)

External patenting office writes the patent, and the inventor participates by including the technical content. We participate in the process and also ensure that business view is also taken into account into the patent. (Person from TTO 2)

The TTO emphasises that although patent itself can be commercially valuable, key inventors should be motivated and willing to participate in commercialisation activities if the patent is sought. Inventors may participate in the spinout strategy also in supporting roles, granting the CEO position to the surrogate entrepreneur who is sought for the spinout project at a later stage of commercialisation activities (further discussed in chapter 4.2.4). In cases where inventors are not interested in taking part in commercialisation activities, it can be that the patent is not sought, since the expenses for patenting are high. The TTO also highlights that the patenting process, in which the majority of the pre-evaluation work on novelty and patentability is performed inside the TTO, and patent writing is outsourced to patent agents, works efficiently due to years of experience.

The patenting works great with the patent agents. I think it would be inefficient if we would do everything when there are professionals who take care of it faster and better. (–) The patent attorneys are selected on the basis of their expertise. (Person from TTO 2)

4.2.4 Gathering resources for spinout formation

After the evaluation has been performed, the TTO aids in gathering resources to facilitate the commercialisation of the invention. It emphasises that there is no clear decision-making policy according to which inventions are commercialised through spinouts or licensing, but highlights that the ability to form a spinout can be seen from the invention itself. In addition, the TTO emphasises that inventor(s) should be willing and motivated to participate in commercialisation activities and that the absence of such participation hinders the possibility of commercialisation.

It can be seen from the invention whether a company can be established from it, or it will be licensed to an existing company. (Person from TTO 2)

The team is the most important [resource]. It is the most important. If you don't have a good team, then even a good thing won't fly. But of course there must be a good idea and market need. (Person from TTO 2)

The TTO emphasises that not all inventors are willing, nor should they be forced to, perform or participate in the commercialisation activities. However, the purpose of the TTO is to identify the individuals who are willing and who have motivation, and then to facilitate the commercialisation activities for their inventions through spinout strategy. In addition, the TTO does emphasise that the participation of the inventor team is a key requirement for the spinout strategy to be considered. The TTO also states that inventors, who are often proceeding in their academic careers are prone to publish their results. One of the reasons for such activity is that their performance as researchers is often evaluated through such merits. However, if inventors would participate in the spinout activities, they may not be able to publish such activities in peer-reviewed journals during the spinout period. Therefore the TTO emphasises that some inventors may see the participation in spinout activities as a challenge for their academic careers. To overcome this limitation, the TTO has developed different alternatives on how the key inventors are locked into the spinout commercialisation strategy.

Team is important. If they are research-oriented and do not want to participate in the company even in a small role, then the establishment of the company is impossible. (–)

We have difficulties in commercialise anything if there is no support from the researchers, because we are not the experts in the substance. (–) It is always good if some researcher can join the spinout full-time. (–) More senior scientists could participate in smaller roles if they want to focus more on their university careers. (Person from TTO 2)

Often, this [period in a company] is not seen as a disadvantage, but while they have done the company work, lets say for two years, without any journal publications, then in practice acquiring a job (in an academic research group at a university) can be challenging. (–) ... there the academic merits are the key features researchers are hired upon. (Person from TTO 2)

One strategy is to allow senior scientists, who often have long and highly established academic careers, to participate in the possible spinout strategy as part-time employees. In addition, key inventors will receive a high portion of the equity shares of the possible future spinout company. Such ownership grants not only managerial ability in the company, but also allows high future profit if the equity ownership of a highly successful spinout company is later sold. In situations where inventors are unwilling to take part in the commercialisation, but where the TTO still proceeds with the commercialisation activities, the university has different strategies for compensation.

With equity [when asked how locking of key members occurs], the key members will become big share owners in the company. (Person from TTO 2)

But if researcher does not want to leave, he or she is not forced to, and it would not be sensible. If they do not want [to leave the university and join spinout], then we have a different system to compensate these researchers. So, if the university gets some profit even if they had not joined, then they still get a compensation. (–) Then, on the other hand, if they do not want to join full time, as often more senior researchers do not want to leave their university careers, then we allow that they can do both. (Person from TTO 2)

In general, the TTO has experienced that spinout strategy often creates higher returns compared to licensing and is therefore the preferred commercialisation strategy. According to the TTO, the licensing strategy would require high investments of capital at in the early stages of the strategy, due to patenting costs, as well as a different strategy in general, when the team is not participating in the licensing commercialisation. Such high levels of investment would also require high tolerance for risk taking. As the TTO sees the spinouts often as more desirable alternatives, it has actively increased resources devoted to spinout-strategy commercialisation by hiring personnel with prior spinout expe-

rience and focussing more on spinout commercialisation. In addition, the TTO has decreased the costs of its patent portfolio by revoking older, non-profitable patents. The TTO mentioned that patenting was likely sought more freely earlier on, which in turn led to increases in the yearly costs of the patent portfolio.

In my field [life science], licensing strategy as commercialisation has not proven to be that good. Instead, they are through start-ups. (–) You don't really get the money out from the licensing cases if you go to look around the world who would be interested in some invention that is just filed for patent and there isn't yet any guarantee that the patent goes through. It [licensing] is a slow and expensive road. (Person from TTO 2)

I think earlier we had more licensing-based [commercialisation], and now the start-ups have been coming along more and more. (–) I was recruited with start-up background, and perhaps there was an interest to steer it [the TTO] in that direction. And that is what I have done. (–) Earlier, when these inventions were patented, let's say, "easier," it accumulated a large patent portfolio from which expenses increased yearly. (–) If you want to do the licensing, then there should be a "wallet" that is used to take the risk. For example, let's patent from that field systematically and when a meaningful set [of patents] has been formed, then we start to commercialise it. (Person from TTO 2)

If the TTO and inventors evaluate that further development of the invention is necessary for commercialisation to occur, the TTO then manages the application for TUTL funding (discussed previously in chapter 4.1.4 and further in 4.4.2).

Basically there are two routes. Either go through the TUTL process, or the project is ready enough that they are proceeded immediately. (Person from TTO 2)

In most of the cases, the inventions emerging from life science research are in their early stages and require TUTL, or similar funding, in order to proceed efficiently in the commercialisation process. The TTO argues that TUTL is one of the most important funding sources sought for commercialisation purposes emerging from academic research. The TUTL funding can be considered of significant size, allowing the inventors and the participants to work towards a common commercialisation goal over one year. In its earlier stages, the TTO wrote most of the applications for TUTL funding. As the number of invention disclosures increased, however, the TTO transferred the writing to be done by inventors. With this move, the TTO believes that the inventors are more efficiently locked to the TUTL process. In addition, the TTO teaches and guides the application process and application writing, lecturing also about the business practices when operating as a possible spinout company.

If the case requires building a prototype or proof-of-concept to show that it works also in real life and not only in the laboratory, then often we start to apply for TEKES TUTL. And if we get the TUTL, then it is typically a year-long project. (Person from TTO 2)

There we have in fact changed. Originally we wrote quite a lot of those few applications here by ourselves. And now, for a few years we have organised, lets say, trainings for these teams where we also teach them to make better applications [for TUTL]. (–) ... [application] numbers are increasing, and we don't have time to be the writers. Plus, because the researcher must commit to the thing [spinout] also from a commercial point of view, then it is better to train them to become businesspeople faster rather than slower. (Person from TTO 2)

The TTO also sees TUTL as the most important funding for the inventions that are not sellable due to the immature stage of the invention, or when the usability of the invention is unknown, hindering the possibility to assess the value of the invention. The TTO thus emphasises that if such high-risk funding would be sought from companies and private investors, the funding would necessitate the ownership transfer of the invention to the funding providers. However, as the core knowledge depends on the participation of the key inventors, such transfer would also create further risk, as the inventors would not be financially locked into the company's success, as they were before. Likewise, the transfer would also create a risk for the funding provider in a situation where high-cost investment becomes valueless due to the resigning of key inventors. Therefore, the TTO sees TUTL-funding as a key funding element for the commercialisation of inventions emerging from academic research institutes. The TTO argues that it is one of the only instruments allowing proof-of-concept development combined with business evaluation.

It [TUTL] is, on Finland's scale, probably the only funding instrument that allows proof-of-concept –development for these research projects which we want to commercialise. Other [funding instruments] are more or less focussed on basic research. (Person from TTO 2)

It [TUTL] is Finland's national competitive advantage third in line after forests and lakes. (–) If it needs to be further developed for one year, then besides this TUTL, there really is not any comparable [funds]. (Person from TTO 2)

If you would invest €400,000 with high risk, then you should get almost the whole 100% of the shares of the company. But there is not any point in owning 100% of a company that is completely based on the team's know-how. The team should play a big role.

So, basically the valuation of the company does not work in the real world. And for that TEKES [TUTL] is brilliant. (Person from TTO 2)

During the term of TUTL-project, multiple different commercialisation alternatives are evaluated, and the most suitable for the given invention emerges as markets are analysed, potential customers contacted, team willingness for different commercialisation alternatives viewed and technology developed. In the TUTL-funded projects, the TTO actively participates in commercialisation evaluations of the invention.

In TUTL projects both [spinout and licensing] are alternatives, and during the project it becomes clear which is better. (Person from TTO 2)

The TTO emphasises that one of the main resources often lacking from the core inventor team is business knowledge. Prior business experience can be seen as essential when the spinout is formed and starts to operate as a company. Therefore, at the beginning of the TUTL-application process, the TTO evaluates the core knowledge of the inventor team and often recognises that while the members have high skills in academic research, the participating team lacks the experience and knowledge in business field. The TTO argues that almost always external business-related skills, such as with surrogate entrepreneurs, are a positive factor when evaluating the potential of commercialisation through spinouts. In addition, the presence and participation of highly skilled people with business backgrounds also attracts the confidence of inventors, increasing the motivation to invest in the possible future venture. Such a person can work in the spinout in the role of CEO, or in other business-related activities. However, the TTO, which scouts for such individuals, emphasises that the finding of such persons to join the company can be challenging. Already during the TUTL-application process, the TTO scouts for such people using its connections, such as alumni networks and LinkedIn-channels. In addition, the TTO actively participates in events such as Nokia Bridge. Thus, the TTO argues that one of the most important tasks is to find, motivate and lock surrogate entrepreneurs with prior business experience into the emerging spinout venture project. However, the individual with specific skills needs also to match the personalities of the inventors, and finding such a person, the TTO argues, is more challenging than finding an individual with specific skills.

We see that, okay, there is a great knowledge in there and there, but often the person with business background is missing. Then we start to search an individual with experience from the field and who gets excited about the project. And if the chemistry hits (with inventors) then we have the team block. (Person from TTO 2)

To find a good match (between business person and researchers) can take a considerable amount of time. (–) And then, in these TUTL projects, we try to get the person to join to the [TUTL] project to familiarise the person with the project early on. (–) But if they are not found at the beginning of the project then we try to find them during the project. (Person from TTO 2)

... often it [an external person with business background] brings more credibility when there is somebody with business experience. But I don't think it excludes that these persons [researchers and external persons with business background] couldn't be equals in the company. And the business person does not necessary need to be the CEO. The person can be, for example, also in sales and marketing. (–) It is case-dependent. If formidable experience (in business) can be found from the team, then clearly the team does not need external person. But it is just common in these projects that they (researchers) have solid research skills and knowledge, and they need a business side to support them. (Person from TTO 2)

Through networks and different events. (–) There have been many of these, now when there have been layoffs, these events where they try to match people. They are brilliant events to go and tell [about projects], because I think that they do not necessarily know that the university has these types of projects to join. (Person from TTO 2)

Although the TTO has heavily extended and developed its contact networks to identify possible surrogate entrepreneurs and investors to join the future spinout projects, the TTO also evaluates that further development of such connections is necessary.

It is a good process [spinout formation], but sometimes it is coughing. (–) ... I think we must still modify the process and utilise new networks that are not used currently enough to find and get contacts (for spinout). (Person from TTO 2)

After the TUTL-funded project has ended, the TTO and the participating team should have the technology and the commercialisation options at a stage where team can proceed further in commercialisation activities.

And when it is ready, then we know by which [commercialisation] route it goes to the market and where the market is and how we sell it there. And the team is ready. (–) Then we establish the company and finalise the negotiations. (Person from TTO 2)

4.2.5 Transfer to external ecosystem

After the TUTL project has ended, the TTO aims to facilitate the establishing of the company as early as possible. The TTO argues that in this stage the commercialisation alternatives have been evaluated, most preferred the one selected, and the team together with business personnel have been locked into it. The fast establishment of a spinout company is performed to reduce the chance of events in which team participants move to other projects that would hinder the possibility of joining later on established spinout.

In practice it starts that we try to get the company established as soon as the funding ends. And if it would start before that, then it would not matter that much because then it would mean that the work is ready and the TUTL funding just ends (when company is established). But then the new life starts in the company. Its better like this than if nothing were to happen after [TUTL] and the workers were to move to new jobs, so you have a great invention on your hands, but the team perished. So you do not have time to wait. (Person from TTO 2)

As mentioned above, the key participants are locked into the formed spinout by equity ownership. The ownership structure is decided when the spinout is established and is often divided between the inventors, possible external persons such as the surrogate entrepreneurs and the university. The TTO emphasises that only the participants that are actively participating in the spinout company activities receive shares, whereas the inventors who do not wish to join the company are compensated from the future profits.

The company will be established with those founding members that are seen at the early steps to be needed. (Person from TTO 2)

The university also has a practice of transferring the IPRs of the invention to the spinout step-by-step, when each pre-set milestone is accomplished. If the spinout is dissolved, the IPRs will be returned to the university for possible future commercialisation activities. However, the TTO sees challenges in such commercialisation efforts, since often in those cases the key participants have joined other projects and may be unavailable for later commercialisation activities, such as the formation of a second spinout.

[We] usually do a licence agreement from the IP that is transferred according to a set of milestones and can be acquire completely. (Person from TTO 2)

It [the IPRs] returns to university [when asked what occurs for the IPR if the company is dissolved]. (Person from TTO 2)

Multiple different institutes can participate in a single commercialisation event. Such events can occur when an invention has emerged from a jointly funded project between different institutes and the commercialisation requires the participation of members from multiple institutes. Therefore, the TTO states that the company establishment practices must be agreed upon already at an early stage of the commercialisation project, as the preferred company establishment practices may differ between participating institutes.

[Commercialisation] must be agreed beforehand if we participate in jointly funded projects. So that it would be known how the final parts are performed. Because these [company establishment] models differ. (–) It must be agreed also because of TEKES mandates. (–) Quite often, it goes that the institute whose researchers have created the invention takes responsibility of management. (Person from TTO 2)

The TTO is an active participant also in the establishment of the spinout company. Once the TUTL project has ended, the TTO focusses on gathering funding for the emerging spinout and participates in the negotiations of investor funding together with inventors.

But of course the team has a big role to play, in that they can attract funding in the future. There, we of course train them at the beginning and meet investors. (Person from TTO 2)

The TTO emphasises that the successful spinout should have an invention with a good market, an enthusiastic and balanced team, an approved patent application, an efficient business plan and realistic market demand. The TTO states that most of the locking of key resources, namely inventor(s) and persons with a business background, are already performed during the TUTL process, when the participants spend a considerable amount of time on the project. However, even if all the resources are successfully gathered and locked into a spinout strategy, the success of the established company cannot be precisely predicted.

It is a guess. If the invention is interesting, meaning that it has market potential and the team is excited also at the prospect of commercialisation and would be willing to sacrifice a bit of their academic career, (–) and when we find a good person or a team, (–) and if we get it through the patent gate, (–) then time will tell whether the team managed to create any business from it. (Person from TTO 2)

4.3 Technology transfer office 3

This TTO's main responsibility is to manage the commercialisation activities of the university. In addition, the TTO offers various support services to university personnel and acts as a bridge function between external stakeholders and university personnel. Such tasks include support on project management, assistance in grant application writing, management of incubator programs for emerging spinouts, and management of commercialisation activities of the university IPRs. The TTO has undergone several organisational changes that have resulted in efficient integration into the research field of the university. Therefore, the TTO can be considered tightly connected to the university.

Tight part, not a separate unit [when asked the connection of TTO to the university]. (Person from TTO 3)

We cover the whole process from the identification of invention to technology transfer to established companies, spinout formation and incubation, meaning growth. (Person from TTO 3)

Our aim is to be closer to researchers, basically the customers. (–) The aim is that we do more work with researchers and research teams, so basically [we aim to] be close [to them]. (Person from TTO 3)

The work performed by the TTO personnel connects tightly with commercialisation activities. Therefore the TTO emphasises that new recruits are often preferred to have business-related skills, such as work experience from private-sector companies. The ideal candidate should have experience with investors, finance, spinouts or entrepreneurship activities. The TTO clearly states that recruiting people with purely research backgrounds is unlikely. Upon hiring new personnel, the TTO first evaluates what types of expertise current employees possess and what new skills should new recruit should have, to create most efficient results. The TTO also states that such needs can differ drastically between positions inside the TTO, as the personnel working with spinout incubators require different skills than innovation experts. The TTO's autonomy over internal development can also be seen when new personnel are hired to the TTO. The TTO is tightly connected to university management, allowing the use of the university's human resource services. It is able to set the skills and requirements in new recruitments, as well as to decide which applicant is selected.

Proposals [for recruitment] are drafted in here inside the unit. (–) The need comes from here, definitely. (Person from TTO 3)

But for us it is very important (–) that there is private sector experience. We cannot imagine that a pure researcher would come to us as an innovation expert. That is impossible idea. (Person from TTO 2)

And when we are hiring a new personnel, then we evaluate the need for new skills and what is missing from the current team, and fill it. (Person from TTO 2)

4.3.1 Arrival of invention disclosure

Researchers who create inventions in the university have a tendency and motivation to publish most of their work, since often they are evaluated on such merits. However, the TTO argues that researchers do not necessarily always recognise that they have created an invention, and thus the invention disclosure is not submitted. Therefore, the TTO has emphasised the increase in the awareness of invention recognition by researchers. The TTO states that to accomplish this goal, they have made multiple organisational changes in which TTO personnel have been transferred closer to the university researchers in terms of physical location. This move allows efficient contact between the university researchers and the TTO personnel. In addition, the TTO has increased the researchers' ability to identify inventions by lecturing and teaching the researchers about topics such as legal issues and novelty research for inventions. These researchers, who use a considerable amount of their work time on invention recognition, then spread the gained knowledge and act to support the TTO's personnel. Once the invention has been recognised, it is submitted to TTO as invention disclosure. Tight integration of TTO members into university departments has resulted in an increased number of invention disclosures, as the TTO intended.

Researchers usually publish everything possible and then notice that this would have been an invention. (Person from TTO 3)

[We] are close to the inventors, people, researchers and groups. This is conscious decision and conscious need, and that is why the whole organisational change occurred. That itself is not enough, because one person cannot do much in a large department. That is why we have acquired spare hands. (–) We have trained them [researchers] and we have a training program for them. In it we train on legal and invention- and novelty-related issues. Also recognition-related topics are explored. They are then there at the

departments to help innovation experts. And the aim is to recognise and find inventions. When that is done, then we have electronic invention disclosure. (Person from TTO 3)

4.3.2 Evaluation of commercial potential

The TTO states that the invention disclosure is simple to fill and does not require substantial time from the person. Once the invention disclosure arrives at the TTO, personnel from the TTO evaluate the contracts under which the invention has been created. With this analysis, the TTO evaluates whether the invention is the property of the university or is owned by other parties. In addition to the ownership analysis, the TTO evaluates the invention's technicality and the demand that the invention meets in the current market. The TTO emphasises that identifying demand in the market and the solution offered by novel inventions can be challenging for researchers to analyse, due to the inexperience in market analysis and the patent process. Besides ownership and market analysis, the TTO also evaluates the team that has created the invention. The team analysis becomes essential especially in the situations where the inventor team has indicated their motivation to move towards spinout strategy commercialisation. In team analysis, the TTO evaluates the team's prior experience and the level of technical state of the invention.

... basic info and short description and then it is submitted. (–) And when it arrives here, X [name redacted] analyses the background, meaning that the person checks from which kind of research, contract or open, the invention came. (Person from TTO 3)

[We] also contact the team. It may come, and often comes, as a need for additional information, for example surveys. (–) Our innovation experts take their business hats and look it as a business case and technology. For a researcher, this may be challenging if they do not have experience in patenting process, meaning what is the difference for patent and journal article? In a patent there is also the business view that there must be a market and a need, meaning a challenge that is solved [with the invention]. And this evaluation is essential. Then, our innovation experts evaluate the technology, need, markets, competitors and the team. And the team is the big topic. (–) Especially if in the meetings it emerges that the team would be interested in establishing its own company from this, then we must put special focus on the structure of the team and what they have already accomplished, meaning, is the technology at proof-of-concept? And has it been tested? What is the stage of the technical approach? And does it need strengthening? (Person from TTO 3)

In addition to discussing with the inventors, the TTO often proposes that inventors be in contact with possible customers to verify the demand and to evaluate whether the invented solution is able to meet customers' need. However, the TTO also emphasises that it is a delicate balance to scout for the need without disclosing information about the invented solution that could later hinder the patentability. To overcome this challenge, the TTO actively teaches the inventors how to contact possible end users and how the scouting of the need should be performed. In addition, the interaction between inventors and possible customers extends the networks of the invertors.

We also want that these inventors and teams contact external customers, basically end-users [of the invention] who tell what the need is and how they see it. So we want to verify the need. And also that the inventors would themselves understand that this is the thing. Often inventions from technical field are technologies and then the need is investigated. This is the wrong way around, because often there is no real need. (–) When we see that there is commercial potential, then there must be a real problem and a customer that is willing to pay. And that is a different thing. (Person from TTO 3)

So we say that go and interview. We can also do some of customer contacting at the beginning of the process. However, more important is that the researchers create new contacts and learn, because they know the potential and strengths of their technologies. This is how they get more benefit from it. We teach them how to contact the customers even when invention has not been protected. (–) this is extremely important to learn, meaning how you get the information about whether there is a need, without telling them anything about technical solution. (Person from TTO 3)

The TTO emphasises that they have performed the organisational changes, where TTO personnel are located closer to the research teams, to increase the number of received invention disclosures. It states that the main task has been to increase the researchers' ability to identify whether they have created an invention. In addition, the close presence allows efficient and informal, confidential discussions with the researchers about how to fill out the invention disclosure sheet.

We aim to help the researchers to identify the possible inventions from their own research. (–) They can also confidentially discuss with researchers how the invention disclosure is filled and send it. (Person from TTO 3)

Our process starts from sent electronic invention disclosure. Then we must identify, is there an invention or not. Innovation experts use a considerable amount of their time in the evaluation of the invention, the novelty and market potential. That is why we have

access to tools and databases. (–) In many other universities, this [evaluation] is not done that much at this point. This is one of the big differences to from others [universities], that we have chosen to do quite a lot by ourselves. Then we also learn and can better assist the researchers. If we would outsource the majority of the invention evaluations, then the learning curve would not grow in our organisation, but instead would go out. (Person from TTO 3)

Once the evaluation has been performed, the invention is evaluated as a commercialisation proposal inside the university and the TTO. Multiple evaluations from different viewpoints are performed, often regarding a highly advanced technical invention. Therefore, the TTO has assigned innovation experts that manage their specific inventions throughout the process and only after commercialisation has been performed does the expert hand the management of the invention to a different unit inside university. The TTO also believes that at the current stage, the evaluation phase is efficient and the most of the major development processes have been performed.

Innovation expert has a responsibility to update their own projects. The project updating occurs until the technology has been transferred. (–) Once technology has been transferred, an innovation expert has a meeting with a financial unit where they go through the case and when the financial department should check that for example the milestone payments have been received. At this point, the management is transferred to financial department. (Person from TTO 3)

We fine tune the evaluation process when needed. Major development processes have already been made, so we do not have any acute, big need for development. (Person from TTO 3).

4.3.3 Protection of invention

The TTO states that, in general, the process of invention protection is efficient, and adjustments have been performed to reach the current stage. The TTO argues that the protection strategy chosen for life-science-related inventions is most often a patent. As above, the TTO emphasises the importance of the evaluation occurring inside the TTO to sustain the learning curve. However, patent-application writing is seen as a special case, and therefore the TTO has chosen to outsource the patent-application-writing process. The decision of which patent agent the application writing is outsourced to is made as a result of accumulated knowledge from prior experience. The TTO has keen knowledge of the most suitable people who match the writing requirements of the specific invention.

From prior experience and thorough evaluation: case by case. (Person from TTO 3)

With a normal patenting process [when asked how the life science inventions are protected]. (–) Trademarks, domains and protections of designs connect primarily to the operation of a company that is being established and are extremely important to perform in time and with the necessary scope. However, in our processes, these are done rarely. (Person form TTO 3)

Certain [patent] offices are better in some research areas than others, meaning we have had good experience with them. Then we utilise those certain offices and patent agents, which is quite natural. (Person from TTO 3)

4.3.4 Gathering resources for spinout formation

The TTO states that the knowledge on which invention the spinout is created is effected by the structure of the team and the characteristics of the invention. However, major emphasis is put on the motivation of the key inventors to take the spinout risk and to the ability to acquire additional skills to strengthen the inventor team's knowledge in terms of business skills. Such skills are often sought by acquiring surrogate entrepreneurs to manage the future spinout company.

The search for such persons often starts by analysing and understanding the areas of skills that the team lacks. As the core inventor team is often formed from researchers who have high experience in their discipline, but lack business experience, so the focus of the search is often on business skills. Most often, the aim is to recruit a person with prior knowledge of how the company is operated and what types of needs the company has in its different stages. The TTO searches the surrogate entrepreneurs from its networks and emphasises that this phase is constantly improved. However, the TTO does not force the core inventor team to approve any surrogate entrepreneur. Instead, the TTO acts as a mediator and connects these two parties, and the core inventor team and possible surrogate entrepreneurs negotiate independently the agreement regarding joining into the possible company and compensation. The TTO emphasises that its function in these negotiations is to support and to give advice, but the inventor team makes the final decision.

The team or independent inventor often expresses their desire for spinout formation. (–) … we start that there should be a team. And if there is a team, then we see and discuss how it can be strengthened. (–) Often they [inventors] are quite blind in it [the need for

surrogate entrepreneur], but when we show in the negotiations that why it is strengthened, then they usually understand it. (–) We have our own networks, like X [name redacted] mentoring network, we know quite a lot of consultants and people who look for them. (Person from TTO 3)

Of course, there must be prior business experience. That is an essential requirement. An experienced person who knowns how this type of technological company operates and what types of needs it has. (–) But when we discuss the core team that goes and runs the spinout, it must be credible also to investors. Because investors first look to the team, so the core task is to build the team to become as credible as possible for investors. (–) A good team makes a product also from a bad technology. But a bad team fails even with best technology, and that is a fact. (Person from TTO 3)

The TTO argues that often the company needs flexibility and ability to change direction, as the first products or services may not be as successful as desired. Such flexibility can be facilitated by gathering mentors who share experiences and giving advice to the managers of the spinout company, but would not be hired by spinout as surrogate entrepreneurs are. The TTO has put considerable focus on acquiring such mentors for the spinout companies. Often, these mentors have long prior experience in similar technological fields as those in which a given spinout operates. Such mentors can be recently retired persons willing to aid the spinout venture without financial compensation.

The gathering of business-related skills, such as those of mentors and surrogate entrepreneurs, increases the probability of success. In addition, the strengthened spinout structure is seen as more credible by possible investors.

If there is a good mentor, then the CEO can have less experience. (–) They [mentors] have learned through mistakes what should not be done. So they offer their support and experience in challenging situations when, for example, company is proceeding too fast and does not recognise the possible pitfalls in its business. (–) And the utilisation of these persons is something we do. (–) Yes, the mentor utilisation is definitely one of the areas that must be developed. We try to do it constantly, more and more. (Person from TTO 3)

Although the TTO gives considerable attention to the search and strengthening of the team with business-related skills, the importance of the match between personalities is essential. In practice, the TTO searches for the most suitable candidates for the business roles and mentoring positions, and acts as intermediary between the core inventor team and found people. Furthermore, as the need for different skills varies between different commercialisation projects aiming for spinouts, the TTO must have vast networks from

which the people with business backgrounds from different fields are searched. Therefore, the TTO has purposefully extended its networks and aims to utilise them further. The TTO argues that the match-making of external persons to spinout groups has emerged to become one of the essential features for it, and the TTO aims for match-making to become one of its key activities in near future.

I know that team could be built by bringing persons from left and right and to say that now you are a team. But often it does not work like that in spinout. Personal chemistries must also match. And this is something that most of the people do not remember to mention. (–) That is why we let the team form itself, but we help to find (the business persons) before the spinout is formed. (Person from TTO 3)

... so how to find them according to a specific need? So when the need emerges, then what are your tools that you can rapidly search and find your expert? So this is what must be developed. (Person from TTO 3)

Aside from strengthening the team and finding a suitable surrogate entrepreneur, the TTO also states that one of the crucial resources is funding. Furthermore, the TTO argues that TUTL funding given by TEKES is one of the most important funding elements targeting the commercialisation of university-based science, and the TTO has allocated substantial resources to aid the search teams in acquiring the funding. It teaches and develops with the team the possible business models for the invention commercialisation and teaches the inventors to pitch their application in the format necessary for TEKES representatives. In addition, the TTO evaluates the team composition to analyse whether the strengthening of the team is necessary prior to or during the TUTL project. Also, the current stages of the technological level of the invention are evaluated to analyse whether the technology should be further developed prior to the TUTL application submission. The TTO also aids in the writing of the final application, and if the funding is obtained, a person from the TTO participates in the TUTL project up until the technology is transferred to established spinout. Moreover, the TTO's processes guarantee that the applications sent to TEKES are targeted towards commercialisation and not only basic research, as required by TEKES.

Well if it [TUTL] did not exist in Finland, it would be really difficult to create research based and developmental money needing spinouts. (Person from TTO 3)

We have developed our process to start early enough before deadline [of TUTL]. It includes training, business model development and pitching, and normal project evaluation. (–) Also, team building and finding a suitable commercialiser are tightly connected

to it. (–) And if the team gets the funding, then our innovation expert participates in the steering group. In addition, the innovation expert follows the IP development during the project. (Person from TTO 3)

... the commercialisation unit takes care that purely research projects are not brought to the application. They are filtered away during our process, meaning that we do not disguise research projects as commercialisation projects. (Person from TTO 3)

4.3.5 Transfer to external ecosystem

After the TUTL project has ended, the TTO actively steers the project group in the most suitable direction in terms of commercialisation probability. One of the most utilised directions is the incubator that appears in close connection to the university and that is currently further integrated into the university. The TTO states that they have actively participated in the design and management of the incubator's activities, and further integration of the incubator into the TTO's actions will result in efficient commercialisation activities.

The TTO emphasises that such a tightly integrated incubator will allow the use of the university's infrastructure, such as laboratories and instruments, to which an emerging spinout team would not otherwise have access due to their limited financial resources. In addition, the incubator will have close connections with university personnel and will allow efficient use of university students in various incubator-related projects. Moreover, besides access to knowledge and infrastructure, the incubator will have close connections to investors that have prior knowledge in investments on technologies emerging from university-based research projects.

... there will be incubators, investors, different types of actors. So it will become an access point into the X [university name redacted]. Its purpose is to visualise X's [university name redacted] knowledge, technologies and to open X's [university name redacted] infrastructure around here. (Person from TTO 3)

4.4 Cross-case analysis

The purpose of this study is to analyse how TTOs facilitate the creation of spinout companies emerging from academic life-science research. The data collection was performed with semi-structured interviews resulting in an extensive quantity of data. This data was

analysed in chapters 4.1–4.3, explaining each of the cases in depth. Following that explanation, the purpose of the cross-case analysis is both to compare and to analyse the results from each of the analysed cases, as discussed in 3.4. Cross-case analysis chapters are divided according to the sub-questions (discussed in chapter 1.2) to facilitate the construction of the revised framework (chapter 5). Chapter 4.4.1 relates to the function and purpose of the TTO in the university setting. Chapter 4.4.2 presents the different stages that through which TTOs process an invention in commercialisation activities. Finally, chapter 4.4.3 presents the activities and changes TTOs have performed in the stages presented in chapter 4.4.2.

4.4.1 Function of technology transfer office

All TTOs highlighted their central role to be the commercialisation of university-based IPRs and the facilitation of such commercialisation. In addition, other functions of TTOs were discovered to be supporting services in project management, grant application aid, and acting as a bridge function between university personnel and external stakeholders. In addition, all TTOs emphasised the importance of business experience and patenting knowledge among new recruits. All these functions can be seen to support the above-discussed commercialisation activities.

Regarding the TTOs' autonomy over internal decision-making, personnel from all TTOs indicated that approval for certain activities, such as the transfer of IPR ownership to established spinout, is sought from university. However, in terms of operations, such as hiring new personnel and internal commercialisation-activity development, the analysis indicated high levels of autonomy among all three TTOs.

4.4.2 Stages in the commercialisation process

The stages performed by the TTOs during commercialisation phase were found to be similar between the case organisations (Figure 13). All three TTOs indicated that they have commercialisation-related activities already in the research phase during which the inventions are created. After invention disclosure has been received by the TTOs, they perform evaluations of the invention, and most commercially viable inventions proceed to the protection phase. After this phase has been initiated, the TTOs manage the acquisition of additional resources, such as funds and personnel, to strengthen the core inventor team. All the TTOs indicated that the TUTL funding granted by TEKES is the most important funding for which they apply in commercialisation activities targeted towards

spinout formation, and therefore one stage in Figure 13 is labelled "acquiring TUTL funding". The purpose of TUTL funding is discussed in more detail in 4.4.3. Once the invention has been developed further and commercialisation alternatives have been evaluated during the TUTL-funded project, the TTOs manage the transfer of the TUTL project team into the external ecosystem, in which the spinout commercialisation strategy continues to be pursued.

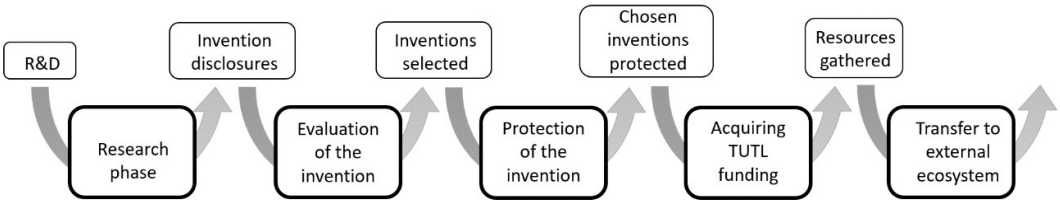

Figure 13. Stages taken by technology transfer offices (TTOs) during commercialisation of inventions towards spinout formation.

The outline of the stages passed through by TTOs during the commercialisation process towards spinout formation are shown in Figure 13. In chapter 4.4.3 each of the above-mentioned stages are discussed in chronological order, presenting different activities and changes performed by TTOs.

4.4.3 Activities of technology transfer offices during commercialisation process

All TTOs indicated that they have concluded that inventors do not always understand what an invention disclosure is, nor are they always aware of the mandatory disclosure practise. All TTOs also identified a need to increase the above-mentioned awareness of the requirement to increase the number of submitted invention disclosures. All TTOs had tested different practices to build such awareness, and the most suitable practices in a given situation are now applied in each of the three organisations. The activities included teaching the research community about commercialisation practises, and informing researchers about the requirement of disclosure and the role of the TTO. In addition, two TTOs adjusted their processes by modifying the invention disclosure sheet to a simple NABC structure, emphasising that such change forces the inventors also to evaluate the commercial potential and possible markets. Furthermore, one TTO had changed its operational structure to locate the TTO's innovation experts closer to the research community, facilitating greater awareness-building on invention-disclosure requirement and allowing efficient and seamless communication between the representative of the TTO and the research personnel.

Figure 144 summarises the emerged activities of TTOs during research phase. In addition, the emerged purposeful changes in the operations of TTOs are presented. '3x', '2x' and '1x' represent the number of cases from which similar themes emerged during the analysis phase that were presented in-depth in chapters 4.1–4.3.

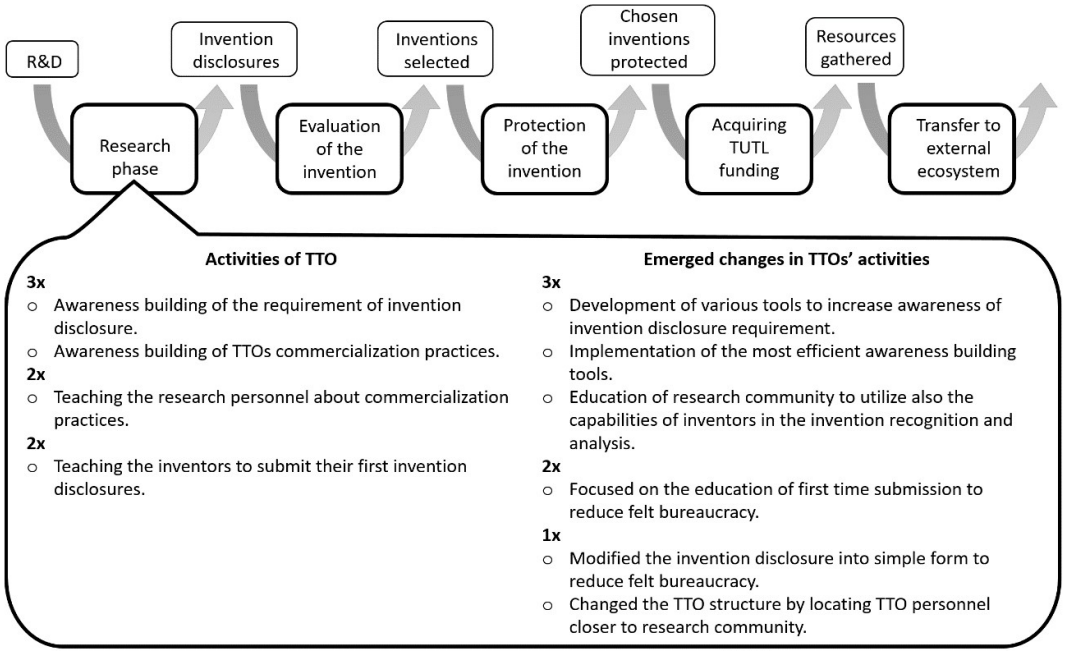

Figure 14. Analysis of the emerged activities and changes during research phase.

Once invention disclosures have been submitted, they arrive at the TTOs. In all the studied case organisations, the first evaluation carried out relates to ownership analysis. In ownership analysis, the TTOs evaluate whether the ownership of the invention belongs to university, inventors or to other parties. In all of the cases, TTOs highlight that if the invention is owned by the university, or if the owner wishes to transfer the ownership rights to the university, the TTOs proceed to other evaluation viewpoints. This is in line with the purposes of the TTOs, as they function to commercialise the inventions owned by university. Following the ownership analysis, TTOs analyse the commercial potential of the invention by evaluating market studies, competitor analysis and technical analyses.

All TTOs indicated that they perform the above-mentioned evaluations internally. In addition, one TTO emphasised that they have purposefully chosen to perform the analyses internally to gain knowledge and build an efficient and fast evaluation procedure. Similarly, one TTO emphasised that the organisation had allocated one person to evaluate certain life-science areas only, from which the majority of the invention disclosures are received, in order to increase the efficiency of the evaluation. One TTO also emphasised that they often perform the evaluation together with the inventor(s). In this practice, the

expertise of the inventors, who are often leading experts in their field, are taken into account. This practice has resulted in an efficient evaluation that is also visible to the inventors. In addition, two TTOs stated that they teach the inventors how to contact possible end-users, without exposing patentable material, to evaluate whether the need for the invention exists. The TTOs stated that this practice both verifies the need and increases the networks of the inventors, creating efficient evaluation of the true market need.

All three organisations also perform patentability analysis of the invention. However, one TTO specifically mentioned that they have outsourced the patentability analysis to external service provider, namely PRH, as an increase in invention disclosures required efficient and fast evaluation achieved through outsourcing. Another TTO mentioned that they perform internal patentability analysis, even when invention disclosure number had increased and, likewise, indicated that they have over time achieved an efficient and fast evaluation process.

Aside from evaluation of the invention from multiple viewpoints, TTOs also indicated that they perform a thorough analysis of the core inventor team and their motivations for participating in the commercialisation activities, especially if the team states their interest in the possible spinout strategy. In addition, one TTO specifically mentioned that they have adjusted the invention disclosure into the NABC model to allow easier submission by inventors and a more efficient evaluation procedure. This TTO also mentioned that the adjustment necessitates inventors to also initially evaluate the possible end-user needs and market, increasing the efficiency of the evaluation performed by the TTO. Finally, one TTO highlights that the increase in invention disclosures has resulted in a situation where they need to expand their resources, namely their number of employees, to allow fast and efficient processing in the future, if the increase in disclosures continues. The results from the cross-case analysis between different organisations are collected in Figure 15.

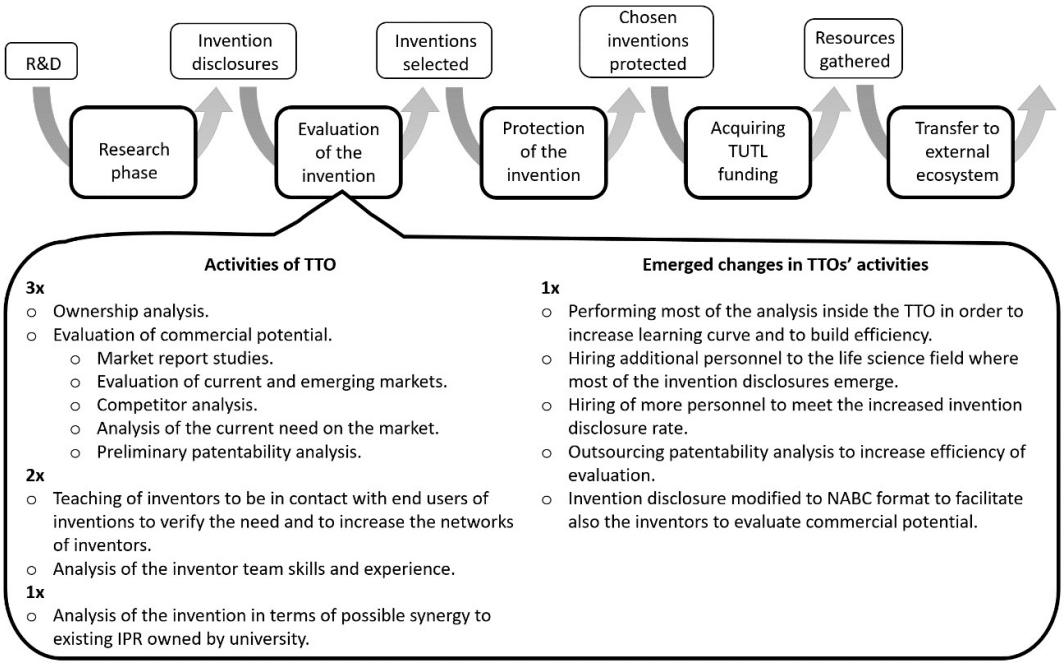

Figure 15. Analysis of the emerged activities and changes during evaluation phase.

Once the invention has been analysed, all TTOs proceed to the protection phase. All TTOs highlight the importance of patents as a legal protection and indicate that patentability is often seen as an essential requirement for commercialisation, especially if a spin-out strategy is later sought. All TTOs also indicated that they have learned through years of experience who Finland's top experts are in writing patents in different scientific fields. All TTOs apply this knowledge by outsourcing the patent-writing for such experts who are selected on the basis of the field of the invention. This practice is indicated to increase the scope of the patent, leading to higher value for the obtained patents. In addition, TTOs mention that the use of such external patent agents creates efficiency and fast patenting practice that will benefit the inventors and not delay the submission of their work into academic journals.

The TTOs participate in patent writing also by ensuring that the commercial viewpoints are taken into account while writing the patent. The TTOs also facilitate the participation of the inventors that contribute to the writing process by providing the technical details of the invention. In the protection phase, one TTO also states that they have assigned patenting tasks to one member from the organisation to increase the efficiency of the process. One TTO also specifically mentioned that the increase in the invention disclosure numbers created a situation in which the resources, namely personnel, participating in the patenting phase had to be increased. In addition, to adjust the practices further, one TTO also began to outsource the patenting tasks to external patent agents. This TTO

argued that such adjustments in the resource base and practices created higher-value patents and resulted in greater efficiency. Activities and emerged changes in TTOs' activities in the above-discussed phase are summarised in Figure 16.

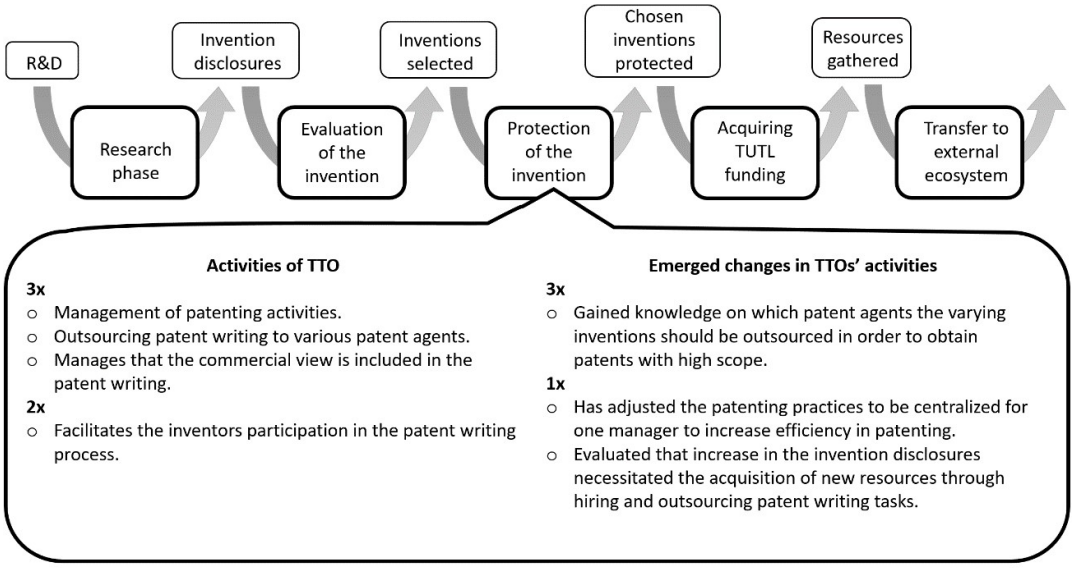

Figure 16. Analysis of the emerged activities and changes during protection of the invention –phase.

After the TTOs have initiated the protection of the invention phase, in all the case organisations the process proceeds with the gathering of resources for further development of the technology and commercial applications. All case organisations highlighted the importance of TUTL funding offered by TEKES. In addition, all three case organisations mentioned that through experience they have observed and learned that TUTL funding is the most efficient publicly available grant available in Finland for academic life-science-invention commercialisation. One TTO also emphasised that they had determined that the spinout strategy that emerges through TUTL is often more profitable than the licensing of the IPRs. All TTOs emphasised that they have adjusted their processes to be efficient in applying the TUTL funding. At the current stage, all TTOs participate in the TUTL funding application by providing assistance in various tasks such as in application writing, evaluation and teaching the inventor how to present inventions in a pitch. The importance of the TUTL application can also be seen in one TTO's statement that they have assigned a dedicated person to manage the TUTL applications emerging from the university, again in order to increase the efficiency. One TTO mentioned that previously it had the main responsibility for writing the TUTL applications, but they developed their practices to teach the inventors to write such applications, in order to both to increase the efficiency in the writing process and the quality of the final applications. In addition, one TTO mentioned that they have modified the TUTL application sheet to a simple structure

to reduce the bureaucracy felt by the inventors and to increase the TUTL application rate. One TTO established a TUTL evaluation board composed of the university management and representatives from external companies to increase the efficiency in evaluation and to obtain external opinions about the invention's potential.

Besides facilitating the acquisition of funding for further development of technology and business alternatives, TTOs also emphasised the importance of strengthening the core inventor team. As indicated in chapter 4.1–4.3, often the inventor team lacks the business experience and knowledge essential for the success of the possible spinout venture. Therefore, two TTOs specifically indicated that they have extended their networks to search for surrogate entrepreneurs who would participate in the team either as entrepreneurs or in other business-related activities, depending on need. In addition, one TTO specifically mentioned that such strengthening of the team is important not only due to the operation of the daily activities of the possible spinout, but also to increase the credibility of the possible spinout venture, as evaluated by investors. However, one TTO also highlights that the strengthening of the team with external persons with business backgrounds does not involve a merely straightforward assessment of skills. Instead, the suitability of the person to the core inventor team is also effected by the personalities of the participants. Therefore the TTO has adjusted its role towards intermediary function, where the TTO constantly expands its networks to search for new business contacts and introduces them to the core inventor team, who decide whether the candidate‘s personality matches theirs and whether they are able to form an efficient working relationship.

Often, senior level-scientists who have much experience in academic research are hesitant to take part in the possible spinout activities due to their potential inability to publish research during the period. To overcome this barrier and to motivate the senior scientists to participate in the possible spinouts, two TTOs highlighted that they have developed contracts that allow senior scientists to participate in the spinouts part-time, granting them the ability to also participate in their academic research. Such contracts increase the possibility of securing senior scientist's' participation in the spinout activity.

In addition, one TTO also highlighted the importance of mentors in spinout-venture formation. This TTO has concluded that the participation of mentors, who are often recently retired with much experience in business-related tasks, increases the probability of success for a spinout company. Such mentors often participate in a spinout venture without compensation and give valuable guidance in challenging issues related to business strategy. The TTO emphasises that they have purposefully developed their networks to search for and lock in such mentors to their projects aiming for spinout venture formation.

One TTO also has developed an internal funding structure under which the inventor team can act as a company inside the premises of the university. This is to teach the core inventor team about the operational and managerial tasks required for future spinout activity. In addition, one TTO has developed internal funding to be applied if TUTL funding

is not obtained. However, the quantity of the fund is modest, compared to TUTL funding. Activities and emerged changes in TTOs' activities in the above-discussed phase are summarised in Figure 17.

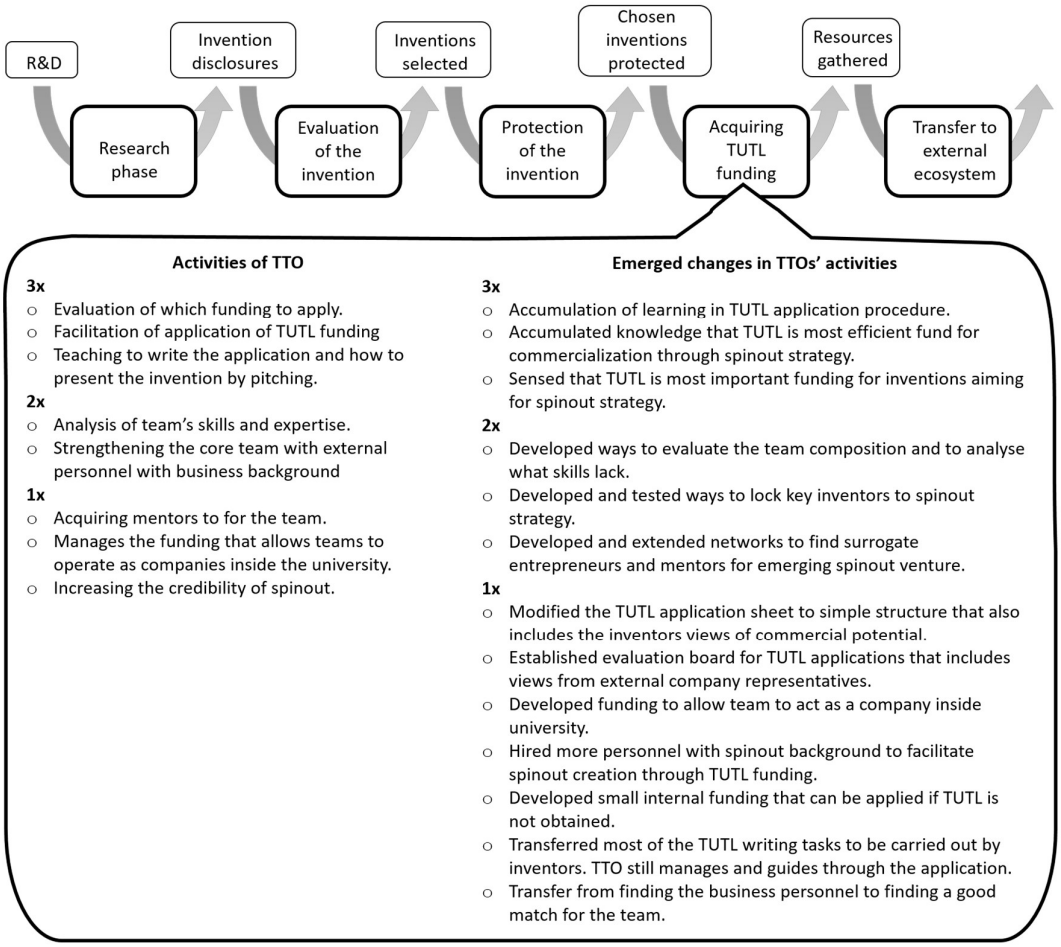

Figure 17. Analysis of the emerged activities and changes during the phase of the acquisition of TUTL funding.

After a TUTL-funded project has ended, all TTOs indicated that the next phase is to facilitate the transfer of the project team into the external ecosystem. All TTOs also highlighted that they have learned through experience where, depending on the nature of the invention, the project team should be steered after the TUTL period had ended. However, one TTO highlighted that they had developed an internal funding element that can be applied for the project team after the TUTL period to increase the value of the invention and to attract investors. In contrast, one TTO had evaluated that the additional funding would not be as efficient as necessary, and has focussed on facilitating the transfer of project team to the external ecosystem. Likewise, two TTOs mentioned that they have tested different ways to transfer the IPRs of the invention to the formed spinout company.

The aim of such actions is to allow the spinout company to have control over the IPRs and to profit from the transaction without creating an unreasonable financial burden on the company. Often, such a transaction is performed through pre-set milestones. In situations where the formed spinout is dissolved, the IPRs are often agreed to be returned to university for future commercialisation activities.

One TTO stated that through experience, they have learned that spinouts should be established rapidly after the TUTL funding has ended to reduce the possibility that key members of the TUTL-funded project will move to other projects. These actions facilitate the locking of key members into spinout activity.

Two TTOs expressed that they had participated in the development of spinout company incubators where most of the spinout-oriented project teams were directed. Life-science inventions frequently require expensive infrastructure, and spinouts would have to acquire access for such machinery. One TTO specifically mentioned that they had developed the incubator to include access to the university's research infrastructure, reducing the need for spinouts to make large investments at the beginning of the venture. In addition, the TTO has developed the incubator to have connections to investors with prior experience in financing in the spinouts emerging from the academic life-science research. Finally, one TTO had developed a portal where the TTO contributes the information of possible investors. This portal is targeted to inform the inventors of the current availability of funding. The cross-case analysis of the transfer stage is presented in Figure 18.

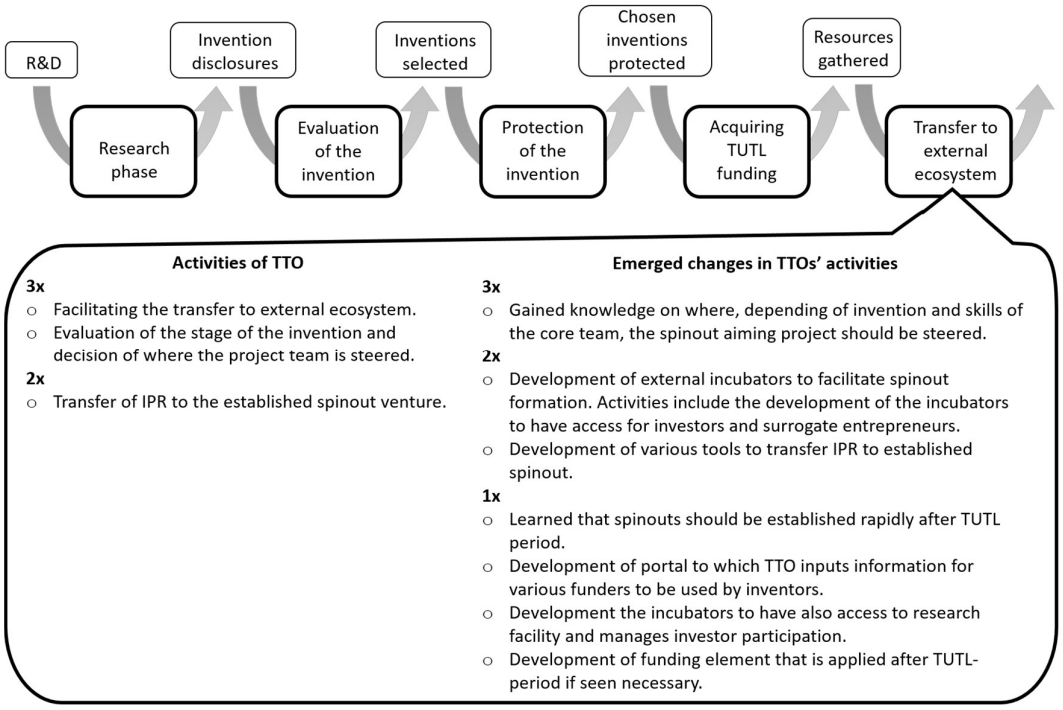

Figure 18. Analysis of the emerged activities and indications of dynamic capabilities during the transfer phase.

5 CONCLUSIONS AND FORMATION OF FINAL FRAMEWORK

The aim of the study is to evaluate the levels of autonomy in the decision-making stages that TTOs undertake in the commercialisation process towards forming a spinout, along with the dynamic capabilities of TTOs. This conclusion chapter is divided accordingly. Chapter 5.1 evaluates the case organisations' autonomy and continues to discuss the stages in the commercialisation process, comparing the results with the existing literature. Chapter 5.2 discusses the reported activities of TTOs in each of the stages and compares the results to the existing literature. In addition, a revised framework in terms of the activities of TTOs and indications of dynamic capabilities are discussed in each of the stages presented in chapter 5.2. While chapters 5.1–5.2 focus on the theoretical implications of the research, chapter 5.3 discusses the managerial implications. Finally, chapter 5.4 proposes suggestions for future research.

5.1 Stages in the commercialisation of academic research towards spinout

Rothaelmer et al. (2007, 740) and Siegel et al. (2004, 121) emphasise the intermediary and gateway function of TTOs in the commercialisation of academic research. The findings in this study support that same aims are also present in the context of the three studied case organisations. Markman et al. (2005a, 247–249) have discussed that the management structure, namely how the TTOs are managed in the context of university, have an effect on the autonomy of the university. In this study, the level of autonomy was evaluated by interviewing TTO members regarding their activities and how they have adjusted these commercialisation activities, as well as their recruiting practises. Some TTOs highlighted that they sought for approval from university management in terms of requiring new personnel and when IPRs are transferred to established spinout ventures. However, such decisions are made by university management on the basis of recommendations and applications by the TTOs. In addition, none of the case organisations emphasised that the aims of the organisations would be to create a profit for the TTO. These findings indicate that the management structure is not-for-profit, as classified by Markman et al. (2005a, 247–249). Therefore, it can be concluded that TTOs have autonomy over their own decisions and processes. This finding further suggests that the development tasks TTOs perform are the results of their own capabilities and are not forced upon them by the higher university management.

As proposed by Shimasaki (2009), there exist multiple routes by which inventions are commercialised. As the focus of the research was to evaluate the activities and underlying

dynamic capabilities of TTOs when a spinout strategy is pursued, this study began on the basis of the sequential stage model illustrated in Figure 5 by Bradley et al. (2013, 5). This view was further developed on the basis of literature review, from which the initial framework in Figure 11 was derived. The results of the study support the early steps of the initial framework, as also seen in Figure 13. In all of the case organisations, the first phase of the TTO's activity occurs within research phase where TTOs perform activities such as awareness-building and offer aid in the submission of invention disclosures. After receiving an invention disclosure, all the case organisations proceed to the evaluation stage, following by the protection of the invention.

However, the initial framework diverges at the resource-gathering stage. In the initial framework in Figure 11, this stage represents resource-gathering and marketing, and no dominant funding element emerged in the literature review that would be preferred by TTOs. However, cross-case analysis revealed that all the case TTOs emphasised the importance of acquiring TUTL-funding, and no other funding option emerged from the case analysis that would be seen as important by TTOs.

All three universities were among the top five Finnish universities in terms receiving New Business from Research Ideas (TUTL) funding from the Finnish Funding Agency for Technology and Innovation (TEKES), from the beginning of 2015 to the present date. As stated by TEKES, TUTL *"*Funding is intended for research groups and researchers in research organisations, who want to build a new business based on their research and realise their idea by commercialising it." (https://www.tekes.fi/en/funding/research_organisations/new-business-from-research-ideas/, retrieved 17.3.2017). Since the TUTL funding is targeted towards the commercialisation of the research, the prevalent use of such funding implies the motivation of the institutes towards these commercialisation activities. Moreover, since there is high competition for such funding, the ability to obtain it indicates an efficient application procedure from the TTOs. It must be noted that not all obtained TUTL funding targets life science research. However, life-science-related research is performed in all the chosen universities, suggesting that at least part of the funding is devoted to life-science-related commercialisation.

After the TUTL-funded project ends, the major stage that emerged from the cross-case analysis was the steering of project teams into the external ecosystems, thus differing from the proposition given by Bradley et al. (2013, 5).

5.2 Activities of technology transfer offices in the commercialisation process and underlying dynamic capabilities

The previous chapter focussed on discussing the stages and chronological order of commercialisation activities of TTOs towards spinout formation. This chapter discusses the

noted stages in detail and compares the results of the study to the existing literature and theoretical background, as presented in chapters 1–2.

The definition of dynamic capabilities applied in this study was presented in chapter 2.3. They can be seen as the underlying capabilities that allow the formation of best practices (Eisenhardt, 2000, 1107), as well as a purposeful modification of existing capabilities that alter the resource base (Helfat, 2007, 4). Universities create novel inventions from multiple disciplines. The TTO's function is to manage and facilitate the commercialisation of these inventions through a process that follows the chronological order proposed in the previous chapter. As indicated in chapters 4.1–4.3, the commercialisation of such inventions is evaluated case-by-case, and no one general commercialisation practice is suitable for every received invention disclosure. Therefore it can be assumed that the market in which TTOs operate is of high velocity, as categorised by Eisenhardt (2000, 1110–1113). In high-velocity markets, the dynamic capabilities often take simple forms and are often without much accumulation of written procedures. The dynamic capabilities are deployed to acquire, evaluate and use newly gained knowledge efficiently and rapidly. (Eisenhardt, 2000, 1110–1113.) These dynamic capabilities were difficult to observe here, due to the short observation period taken in this study, as proposed by Helfat (2001, 1245–1249). Also, different case organisations may have different levels of capabilities, as discussed by Winter (2003, 992). Therefore the categorisation of all case organisations capabilities in certain stages as dynamic capabilities is challenging, as some capabilities may have the characteristics of both operational and dynamic capabilities, and capabilities that may have characteristics of dynamic capabilities in one organisation could be classified as operational capabilities in other case organisations, as suggested by Helfat and Winter (2011, 1245–1249). Thus, the discussion is limited to indications of dynamic capabilities in the various reported activities of TTOs. Further studies are proposed in chapter 5.4 to study further the implied dynamic capabilities.

Dynamic capabilities focus on the adjustments of existing resource base (Helfat, 2007,4). Therefore, also the resource base connecting to commercialisation of inventions will be briefly defined. As noted in chapters 4.1–4.3, TTOs' resource base can be seen to consist of the resources the organisations apply in the commercialisation phases. In addition, the invention itself can also be seen as a resource for commercialisation, as Eisenhardt et al. (2000) discussed regarding the search for oil by oil companies. Cross-case analysis revealed that case organisations proceed through commercialisation process by accomplishing each stage in sequence, and none of the case organisations indicated an ability to exclude any of the emerged stages. It can be therefore proposed that the order of the stages is pre-set. Eisenhardt and Martin (2000, 1110–1113) suggest that organisations apply strict routines when proceeding through pre-set orders of stages. Eisenhardt and Martin (2000, 1110–1113) further suggest that organisations apply dynamic capabilities in situations with higher freedom, such as in the activities and developments carried

out in pre-set stages. Similar indications were also found in this study, where all three case organisations proceed through pre-set stages, although they applied various dynamic capabilities during each of the stages to extend resource base. The pre-set stages also indicate that the motor of the progress in the process is life-cycle, as proposed by Van de Ven (1995, 513–515).

The research phase emerged as the first stage in the commercialisation process. Siegel et al. (2003b, 30) have argued that not all inventions are disclosed in the US, although legislation dictates their mandatory submission. Jensen et al. (2003, 2) reported their suspicion that half of inventions are not disclosed. Cross-case analysis confirmed that all TTOs evaluated that some inventions are not submitted. However, the precise number of the undisclosed inventions were not quantified during in this study. Siegel et al. (2003b, 42) also argued that if the inventors do not have incentives for commercialisation, they may be discouraged from submitting invention disclosures. To overcome this challenge, the case organisations had developed methods to compensate inventors whose inventions are successfully commercialised but who do not wish to participate in the commercialisation activities, increasing incentive to submit invention disclosures. Other reward systems proposed by Rothaermel et al. (2007, 739) did not emerge in this case analysis. However, the reward systems for the university personnel were not the focus of this study and therefore their absence in the cross-case analysis does not imply their absence in the case organisations.

Lockett and Wright (2005, 1046) propose that invention rate could be increased by increasing the awareness of invention disclosure requirement, and all three case organisations had performed similar awareness-building activities. The case organisations mentioned that they had sensed that the invention disclosure rate could be increased through awareness-building. The TTOs built this awareness by testing and implementing multiple different tools, from which the most efficient ones were retained. It can be therefore argued that all TTO's utilised dynamic capabilities when sensing, seizing and managing the purposeful adjustment of the practices to increase rates of invention disclosure. In addition, the testing of multiple awareness-building tools, from which most the efficient ones are currently applied, suggest the process motor to be evolution, as discussed by Van de Ven (1995, 517–519). Interestingly, although TTOs are separate institutes without shared managerial layers, all the TTOs applied dynamic capabilities to increase the awareness of invention disclosure submissions. This finding supports the notion of Eisenhardt and Martin (2000, 1110) that dynamic capabilities cannot be the source of sustainable competitive advantage, as the dynamic capabilities can be generated independently.

Other purposeful changes in the organisations that indicate the presence of dynamic capabilities, as proposed by Helfat et al. (2007, 4), were the development of teaching practices for the research community to both notice and to evaluate the commercial value of the inventions, as well as to adjust the invention disclosure to include elements of the

inventor's knowledge in the commercial potential. In addition, purposeful reduction in the bureaucracy felt by the inventors for invention submission, as well as changing the organisational structure to locate TTO members closer to the inventors and facilitate awareness building, have the characteristics of purposeful modification of TTO's resources, suggesting the presence of dynamic capabilities. However, the analysis phase did not reveal which Van de Ven and Poole's (1995) underlying motors were present in these developments. The revised framework of the research phase is thus presented in Figure 19.

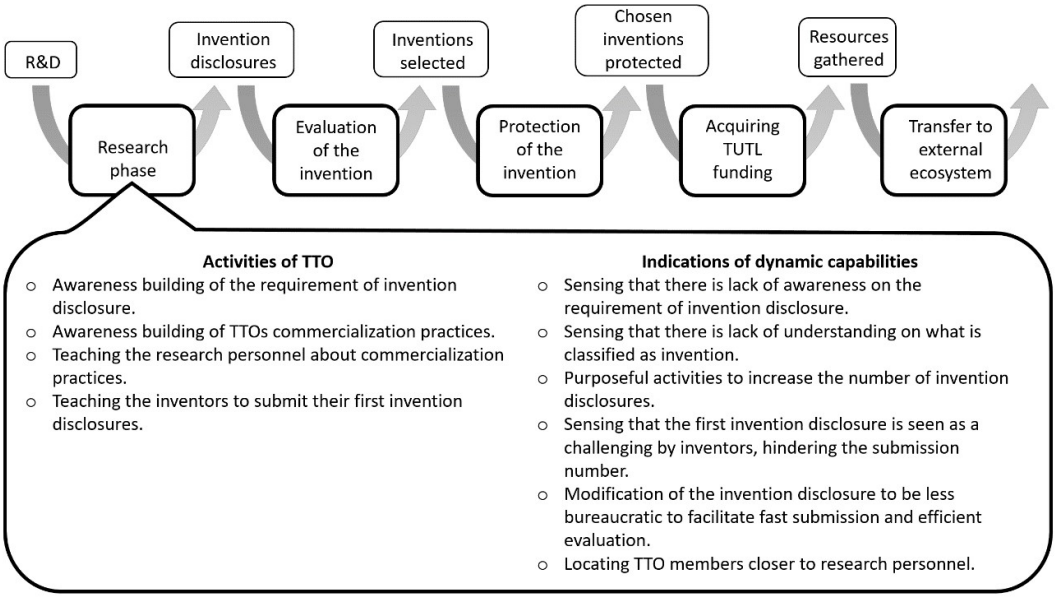

Figure 19. Revised framework of research phase.

Vohora et al. (2004, 151–157) have proposed that invention disclosures should be evaluated from multiple viewpoints, such as technological and market-potential perspectives, to assess the value of the invention. In addition, Lockett et al. (2003, 118) have argued that this evaluation should not be performed only by academic personnel disciplined in the field of the invention. Lockett and Wright (2005, 1047) have proposed further that evaluation should be performed by persons with various backgrounds, such as business-related experience. Similarly, Vohora et al. (2004, 159–160) have suggested that evaluations performed by only research personnel could either overestimate or underestimate the value of the invention. The findings of this study show that the case organisations have purposefully recruited personnel with various backgrounds and prefer business-related knowledge in hiring staff, increasing the efficiency of commercialisation and efficiently evaluating the opportunities the invention presents.

Ndonzuau et al. (2002, 284–286) have argued that invention ownership analysis is one of the most important analyses performed by TTOs. Similar results were found in this

study, where all the case organisations performed the ownership analysis prior to any other analyses, as the purpose of the case organisations is to commercialise university-owned IPRs. In addition, the TTOs completed various evaluations, such as technical analysis, commercial potential and competition analysis, and preliminary analysis of commercialisation alternatives. Such evaluations are in line with the recommendations given by Ndonzuau et al. (2002, 283–284). In addition, the case organisations had purposefully modified the invention disclosure sheet to include aspects of commercialisation and developed practices to teach the inventors how to acquire knowledge of demand from potential customers without revealing patentable information. Both of these activities indicate the presence of underlying dynamic capabilities that facilitate the extension of a resource base. However, the precise motor of Van de Ven and Poole (1995) for such developments could not be determined from the analysed data. The presence of dynamic capabilities were also indicated in the activities where case organisations met the increased workload resulting from the increase in invention disclosures: TTOs either hired new personnel to manage the increased workload, or the resource pool was extended by outsourcing specific tasks to specialised offices. The revised framework of the evaluation phase is presented in Figure 20.

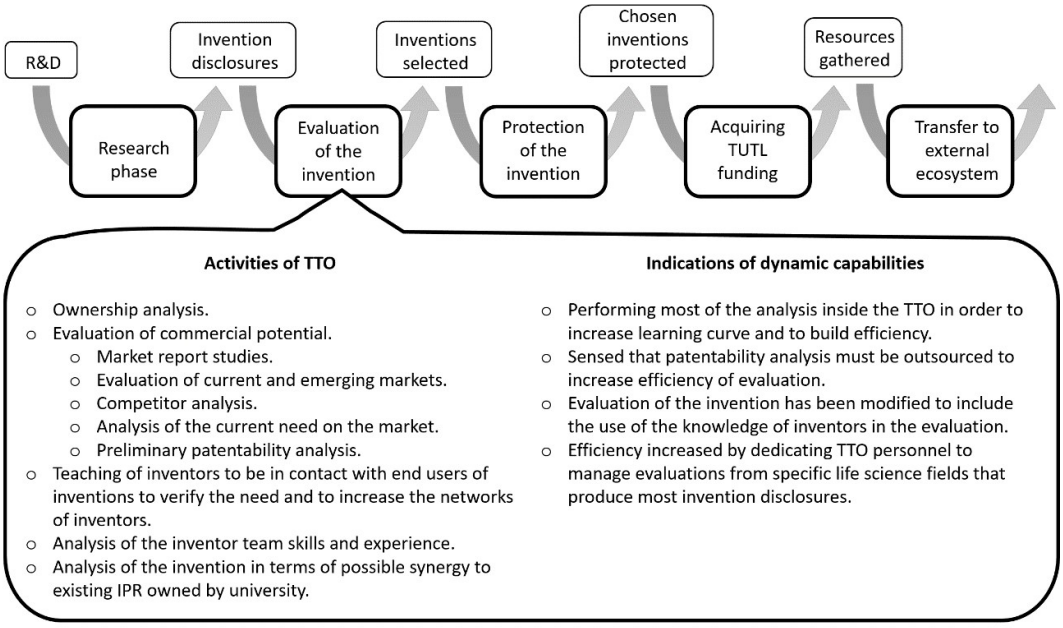

Figure 20. Revised framework of evaluation phase.

Lockett and Wright (2005, 1047) argue that inventions can be difficult to commercialise without patent as a protection. Similar results were found in this study, as the analysis indicated that TTOs find challenges in commercialising inventions without patented protection. Bradley et al. (2013, 10–13) suggested that persons with business backgrounds

are also recommended to participate in patent evaluation and writing. Similar results were found in this study, where case organisations managed the patenting phase and participated in patent-writing tasks to include a commercial perspective in the final patent.

The accumulation of knowledge can be seen especially when TTOs decide to which patent agent the patent-writing is to be outsourced. Such an activity is the result of multiple experiences. In the selection, the aim is to outsource the writing task to a person with the most knowledge relevant to the specific invention, as well as the capabilities to write a patent application with greatest scope to increase the value of the patent. Such activity has clear indications of dynamic capabilities in terms of accumulation of knowledge (Teece et al. 1997) and by extending the resource base (Helfat et al. 2007, 4). Each outsourcing event can be seen as an individual action. Therefore, the outsourcing of inventions from specific field and the gaining of knowledge concerning who is the most suitable patent agent in the field has elements of the evolutionary process motor, as the preference on the patent agent is also retained (Van de Ven and Poole, 517–519). Other purposeful alterations of the resource base that indicate the presence of dynamic capabilities were outsourcing of patentability analysis and recruitment of personnel with patenting expertise to facilitate the patenting phase. The revised framework of the protection phase is presented in Figure 21.

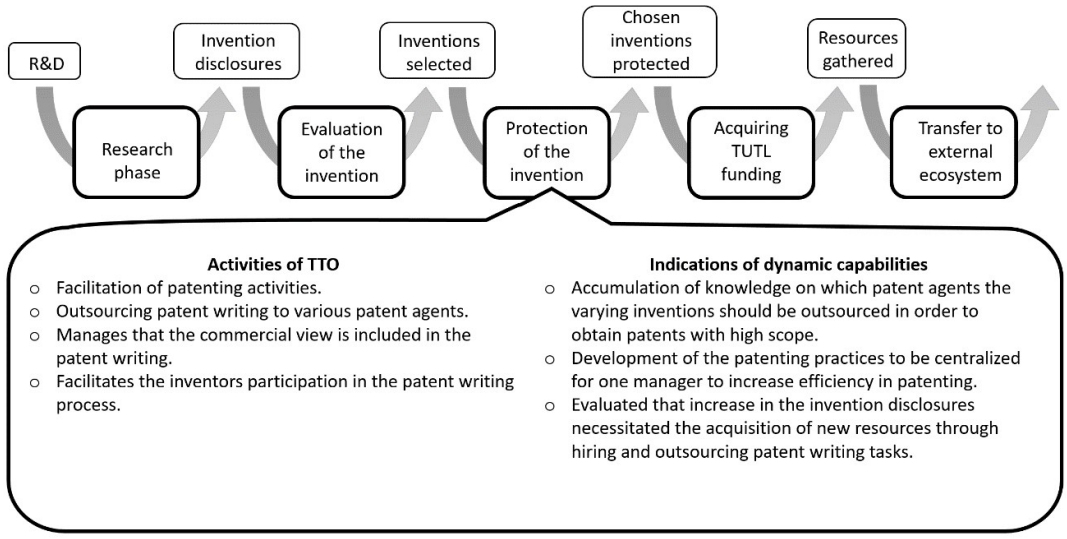

Figure 21. Revised framework of protection phase.

Ndonzuau et al. (2002, 285–286) have stated that since disclosed inventions are often at a phase in which they require further development, the acquisition of funding can be challenging. Vohora et al. (2004, 151–156) has further argued that such further development may take years to complete before inventions can be commercialised. The case organisations indicated a strong preference for TUTL funding to meet the above challenges.

The development of the TUTL application process in the case TTOs can be seen to have accumulated both from their knowledge and experience, indicating the presence of dynamic capabilities in the development phase. In addition, as the development has reached a stage in which the case organisation sees TUTL as the main source of funding for technology and business development, it can be argued that the motor for the process is evolutionary, as indicated by Van de Ven (1995, 517–519).

The application period for TUTL can be also understood as the result of dynamic capabilities. Case organisations have adjusted the application sheet to include the inventor's view on the invention's business potential. One organisation emphasised the evaluation board to include the knowledge of external company participants for the application, and one organisation changed the practice from writing TUTL applications to teaching inventors to write the applications. All these purposeful activities were performed to increase the resource base for TUTL funding, as well as to increase efficiency in the application process.

Vohora et al. (2004, 160–164) have emphasised the importance of surrogate entrepreneurs to compensate for the lack of business experience in the core team to both to increase the success of the daily operations of the emerging spinout company, as well as to increase credibility of the spinout for possible investors. Timmons (1994, according to Ndonzuau et al. 2002, 286) states that the failure of a spinout often arises out of challenges in management and not in technology. All case organisations sensed the importance of surrogate entrepreneurs and developed capabilities and methods find and secure such people in emerging spinout ventures. In addition, one case organisation had developed methods to attract mentors for the spinout venture. Such purposeful extensions on the resource base are clear indications of dynamic capabilities. Vohora et al. (2004, 160–164) stated that the different views of the inventors and possible surrogate entrepreneurs, as well as mentors in this study, create challenges, and they may reduce the commitment of participating shareholders. To overcome this potential problem, one case organisation had indicated that the match between personalities of inventors and possible surrogate entrepreneurs and mentors is the most important feature. Thus, the organisation had altered its processes not to force the interaction between inventors and surrogate entrepreneurs, but to act as intermediary and to allow the inventor team to decide whether the person would be appointed to the company. It can be proposed that the underlying motor in such interaction by Van de Ven and Poole (1995) is a dialectic motor, where opposing views are merged to form consensus.

Siegel et al. (2003b, 42; 2004, 130) emphasised that inventors have the tendency to publish the majority of their results in peer-reviewed journals, as they are often evaluated using such metrics. If a person is proceeding in his or her academic career, he or she might be hesitant to join the spinout company, as the required period in the spinout venture may hinder publication success. Cross-case analysis revealed that to overcome this challenge

organisations developed methods to allow also part-time participation in the spinout, especially for senior scientists who already have distinguished careers in the academic field. However, analysis also shows that it is often preferred that key inventors participate full time. The purposeful alteration of the capabilities by developing practices to secure senior scientists indicates the presence of dynamic capabilities. Other adjustment that indicate dynamic capabilities are the development of internal funding to be applied by inventors to learn how to manage a company on university premises, along with the reduction of possible fears felt by the inventors towards their success in the daily operations of a spinout company.

Jensen and Thursby (1998, 23–24) have suggested that spinouts where the university is equity owner, compared to situations where the patent is commercialised through licensing, provide higher revenues for the university. Similar results were found in one case organisation, where the organisation had evaluated that spinouts are more profitable alternatives for commercialisation than licensing is. This organisation had therefore recruited more personnel, especially with spinout-related capabilities and expertise, indicating the presence of dynamic capabilities inside TTO management to steer their capability to create spinouts. However, the generalisability of these results is unknown, due to the lack of publicly available statistics on university commercialisation expenses and profits. The final framework of the stage of acquiring TUTL funding is presented in Figure 22.

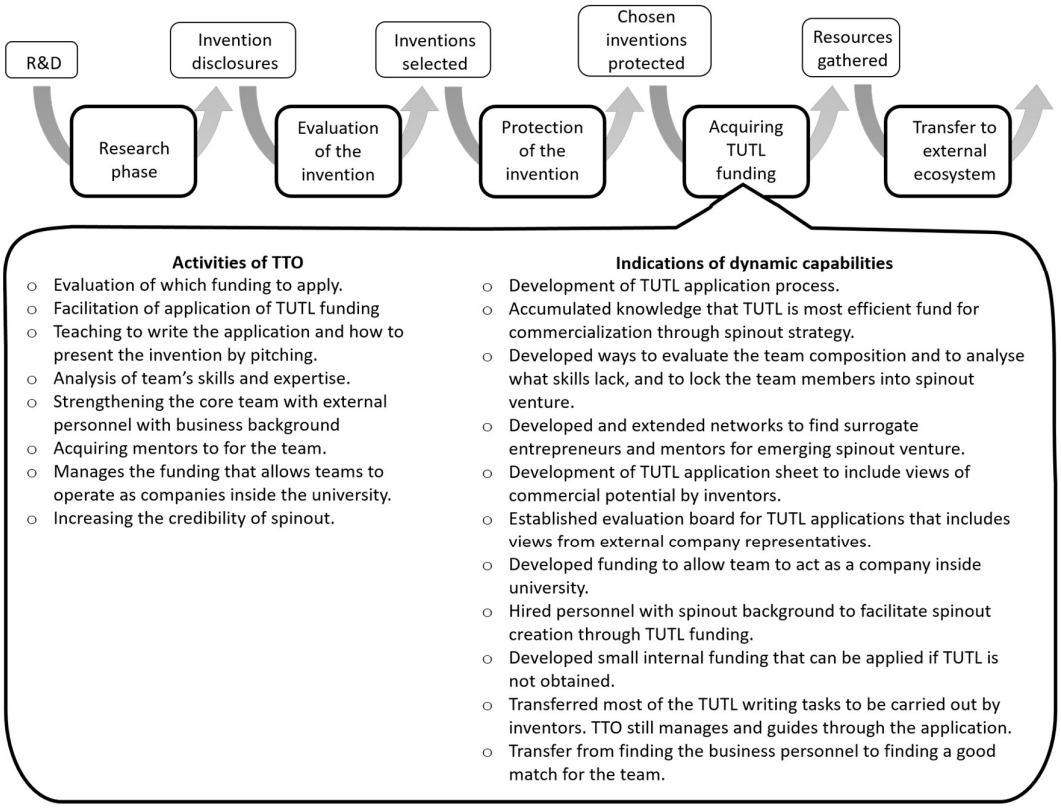

Figure 22. Revised framework of acquiring TUTL funding –phase

Ndonzuau et al. (2002, 286–287) argues that if establishing takes a long time, inventors may have moved to other positions and may be unavailable for the later spinout activities. To overcome this problem, and to lock key inventors into the spinout company, one case organisation specifically stated that they establish the spinout immediately after the TUTL period to reduce the possibility that the inventors may be unavailable at later stage.

Indications of dynamic capabilities can be also found from the development of external ecosystems, namely spinout incubators. Case organisations had participated in the development of external ecosystems to allow the efficient transfer of the spinout ventures to the most suitable business incubators. Depending on the incubator, the spinout ventures receive premises, access to university research infrastructure, mentors and possible surrogates, if such members have not already participated in the spinout project. In addition, inventor teams obtain further aid in the development of their business plans and access to investors. As the case organisations have actively developed the incubators and route to them, it can be argued that the activity can be seen as purposeful extension of resource base, indicating dynamic capabilities. However, the underlying motor of Van de Ven and Poole (1995) did not emerge during the analysis. The development of various methods on how the IPRs are transferred to established spinouts can also be seen as a dynamic

capability, and the underlying motor carries indications of an evolutionary motor. The revised framework of the transfer stage is presented in Figure 23.

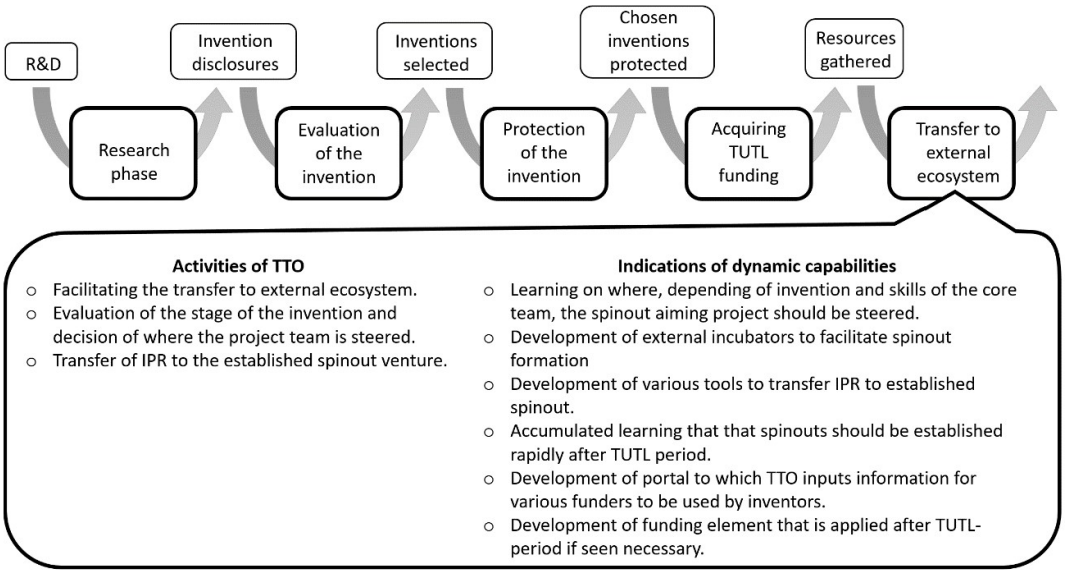

Figure 23. Revised framework of transfer stage.

There exist little empirical research on dynamic capabilities, in general (Ambrosini & Bowman, 2009, 37), and prior research into the dynamic capabilities in the TTO context in Finland was lacking. This study revealed multiple different events that have the characteristics of underlying dynamic capabilities, as summarised in the Figures 19–23. The TTOs operate in a market where new resources, such as inventions, are constantly emerging, and TTOs develop their competences and capabilities to commercialise the emerging inventions efficiently. Thus, the results indicate that the field in which TTOs operate is characterised as a high-velocity market, as classified by Eisenhardt and Martin (2000, 1115). Eisenhardt and Martin (2000, 1110–1113) have further proposed that in such markets, the dynamic capabilities allow the rapid acquisition of knowledge and later take the form of written procedures. The findings in this study are in line with such notions. The fast acquisition of knowledge can be seen in multiple different events that indicate the presence of dynamic capabilities. In addition, the alterations of resource pools can be later seen to be included in detailed procedures, such as in the case of the continuous increase of the awareness of the necessity of invention-disclosure submission. Interestingly, although each of the case organisations are separate, independent units without shared management, multiple similar indications of dynamic capabilities were discovered. This finding is in line with the proposition that each organisation can develop their own dynamic capabilities (Eisenhardt & Martin 2000, 1110). It also follows that the dynamic capabilities are not a source of sustainable competitive advantage, as proposed by Eisenhardt and

Martin (2000, 1110). In addition, aside from contributing to the empirical field of dynamic capability studies in general, this study revealed that there exists multiple indications of the presence of dynamic capabilities in the operations of TTOs. These multiple findings can be used as a foundation upon which further empirical studies of dynamic capabilities in TTO contexts can be initiated.

5.3 Managerial implications

Besides theoretical implications discussed in the previous chapter, this study contributes alto to the field of research management, namely the operations relating to the commercialisation of academic research emerging from life-science research. The selected case organisations were all among the top five organisations in terms of obtaining TUTL funding, proposing that case organisations have well-established commercialisation processes. The focus of the study was to discover how three TTOs have changed their existing resource bases and what the underlying dynamic capabilities are. The study revealed multiple different alterations to the resource base performed by case TTOs to achieve their current, efficient commercialisation processes. In addition, the study has indicated the presence of underlying dynamic capabilities in these changes, as well as the commercialisation processes in detail.

Thus, these findings can serve as a model for other similar organisations with similar development needs, such as Applied Universities as mentioned by the representative from TTO 3, and this study contributes to their commercialisation development especially when their aim is invention-commercialisation through spinout formation.

I would say that in Finland, the Applied Universities come now in the next wave and they will learn what have been discovered here in the larger universities and X [university name redacted]. And this knowledge must also be granted to them. (Person from TTO 3)

5.4 Limitations and suggestions for future studies

The focus of this study was to analyse how Finnish TTOs in university setting facilitate the commercialisation of research outcomes to form spinout companies. Moreover, both the assumption during the case selection and emerged results suggested that the selected case organisations were all efficient at their commercialisation practices when commercialising the research results towards spinout formation. Thus, the results of this study represent the processes and dynamic capabilities in the selected case organisations. The observed commercialisation processes had similar stages as in the initial framework of

the study presented in chapter 2.4, which was a synthesis of existing literature, implying the more general nature of the process. However, the generalisation of the results to wider population, such as to other Finnish universities, was out of the scope of the study. It is therefore recommended that additional studies are performed with other organisations to extend the generalisability of the here reported study.

This study adopted a qualitative research design that allows the collection of data from complex processes (Creswell, 2007, 40). The data was collected with semi-structured interviews with *"*key decision makers" (Nummela et al. 2016, 57) from three case organisations, as well as by gathering information from secondary sources, such as Internet pages, to facilitate triangulation. The semi-structured interviews presented an efficient data-collection method allowing for the use of open-ended and probing questions (Meyer, 2001, 345; Cohen & Crabtree 2006, 1). However, such a data-collection method relies on the retrospective sensemaking of the occurred events of the interviewees, and can thus be prone to bias (Eisenhardt & Graebner, 2007, 28). Aside from such possible bias, dynamic capabilities in general can be challenging to observe. As discussed by Helfat and Winter (2011, 1245–1249), the change in the resource pool by dynamic capabilities can take a long time, and a short observation period, as applied in this study, may face challenges in classification of the capabilities. In addition, Helfat and Winter (2011, 1245–1249) have proposed that the adjustment of the resource pool and capabilities are not necessary radical, and depending on the capabilities of organisations, capabilities that have the characteristics of dynamic capabilities in one organisational setting may be standard operational capabilities in other organisations. To overcome such limitations, this study proposes that further research work should be conducted with ethnographic study to allow a longer observation period, as also recommended by Helfat and Winter (2011, 1245–1249).

This study adopted a definition of dynamic capabilities from Helfat et al. (2007, 4). The chosen definition has wide limits which allows the incorporation of the seminal works of both Eisenhardt and Martin (2000) and Teece (2007), as discussed in 2.3.1. In addition, the study adapted the capability perspective, by which capabilities are not disassembled to include themes such as personal self-interests, as discussed by Parmigiani and Howard-Grenville (2011, 413–417). The chosen definition combined with capability perspective allowed efficient classification of emerged themes into dynamic capabilities. However, there are multiple definitions of dynamic capabilities (see Ambrosini & Bowman 2009, 32–33). Thus, it is expected that if other definitions of dynamic capabilities are applied, not all of the capabilities that are classified in this study as dynamic capabilities will be classified as such.

This study presents multiple indications of the presence of dynamic capabilities present in various phases of the commercialisation process. The emergence of multiple indications of dynamic capabilities suggest that TTOs are excellent case organisations for the

empirical study of dynamic capabilities. Thus, it is proposed that future dynamic capability studies should be conducted with ethnographic data-collection methods on TTOs. In addition, as the results imply that the development of commercialisation processes are at different developmental stages in different organisations, future studies are also recommended to be conducted in the institutes where commercialisation is still emerging, earlier than the stage at which the case organisations were at the time of this study. By performing ethnographic studies in such organisations, the studies may also facilitate the evaluation of the presence of motors, following Van de Ven (1995).

6 SUMMARY

University research contributes to economic growth. In most of the universities the commercialisation of such research outputs is tasked to specific TTOs. These TTOs manage the commercialisation of university owned IP. Commercialisation strategies can be selling of the patented technology, licensing or by managing the establishment of spinout that will carry out the commercialisation of the invented technology.

The aim of the study was to analyse how TTOs facilitate the spinout formation from academic life science research. Technology transfer offices operate in the field where novel research results are constantly evaluated and commercialised. The assumption of the study was that the continuous development in the evaluation and management of commercialisation activities require constant adjustments in the existing resource pool, suggesting the presence of dynamic capabilities. To achieve the research aims, three different sub-questions were applied: one revealing the autonomy of the TTOs, one to reveal the stages of commercialisation process, and finally to analyse how and why the selected case organisations have developed the commercialisation practices aiming towards spinout formation.

Initial framework was constructed from existing literature. Three Finnish case organisations, all which are expected to have an efficient practises for commercialisation, were selected for study material. Data was collected by applying qualitative research design with open-ended semi-structured interview questions. Secondary data was collected from Internet pages and from newspaper articles. Collected data was analysed first within single cases following cross-case analysis to evaluate the emerged similarities and differences between the cases.

Results revealed that all three case organisation have high autonomy over their internal development tasks. In addition, the commercialisation process in general proceeds with similar chronological order between the cases. Interestingly, the results indicated the presence of multiple different dynamic capabilities in various phases of the development of commercialisation procedure.

There exists only a few empirical studies on dynamic capabilities and this here presented study is the first study where dynamic capabilities are evaluated in the context of Finnish TTOs. The emergence of multiple different indications of dynamic capabilities suggest that they are present in various forms of commercialisation process development. It is thus suggested that the TTOs are an excellent organisations also for future studies where dynamic capabilities are empirically analysed. In addition, the results of this study are also beneficial for managers in various academic institutes that aim to develop their commercialisation practices of academic life science inventions.

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8 APPENDIX

APPENDIX 1 Participant information sheet and consent form

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PARTICIPANT INFORMATION SHEET AND CONSENT FORM

This study is part of principal scientist's Master's thesis work. The purpose of the Master's thesis work is to study the commercialization processes performed by Technology Transfer Offices in Finnish Universities. You have been asked to participate in this study because you have extensive knowledge in this topic.
The thesis is not designed to serve the need of any specific organization or company, and is not financed by any party except principal researcher. The topic of the Master's thesis is formed solely from the principal scientist's own personal interest.
The collected research material will be used only for the Master's thesis work of the principal scientist. If the interview transcript is considered to be research material for any additional research project, new written consent is required from the participant.
The research material will handled with confidentiality and in good manner. Recorded audio tape will be transcribed to text, and copy of interview transcript is made available to participant. Participant may review and exclude parts from transcript.
Participant can contact principal researcher at any point of the research work for further information. At any point of the research, participant can forbid the use of their research material.

Thank you for taking part in this study!

	Yes	No
My interview material can be used for Master's thesis work of the principal scientist	☐	☐
My interview can be recorded	☐	☐
My name can be mentioned in the Master's thesis of the principal scientist	☐	☐
Principal scientist can contact me for further questions	☐	☐

This form is signed in two copies, one to be stored by principal scientist and one given to participant.

Place and date

_____ _____

Signature and name of the participant | Signature and name of the principal researcher

_____ _____

Contact information of the participant | Contact information of the principal researcher