THE EFFECT OF TECHNOLOGICAL NATURE ON THE DUTCH UNIVERSITY TECHNOLOGY TRANSFER PROCESS

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Executive Summary

The phenomenon of technology transfer in general and technology transfer from universities have been widely studied by scholars. However, it was not yet studied how the nature of the transferred technology could affect the technology transfer process from universities, through technology transfer offices, to society. The aim of this research paper was therefore, to identify the effect that technological nature could have on the technology transfer process from universities through TTO's to society. In order to investigate this issue a typology of technology had to be chosen. The typology that is used within this research is discrete technologies vs. complex technologies. This typology is chosen, since the typology discrete versus complex technologies is developed for patent analysis, to make a distinction between technologies. Patents also play a role in the transfer of technologies, since the patent(s) needs to be transferred for the use of the technology. By using this theoretical viewpoint it can be seen if technological nature has an effect on the technology transfer process.

In order to investigate this issue, several TTO's in the Netherlands were contacted for interviews. Four TTO's were interviewed. The TTO's were situated in Amsterdam, Leiden, Rotterdam and Utrecht. The results that came forth out of the interviews showed that there is little to no difference in the technology transfer between different natures of technology. There are some slight nuances, but the general outlay of the process remains the same. According to the results the nature of technology did not hold any significant effect on the process of technology transfer for the TTO's in the Netherlands. This could also be related to organizational characteristics, since the TTO's stated that most of the TTO's do not have that much personnel, most of the TTO's are not that old and that they do not have the resources to work with every technology that comes in. Therefore, these characteristics could help understand why the process is more or less streamlined and not focused on different technological natures. In order to see, if these characteristics do play a role in the organization off the process, more research will be needed.

What is maybe more interesting is the fact that the theoretical typology that is used within this research paper is not that suited to be translated to a practical setting. From a theoretical viewpoint this typology can be used because it only entails patents and how they are used in doing business with these kind of technologies. But when translating it to a practical example, like the transfer of technology through TTO's, it becomes clear that the typology falls short, since there is more to the transfer and the decisions that have to be made than the patents alone. The subsequent development of the technologies plays a big role in the negotiations for the transfer of the technology. A more suitable typology is therefore, product vs. platform technologies. This technology is more in line with the examples that were given by the interviewed TTO's and this typology also revolves more around the development of technologies.

Keywords: Technology, Technology Transfer, TTO's, Discrete, Complex, Dutch, University, Process

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INTRODUCTION

The subject of technology transfer has been studied for a long time. The seminal work of Mansfield (1975) was one of the first pieces to start research on technology transfer and its components. Most of the earlier literature focused on the international and inter-firm context of technology, because there were several reasons why universities did not focus on transferring and commercializing their research findings. This was mainly so because of the cultural differences, the focus of universities was on creating knowledge and universities were not focused on commercializing its technologies, in contrast to firms. Furthermore, the status of a researcher was mostly made through publications of its research findings and not by commercializing it to industries (Siegel et al., 2004). Another reason was the lack of resources of a university, universities do not have the necessary resources to protect every discovery. Furthermore, there are publishing blockades when an invention is disclosed and a patent is applied for (Genua and Nesta, 2006), and universities want to publish their findings. And mainly because of the source of the knowledge, research in universities is more fundamental in nature, whereas the research that is done within firms is more applied research (Brisson et al., 2010). However, since universities nowadays are more eager to commercialize their research findings to society, because it helps them fulfill their academic mission and also fulfills societal benefits, like the creation of wealth, jobs and new solutions for problems (Carlsson and Fridh, 2002), the role of universities in facilitating the process of technology transfer from universities to society has become of bigger importance in research.

The trend that universities are more eager to commercialize their findings is because of the more fast paced innovation cycles. On account of these shorter innovation cycles, there are no organizations left that have sufficient human capital in-house that can cover all the scientific disciplines that contribute to the product offerings of the organization. Therefore, the organizations tend to purchase or license discoveries, inventions and innovations from other institutions and players or co-develop these inventions with other parties, which makes this a economically viable path to look into for universities (Markman et al., 2008). There is a trend occurring that there are more public-private partnerships formed to cope with the above stated *problem*. This trends focuses on commercialization of findings and this has implications for universities. As Markman et al. (2008) state: "*The trend towards commercialization gives pressure to maximize the social return on public investment in research and effort to enhance universities' self sustenance*" (p.1402). Because of the fact that the transfer of technology fulfills different purposes, like the academic mission and a subsequent revenue stream, the technology transfer process from universities to society becomes more important.

PROBLEM DESCRIPTION

There has been substantial amounts of research done on technology transfer in the international context and most of this research focuses on the transfer of technology between firms or between countries. Furthermore, research is done on the process of technology transfer for universities in the United States (Carlsson and Fridh, 2002; Siegel et al., 2004; Jensen et al., 2003). These scholars focus their research on why universities are more eager to commercialize their findings and how they intend to fulfill the technology transfer process from universities to society. Those research papers show that there is an important role reserved for the Technology Transfer Offices (TTO's) in this technology transfer process. Furthermore, it shows how the process is organized and how the different parties (researchers, TTO's, society) asses the process. The main focus of those research papers is on the overall process of technology transfer from universities to society and they try to map the overall context of the process and how the process of technology transfer is organized. Furthermore, those research papers also focus on how university researchers can be persuaded in disclosing their invention more often and on how to keep them involved in the subsequent development of the invention after it has been disclosed (Jensen et al., 2003). However, the literature does not take different natures of technology into consideration.

My research can therefore contribute to science, because it focuses on the technology transfer process for Dutch universities and looks if the overall process and organization is different for different kinds of technology. In order to get a proper view of these differences, technologies will be divided into discrete and complex technologies. This typology is chosen, because the typology discrete vs. complex plays a major role in the patent analysis literature, which shows that patents are used in different manners for the two types of technology. According to the literature, patents are an important asset in the transfer of technologies, this typology can be used to describe the effect that technological nature could have on the technology transfer process (Baron and Delcamp, 2010). A discrete technology can be seen as a technology that can easily be protected by a patent and can be sold or licensed as a ready-made package that can easily be implemented (Baron and Delcamp, 2010). Furthermore, a complex technology is a technology that is build up from cumulative knowledge that is less easily protected by a single patent. These complex technologies are protected by several different patents that all represent a part of the technology. Therefore, there will be more know-how that needs to be transferred when transferring a complex technology, which makes it more difficult to use, when you do not have the necessary expertise or know-how to use the technology (Baron and Delcamp, 2010). Because of the different nature of these technologies it will be insightful to see if the overall process of university technology transfer will differ for the different natures of the technology, so that the overall process can be organized according to different technological natures.

Furthermore, research on the technology transfer process for universities in the Netherlands is not widely available. The societal relevance of this research paper lies in the fact that the Dutch government has the ambition to bring the Netherlands in the top 5 of knowledge economies in the world. In order to get in this top 5, it would be necessary to invest in universities and education in general. So that better research can be developed. The government is giving a contradicting signal by diminishing the funds that they are giving to educating institutions in comparison with their expressed ambition. By giving less funding to the educating institutions, less valuable research can be done, which in turn could hamper the international competitive position of the Netherlands (VSNU, 2011). Major international players situate themselves in locations where there is high-quality knowledge. This in turn leads to employment for the different layers in society. By not investing in new research and innovation the Netherlands will not be able to provide this high-quality knowledge in comparison with other countries all over the world. Which in turn makes the Netherlands a less attractive country to be situated in (VSNU, 2011). Therefore, it will be even harder for the Netherlands to get in the top 5 of international knowledge economies. By taking a more in-depth look at the process of technology transfer from universities to society, and if the research show that technological nature could have an effect on the technology transfer process, this research could have implications for the technology transfer through universities.

RESEARCH QUESTION

This research has its focus on the organization of the technology transfer process, which is facilitated through technology transfer offices, and how this process is affected by technological nature. This research will therefore, focus on the effect that different kinds (discrete vs. complex) technologies have on the technology transfer process from universities through technology transfer offices to society. The main research question will therefore be (RQ1):

"How is the technology transfer process from Dutch universities to society influenced by the nature of the transferred technology?"

This broad research question can be divided into different sub-questions:

Sub-RQ 1: *Which technological features of discrete and complex technologies shape the organization of the process?*

To see if different kinds of technology influence the technology transfer process, a typology for technologies must be identified. Furthermore, it will be important to see which features of the different technological natures are importance for the organization of the overall process.

Sub-RQ 2: *How is the general technology transfer process in Universities the Netherlands organized?*

In order to see if the technology transfer process differs for different kinds of technologies, it will be helpful to identify the overall structure of the process. To see how the process is organized in general.

Sub-RQ 3: *What are the differences in the technology transfer process between complex and discrete technologies?*

When the overall structure of the process of technology transfer is established and the features of the technologies that could shape the process are identified, differences between discrete and complex technologies can be examined. This is useful, because the differences can give leads, as to how the technology transfer is influenced by different natures of technology.

This research question and the subsequent sub-questions should be of significant importance for the organization of technology transfer from universities through TTO's to society.

2. THEORY

The theory section will provide the necessary theoretical background for this paper that is focused around the effect that different natures of technology could have on the technology transfer process from universities through TTO's to society. In order to establish this theoretical framework, the first part of the theory section will be reserved for what technology transfer is and what the difference is between discrete and complex technologies. The second part will be reserved for a literature overview on the research that is done on technology transfer from universities. And the last part will link the technology section to the literature review on universities to form assumptions that can be used to guide the research.

2.1 TECHNOLOGY TRANSFER

Teece (1977) stated that it was long thought that technology was nothing more than a set of blueprints or codified knowledge that could be used by anybody who wanted to use it. However, this is not the case, as can be seen from the various types of technology and the way technology is build up. Both Teece (1977) and Maskus (2004) talk of the fact that technology is build up of two parts. First, Maskus (2004) sees technology in two forms. There is the embodied part of the technology, whereas the technology can be seen as a particular product. The underlying process of the technology can then be discovered or gathered throughout imitation, reverse engineering or blueprints. And there is the disembodied part of the technology, which is the know-how of the technology, the way to efficiently use the technology to improve the processes and the productivity of a process. Teece (1977) made the same division and also talks about an embodied part and a disembodied part. The first form that Teece (1977) distinguishes is the physical form (embodied) of the technology. The physical form are represented by items such as tooling and blueprints. This can be seen as codified knowledge, which is knowledge that can be written down and transferred (Teece, 1977). The second form is the know-how that needs to be gathered/acquired if the physical equipment is to be used effectively. This know-how can be seen as tacit knowledge, this is knowledge that is difficult to write down in a way that is meaningful and readily understood. "*We know more than we can tell*" (Teece, 2005; p.21). Teece (1977) states that the knowledge: "*Relates to the methods of organization and operation, quality control and other manufacturing procedures. This is the crux in the transfer process*" (p.245).

In order to transfer the technology, three different phases can be identified that help see the process of the technology transfer (Mansfield, 1975). The first phase is the material transfer phase and it entails the transfer of materials or new products, to a particular location. After the transfer of materials is done, the second phase kicks in. This phase can be identified as the design transfer phase, in this phase the designs or blueprints are transferred. The design and the blueprints are necessary to facilitate the manufacturing process of the new material/product. The last phase is called the capacity transfer. This phase entails the transfer of the necessary know-how to use the technology (Andresso and Wei Qian, 1999). These three phases can also be grouped under the division that Teece (1977) and Maskus (2004) made for their forms of technology. The first two phases of the technology transfer encompass the transfer of the embodied part of the technology, which are the materials and the blueprints. And the third phase of technology transfer is the transfer of the disembodied part of the technology, which is the know-how of the technology, to use it efficiently. In most cases the third phase is the most important phase in the technology transfer process, because the technology has to be adapted to the new circumstances (Andresso & Wei Qian, 1999).

The typology of technology (discrete vs. complex) that is used in this research paper can also be linked to the way Teece (1977) and Maskus (2004) explain technology. However, to do this the notions of discrete technology and complex technology have to be discussed.

2.1.1 DISCRETE VS. COMPLEX TECHNOLOGY

The typology of discrete vs. complex technology is used in this research paper, since this typology plays a major role in the patent analysis literature, this literature strand shows that patents are used in different manners for the two types of technology, which can be seen in table 1. Since patents play a central role in the transfer of technologies, it can be expected that the different usage of patents for these technologies could have an effect on the technology transfer process. Therefore, this typology can be used to describe the effect that technological nature could have on the technology transfer process because (Baron and Delcamp, 2010; Reitzig, 2004). A discrete technology can be seen as a technology that can be protected by a single patent or a few patents and can be sold or licensed as a ready-made package. Or as Reitzig (2004) stated in his article, discrete technologies are situated in *tight* industries, which means that there is high appropriability. One patent or a few patents are enough to fully protect the technology. Which gives the owner of the patent exclusive right to make use of the technology. Technologies that are usually seen as discrete technologies are technologies from pharmaceuticals and chemistry sectors, because then a formula/antibody can be patented that can be transferred as a ready-made package (Baron and Delcamp, 2010), this research will also treat discrete technologies as inventions from pharmaceutical/life sciences technologies. Furthermore, a complex technology is a technology that is build up from cumulative knowledge that is less easily protected by a single patent, which means that the appropriability for complex technologies is lower than for discrete technologies (Reitzig, 2004). These complex technologies are protected by several different patents that all represent a part of the technology, that are actually needed to make the product. The main difference between discrete and complex technologies is therefore, the amount of patents that are needed for a single technology (Cohen et al., 2000). Because there are more patents involved by complex technologies, there will be more know-how that needs to be transferred when transferring a complex technology, which could make it more difficult to use when licensed or bought, when you do not have the necessary expertise or know-how to use the technology (Baron and Delcamp, 2010). Technologies that are usually classified as complex technologies are technologies from the ICT sector, electrical equipment and biotechnology sector.

Because there are differences in the amount of patents that are needed for complex and discrete technologies and there are also differences in how these patents are used. The differences in usage of these patents, could affect the technology transfer process since patents are not only used to protect the inventions. Table 1, gives a short overview of the differences between complex and discrete technologies.

Discrete Technologies	**Complex Technologies**
Few patents are needed for the use of the technology (Bessen, 2003)	More patents needed for one technology (Bessen, 2003)
Owner of the patents has exclusive rights on the invention (=patents are valuable) (Hall, 2004)	No exclusive rights, since several players have patents for a single technology (Bessen, 2003)
Patents are used to protect the invention (Blind et al., 2006)	Players build a patent portfolio, by applying for numerous patents for the technology (=value of patents decreases) (Hall, 2004)
Patents around the core invention are applied for, to block the development of substitutes by rivals (Cohen et al., 2001)	# of patents (=patent portfolio) represents the strength and defense for a firm, not the quality of the patents (Hall, 2004)
Exclusive licensing: For discrete technologies, Innovation more or less stands alone as isolated products (Levin, 1988). Which means that one player can produce a discrete technology. Therefore, when a discrete technology is licensed it will be exclusively licensed to a player in an industry. Otherwise the incentive to innovate and produce the discrete technology will not be as high.	Complex technologies have shorter innovation cycles and build up on other innovations. Therefore, firms may patent for strategic reasons. Patents and the patent portfolio are therefore, used as bargaining chips in negotiations, to set up cross-licensing between firms and to protect themselves against law-suits (=the more patents a firms has, the stronger the firms stands when sued) (Hall & Ziedonis, 2001; Hall, 2004; Cohen et al., 2001)
	Non-exclusive licensing: Complex technologies are based on cumulative knowledge, so innovation can be seen as *building blocks*. And spillovers of these building blocks can increase technical advance and R&D investment (Levin, 1988). Complex technologies are therefore

	licensed to more players in the industry, so that the technology can advance

TABLE 1: DISCRETE VS. COMPLEX

Next to the differences in the usage of patents for the different technologies, the technology typology can also be fed back to the notions of Teece (1977) and Maskus (2004). Discrete technologies can be more easily transferred, since there is less tacit knowledge involved with discrete technologies. The disclosed invention, in the form of a single/few patents holds the know-how for the technology. So the transfer of the embodied part (Maskus, 2004), or the transfer of the codified part (Teece, 1977) could be enough to successfully fulfill this transfer. This will not be the case with complex technologies. These technologies are, as stated above, protected by several different patents, which may cause a *patent-thicket* (Shapiro, 2001). These technologies have shorter innovation cycles and are build up from cumulative knowledge, so there is more tacit knowledge related to the discrete technologies (Baron and Delcamp, 2010). Therefore, it is safe to assume that the transfer of the embodied/codified part, the patent(s), will not be enough to make proper use of the complex technology. The know-how, or the tacit knowledge/disembodied part will also have to be transferred to ensure a proper use of the technology. Which could make the process of technology transfer more intensive.

Now that the link between the typology of technology and the technology transfer has been explained, there is need to delve a bit deeper in the research that is already done on the technology transfer from universities, to see how technology transfer process is globally organized. So that it can be seen where the process could be affected by the nature of technologies.

2.2 Technology Transfer by Universities

Before this research looks at the overall process of technology transfer from universities through TTO’s to society, the overall context will be sketched as to why universities involve themselves with the transfer of technology. There has not been that much research done on universities in the Netherlands, so the literature review will be based on research that is done in the US.

2.2.1 University Technology Transfer

Because of more fast paced innovation cycles, there are no organizations left that have sufficient human capital in-house that can cover all the scientific disciplines that contribute to the product offerings of the organization. Therefore, the organizations tend to purchase or license discoveries, inventions and innovations from other institutions and players or co-develop these inventions with other parties (Markman et al., 2008). There is a trend occurring that there are more public-private partnerships formed to cope with the above stated *problem*. This trends focuses on the commercialization of findings from research and this has implications for universities. As Markman et al. (2008) state: “*The trend towards commercialization gives pressure to maximize the social return on public investment in research and effort to enhance universities’ self sustenance*” (p.1402). Because of this self sustenance, universities are more eager to commercialize their research findings and therefore, the technology transfer process from universities to society becomes more important.

Before the process of technology transfer can be described a definition of technology transfer is useful. The transfer of technology form universities to society can be defined by the following general definition: “*the transfer of results of research from universities to the commercial sector*” (Bremer, 1999 in Carlsson, 2002). A more narrow definition is the following: “*the process whereby inventions or intellectual property from academic research is licensed or conveyed through the use of rights to industry*” (AUTM, 1998 in Carlsson, 2002).

These definitions of technology transfer from universities to society imply that there are two sides that play together in the technology transfer process. The quality and quantity of these transfer is determined by several factors, so not only by the interface between the sides, but also by what the two sides bring to the table. Carlsson and Fridh (2002) state that knowledge, preparedness, organization, culture and attitudes of the both sides are also important for successful transfers.

The technology of transfer from universities has obvious benefits for the universities, like income. But the transfer also contributes to the mission of the academic institutions of education, research and the public service that they want to provide, which makes the universities more eager to involve themselves in the transfer of technology to society (Carlsson & Fridh, 2002). Several points that contribute to this mission are stated below:

- A mechanism for important research results to be transferred to the public;
- Service to faculty and investors in dealing with industry arrangements and technology transfer issues;
- A method to facilitate and encourage additional industrial research support;
- A source of unrestricted funds for additional research;
- A source of expertise in licensing and industrial contract negotiations;
- A method by which the institution can comply with the requirements of laws such as the Bayh-Dole Act (AUTM Licensing Survey FY 1991 – FY 1995, p.6)
- A marketing tool to attract students, faculty and external research funding (Carlsson & Fridh, 2002; p.201).

Next to the contributions it can have to the mission of the academic institutions, the transfer of technology from universities to society also has several benefits for the society, several of the benefits are the creation of wealth, new jobs and that it provides new solutions to existing problems in society (Carlsson & Fridh, 2002)

Since the the transfer of technology is important for several actors in the community, several scholars have done research on the technology transfer process from universities to society in the USA, to see how the process is organized. Several scholars that have looked into the process of technology transfer are Jensen (2001; 2003), Siegel et al., (2004) and Carlsson and Fridh (2002).

2.2.2 Technology Transfer Process

Most of the research that is done on the process of technology transfer in universities, is done: (i) on the amount of inventions that are disclosed by researchers within an university; (ii) how the researchers can be pursuaded in further developing the invention and (iii) how this number could be raised for more succesfull technology transfers (Macho-Stadler et al., 2007). These problems, that are mostly issued on ineffeciency, have been studied by Jensen et al. (2003), Jensen and Thursby (2001), Macho-Stadler et al. (1996) and Lach and Schankerman (2003) and these studies showed that the amount of disclosure and the involvement of the researcher can be raised when there are appropriate incentive schemes in place, where the researcher gets a substantial amount of the revenue shares, which also results in higher license incomes for the university (Macho-Stadler et al., 2007). "*The incentive effects seems to work both by encouraging higher levels of effort and by attracting more productive researchers*" (Macho-Stadler et al., 2007; p. 485).

Other studies that researched university technology transfer were focussing on regional or international comparisons between universities and their respective ways of technology transfer. These studies for example foccused on the difference between commercialization practices between universities (Di Gregoria & Shane, 2003), or like Owen-Smith et al. (2002) compared the practices that were used for university-industry relations for universities in Europe and the USA.

Other scholars focussed on the outputs of university research, like patents, licencenses and spin-offs. These studies were mostly done from a perspective of efficiency or on how these outputs contributed to society for certain research fields. Trune and Goslin (1998) focussed on the TTO's to see if these are profitable and beneficial to the economy. Furthermore, scholars focussed on patenting within universities and how this could affect the competition between universities and hamper open science and knowledge transfer (Geuna & Nesta, 2006; Sampat, 2006).

Furthermore, there are also scholars that looked at university research and technology transfer from a perspective of what impact university research could have on industrial innovation. These reports showed that research from universities had a significant impact on a large share of industrial R&D for a broad range of industries (Cohen et al., 2002). Other scholars like, Bennet et al. (1998) focussed on the collaboration and knowledge transfer between universities and industries in the poorer regions of the USA, to measure the impact of university research.

And at last, there have been several studies on technology transfer within universities that use the perspective of the organization of the technology transfer process to describe the inefficiencies in the process of technology transfer from universities to society. The scholars that looked at ineffecency issues were stated before. Since this research will focus on the effect that technological nature could have on the organization of the technology transfer process, the scholars that looked at the organizational side of the process will be looked upon, to see where technological nature could affect the organization and the overal process. A short review of what has been done on the organizational side of the the technology transfer will therefore be presented hereafter.

2.2.3 Organization of the Process

To organize the transfer of technology from universities to society, technology transfer offices (TTO's) were created by the universities. These TTO's are mediators that facilitate the transfer of technology from the universities to society. Siegel et al. (2004) mapped the process of technology transfer in universities and came up with a schematic flow-chart of the process. This process can be seen in figure 1.

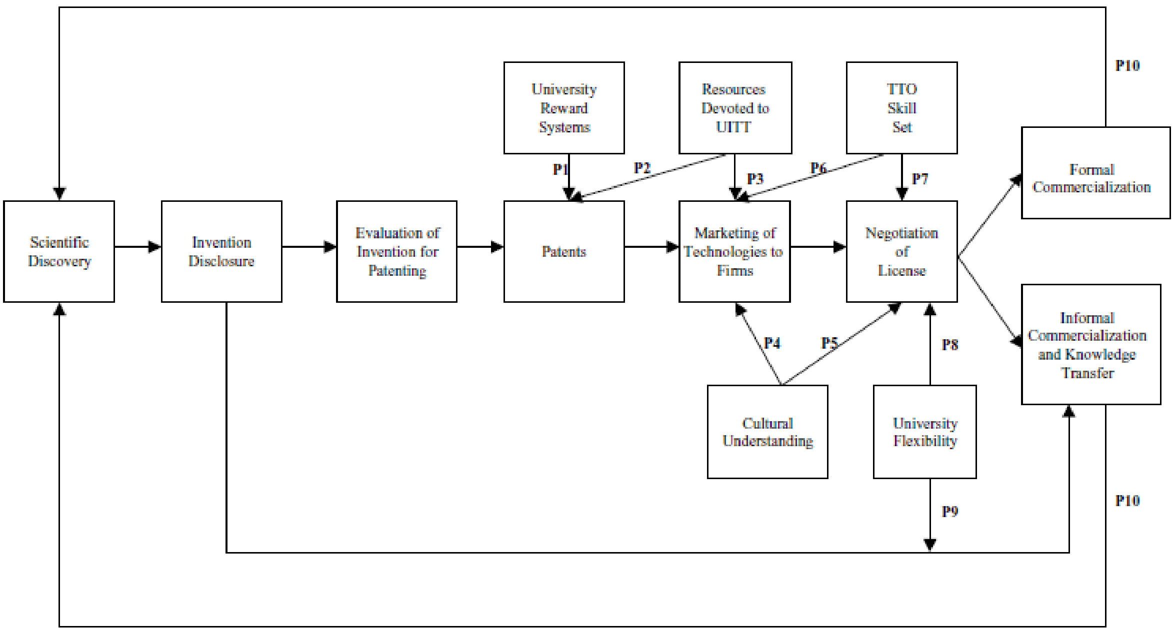

FIG. 1: PROCESS OF TECHNOLOGY TRANSFER (SIEGEL ET AL., 2004)

Siegel et al. (2004) state that the researchers at the university are present in every step of the process and that the TTO's are present from block 2 (Invention Disclosure). This makes the role of the TTO's very important for dissemination of technology from the university to society. The process starts 1) with a scientific discovery. After this, the researcher has three options: (i) the researcher could stop working on the invention; (ii) or he/she could further develop the invention to a lab-scale prototype and disclose the invention later on (Jensen et al., 2003); (iii) or he/she could disclose his discovery to the TTO immediately, so that the discovery can be evaluated and that the decision can be made to file for a patent or not (Siegel et al., 2004).

Most of the research that is done on the organization of the technology transfer process is done in the context of universities and their TTO's in the US. However, a small internet search for the technology transfer process in universities in the Netherlands, shows that overall structure of the organization is comparable with their US equivalent. Researchers from Dutch Universities can go to the TTO to evaluate their invention, so that the decision can be made to file a patent for the invention or not. The following figure represents the next step in the technology transfer process, which is the valorization process. Another example of the similarities can be seen in the figure that can be found for the TTO in Utrecht, Utrecht Holdings, which can be found in the appendix.

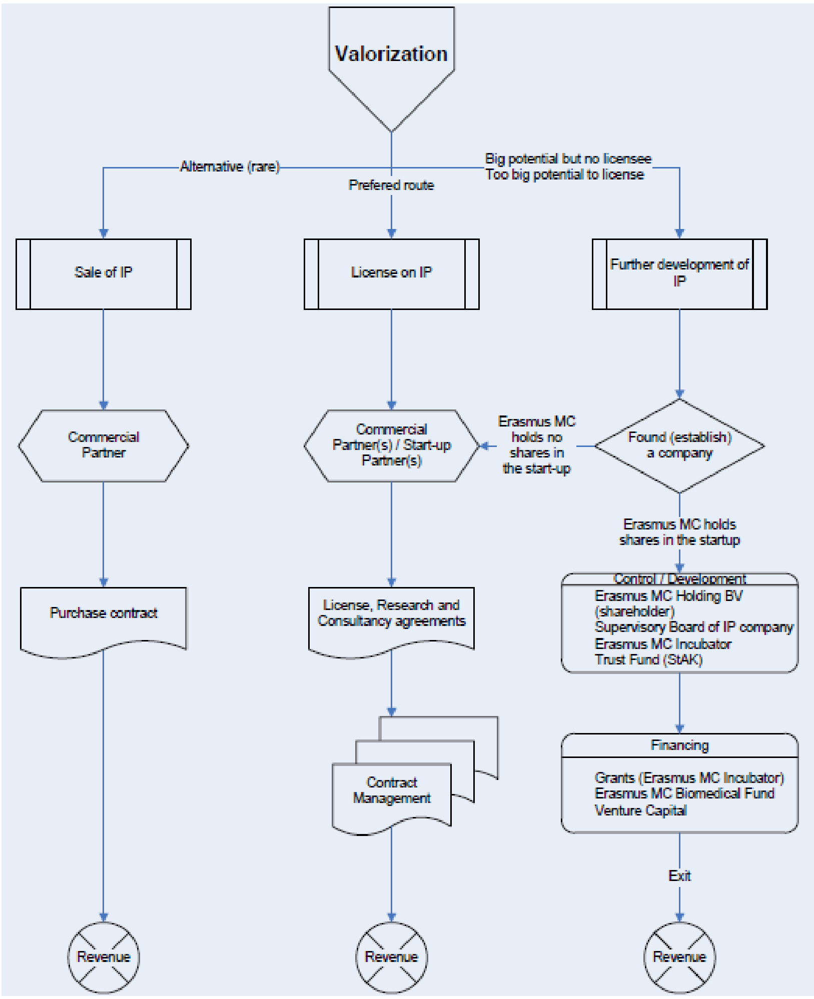

FIG. 2: VALORIZATION PHASE OF TECHNOLOGY TRANSFER PROCESS (EMC)

The overall process is not that straightforward as the different flowcharts show. There are several dilemma's in the overall technology transfer process. The first dilemma occurs, when a university has to decide whether or not the invention should be patented. This decision is often a dilemma, because a university has limited resources for patenting. The decision is made easier if there is already interest from a party from an industry partner. Because this will be a measure that the discovery will be economically feasible. This is the reason that most universities/TTO's search for a license partner before applying for a patent (Siegel et al., 2003). When a patent is filed the invention can be licensed to an industry partner, where the university can get royalties for the patented invention or agrees to do "follow-on" sponsored research. This is often the case, because the licensed inventions are often in an *embryonic* state, which means that they are in the first stages of development, which is also called a *proof of concept* when it comes to pharmaceutical inventions or a prototype for other technologies (Jensen & Thursby, 2001). The royalties and the sponsored research are offered, because there is no real estimation for the commercial potential of the proof of concept. By not giving the full reward at the moment the invention is licensed there will be more incentive for the university scientists to help further develop the invention, because their payment will be based on the further development of the invention and the eventual success of the invention (Jensen & Thursby, 2001). When the researcher ops for the second option, as explained in the process description, the invention will be further developed, which involves a time and effort cost. Furthermore, the additional development will also help the TTO to find a industry partner to sell a license to (Jensen et al. 2003). Next to the licensing of the patent, another outcome of the process could also be the start-up of company, where the university gets a equity share in.

2.3 Concepts

Now that the overall context of technology and the overall context of the technology transfer process from universities through TTO's to society has been sketched. The flow-chart of Siegel et al. (2004) will be examined to find concepts that could be influenced by the nature of the transferred technology. After the explanation of these variables and how they may change according to nature of the technologies, several assumptions on the effect that the different technologies can have on the process are given.

2.3.1 Business models

Waugaman and Gray (1999) identified five different business models that can be used by universities when transferring technology to society. The five business models are the following:

1. Industry-sponsored contract research
2. the Consortial approach
3. Consulting arrangements
4. Licensing of University-developed Technology
5. Joint Development and commercialization of Technology

Next to the five business models that are mentioned above, there is always the opportunity for a university and their TTO to create a start-up around the invention of the researcher:

6. Start-Up Creation

Most of these different models can be linked to typology of technology that is used in this research paper, discrete vs. complex technologies. Consulting arrangement (3) can be neglected, because there is not really any technology transferred. The university is contacted by industry partner for collaboration and to give advice (Waugaman and Gray, 1999). The university is not developing any technology for the industry partner. For this reason, this business model is not included in the research paper.

The remaining five business models can be used in this research paper to explain the effect of technological nature on the technology transfer process. This research paper will mainly focus on the creation of start-ups and the licensing of university-developed technology, since the websites of the Dutch universities also state this as the possible outcomes of their technology transfer process. The other business models will be mentioned hereafter, because it is important to know that there are indeed other business models, besides the licensing and start-up creation, but the assumptions will be based on start-up creation and licensing in contrast to the typology of technology.

Business model 5 is more likely to go with complex technologies, because the industry will joint develop the technology in order to ensure that the technology will be viable when it is transferred to the company and that the necessary know-how is also in-house to exploit the technology. This joint development can also happen after the licensing of the university-developed technology to an existing industry partner. Licensing of university-developed technology (4) is more for discrete technologies, because then the patent is only licensed and transferred to the industry and their tend to be less tacit knowledge transferred, this can be done for discrete technologies, because they exist of ready-made packages. In the case of discrete technologies, the involvement of the university and the research could stop at the point of licensing.

Industry-sponsored research and the consortial approach can be used for both kinds of technologies, in the case of industry-sponsored research, the industry will merely supply the necessary funds to develop the technology, this could be either a discrete or a complex technology. Furthermore, in the case of the consortial approach, industry partners will set-up a research consortia within an university to develop new technologies for the industry partner (Waugaman and Gray, 1999).

Next to this, universities can also opt for start-up creation. As Reitzig (2004) stated in his article, discrete technologies are situated in *tight* industries, which means that there is high appropriability. One patent is enough to fully protect the technology. Which gives them the chance to start a business around the invention, since it very well protected and gives the university the sole right to use the invention. This is not the case with complex technologies, since competitive advantage mostly comes from the tacit knowledge of the invention. And since several parties in society hold patents to produce parts of the technology it is difficult to start a company since appropriability is low. Therefore, start-up creation could be higher for inventions of discrete technologies in comparison to complex technologies.

Assumption 1: Start-up creation is higher for discrete technologies in comparison to complex technologies

Universities can make choices between these different business models, on the basis of how they want to finance their research. Most of the business models can be used for both types of technology. But as described, (5) could be used for complex technologies, because then know-how could be more easily transferred from the initial researcher to the partner in the industry and (4) could be used, next to start-up creation for discrete technologies, because only one patent have to be licensed to make use of the technology.

Assumption 2: Complex technologies will be co-developed with an industry partner after licensing in contrast to discrete technologies

Assumption 3:Licensing of a technology to an existent firm is considered to be more appropriate when the transferred technology is an discrete technology

2.3.2 Involvement of the researcher

According to Siegel et al. (2004), the researcher that does the invention at the university is involved in every subsequent step in the technology transfer process. From invention disclosure to the marketing of the invention. However, when the typology of technology (discrete vs. complex) is linked to the flow-chart of the technology transfer process, it can be expected that there could be differences in the involvement of the researcher in the technology transfer process. For the discrete technologies the involvement of the researcher can stop when the patent is applied for and is granted. Because the patent ensures protection of the invention, since appropriability is high for discrete technologies, and can then be marketed and licensed/sold as a ready-made package for possible customers. For complex technologies there is more tacit knowledge involved, which makes the technology harder to understand and use for possible industry partners, without the expertise of the researcher, which could imply that the involvement of the researcher is far greater when it comes to complex technologies.

Assumption 4: When a discrete technology is transferred, the involvement of the researcher is often limited

Assumption 5: When a complex technology is transferred, the researcher will be assisting the firm throughout the whole transfer process, to ensure the transfer of the necessary know-how.

2.3.3 Time of Disclosure

As can be seen in the theory section, the researcher will have several options when he/she does an invention (Jensen et al., 2003). He could disclose the invention when the researcher does the invention and when it is still early in development or he/she could wait and first further develop the invention, to make the chance of successful technology transfer greater, so that the potential commercial value of the invention can be more properly assessed. Discrete technologies could be disclosed at the moment they are found, because the principles of the technology could be more easily assessed, because of the technological nature. Complex technologies, on the other hand, could benefit from more development time, so that it is clearer what the invention is, and what the possible commercial value of the invention could be so that a potential industry partner could more easily be found.

Assumption 6: Complex technologies benefit from more development time in contrast to discrete technologies, to make their commercial value more clear, so they will be disclosed later on

More development time is not related to overall development time, since complex technologies tend to have shorter innovation cycles then discrete technologies, so the actual development time for discrete technologies tend to be longer. But it is related to the time that is necessary to further develop the invention, to show the commercial value, after the invention has been done and the invention could be disclosed.

2.3.4 Summary

The concepts that were stated above are the concepts that gave leads to base assumptions on by the gathered theoretical strands. The flowchart of Siegel et al. (2004) had some other interesting concepts, like the kind of contracts closed and how the payments are arranged, but the theory did not give clear leads on how the typology of technology could affect these concepts. Which is the reason, that there are not assumptions based on these concepts. However, these concepts will not be forgotten and can come up while conducting the interviews. Next to this, the assumptions that were based on the concepts and the different theoretical strands will be assessed by interviewing several TTO's from Dutch Universities, to see if these assumptions are correct and if the nature of technologies has effect on the process of technology transfer from universities through TTO's to society.

3. METHODOLOGY

The aim of this research paper is to investigate if technological nature has effect on the process of technology transfer from universities through TTO's to society. In order to see if technological nature has effect on the process of technology transfer, a qualitative assessment of the literature and the assumptions that were based on the literature is necessary. In order to assess the assumptions, a technology typology is chosen so that different technological natures can be compared to each other for the technology transfer process. This technology typology will be used to assess the differences in the technology transfer process for four different TTO's in the Netherlands. The reason for approaching four different TTO's in the Netherlands, is that the results will not be dependent on only one TTO and their respective process. By incorporating four TTO's in the research, the results from these TTO's can be compared to each other, which will improve the reliability of the research (Yin, 1994). The typology that is chosen for this research is discrete technologies vs. complex technologies, the reason for this typology will be presented shortly hereafter. This research stays rather on the surface of the technologies that are chosen, since the technologies that are chosen for this research are not in-depth investigated. This research will purely look if the typology could affect the technology transfer process in which they are used by universities in the Netherlands.

3.1 TECHNOLOGY TYPOLOGY

In order to see if technological nature could have effect on the technology transfer within universities a clear typology for technological nature had to be chosen, as was mentioned before. The technology typology, discrete vs. complex, that is chosen for this research is therefore, done a theoretical basis, which means that, opposed to quantitative studies that use random sampling, the typology for this research, was chosen consciously to identify if there are differences in the technology transfer process for these Technology Transfer Offices. This typology is chosen because it is frequently used in patent analysis literature to compare differences in how patents are used for these types of technologies (Baron and Delcamp, 2010; Reitzig, 2004). Furthermore, by assessing the literature, patents play a significant role in the technology transfer process. The literature on patent analysis shows that patents are differently used in society for the different types, discrete vs. complex, of technology (Bessen, 2003; Hall, 2004; Levin, 1988). It could therefore, be expected that there are differences in how these technologies are transferred. This typology is therefore, suitable to assess the influence that these two technological natures could have on the technology transfer process. The main difference between complex and discrete technologies is the amount of patents that are needed for a single technology. In other words, whether a new, commercializable product or process is comprised of numerous separately patentable elements (=complex) versus relatively few (=discrete) (Hall, 2004). By using two types of technologies that are on either side of the spectrum, in terms of the amount of patents, a clear distinction can be made and it could become more clear on how and why the nature of technologies could influence the overall technology transfer process. Discrete technologies can be seen as technologies from pharmaceutical or drug industries, like antibodies for example and complex technologies can be seen as technologies biotechnology. Technologies from these fields of research are chosen because they both stem for the Life Sciences sector. By choosing examples that can be placed in one sector, the variable for different sectors is handled and stays the same in the process, in terms of how fast technologies can be brought to the market and what kind of test are needed before the technology could be placed within the market. In the course of this research, the different TTO's will also be approached with this distinction for discrete and complex technologies kept in mind.

3.2 THE UNIVERSITY TECHNOLOGY TRANSFER OFFICES

The universities that were approached for this research were also picked on a theoretical basis. Since the outcome of the technology process, according to the flowcharts of Siegel et al. (2003) and the Dutch universities, is the licensing of a patent to an existing company or the formation of a start-up company, universities were approached to see if they handle both kinds of outcomes of the process. By checking how the process was schematically organized within the TTO's of the different universities, universities could be compared at a general level. TTO's that showed similar characteristics were taken as subjects for the research, so that the differences in the process could be more easily described by the different natures of technology than by then by the differences in how TTO's perceive technology transfer. The vision of the different TTO's can be found in the background chapter. In order to get a good overview of the general process of technology transfer, several TTO's had to be approached. In order to make the results of this research more reliable, four different TTO's were approached. By approaching four TTO's the outcomes can be compared to each other, to come up with more general conclusions for the research.

As mentioned before, to select the universities that are subjects to study for this research, a internet search was necessary. By examining the websites of the different universities in the Netherlands, the TTO's can be looked upon. At first glance the process of technology transfer for these TTO's seems to be the same for all the TTO's. A researcher does an invention and contacts the TTO, so that the invention can be evaluated. After this evaluation the TTO can help the researcher protect its invention, but first the invention has to be disclosed to the TTO. After the evaluation and when the invention is protected, the TTO will help the researcher with transferring its research to feasible partners.

In order to find Technology Transfer Offices that could be contacted for this research a closer examination of the websites was necessary. According to several TTO's that were contacted, the TTO's do not usually opt for Start-Up Creation at first. As Tan (2012) of the TTO of the VU & VUmc in Amsterdam stated:

"Licensing of technologies is far less risky, and therefore more promising......Start-up creation is far more labour-intensive, because you have to set-up a BV, attract managers and arrange the finances..... So, at first you try to license the technology. A start-up can be created when the technology has a lot of potential, so that you are willing to take the risks."

Fallaux (2012) of Utrecht Holdings also said the same, the decision for start-up creation or licensing will be based on the potential of the technology. When a technology has high potential (= more than n=1 IP opportunities), the TTO will opt for start-up creation. The decision for the different business models is therefore dependent on the potential of the technologies that will be presented to the TTO's.

The first two TTO's that were approached for this research were therefore the TTO of the VU & VUmc in Amsterdam and the TTO in Utrecht, called Utrecht Holdings. Both TTO's gave the same reasons for decision making on different business models. The other two TTO's that were approached for this researcher, LURIS in Leiden and the TTO of the Erasmus MC in Rotterdam, were chosen with the information that was provided by Utrecht Holdings and the VU in Amsterdam in mind, to make sure that differences in the process are not determined by big differences in how universities work. Descriptions of what the TTO's aim to do can be found in the next chapter, with information that could be found on their respective websites.

3.3 Data Acquisition

The chosen methods to acquire the necessary data for the research are an extensive document analysis and conducting semi-structured interviews. The document analysis was chosen as a method to gain the necessary background information on the process of technology transfer, which is used to form assumptions on the effect that technological nature could have. Interviews were chosen as a primary research method to acquire the data on how technological nature could affect the technology transfer process from universities through TTO's to society. Semi-structured interviews were chosen as a data collection method, because they permit flexibility in location and allow the opportunity to explain the questions and clarify answers. Semi-structured interviews with managers of TTO's of Dutch Universities will be conducted. The aim for the researcher was to approach the managers of these TTO's, because they should have the most in-depth information on the overall process. However, this was not always possible, as can be read in the discussion. The advantage of conducting semi-structured interviews is that it provides opportunities to gather unforeseen information. This could be important for this research because the variables that were indentified in the theory that could be influenced by the nature of technologies, could not be the only ones that are affected by the nature of the technology. By conducting these semi-structured interviews there is a structure on how these interviews should develop, but there is room to gather new information. When using surveys or structured interviews this is not possible, because then it is assumed that the variables in this research are the only relevant variables in this research. A more open interview method offers the chance to widen the research where necessary (Baarda et al., 2010).

3.4 Method of Analysis

Yin (1944) introduces six techniques to analyze the gathered data, which are i) Pattern matching; ii) Linking data to proposition; iii) explanation building; iv) time series analysis; v) logic models and vi) cross-case synthesis. The method of analysis that is used for this research paper is linking data to proposition. By comparing the data of the interviews to the propositions/assumptions that were made in this research, it could be seen were the nature of technology has effect on the overall process of technology transfer, since the propositions/assumptions are based on several steps that occur in the overall process. Linking data to propositions/assumptions is therefore a useful method of analysis for this research, since several pieces of information that are gathered throughout the research could be related to theoretical assumptions and the different sub-questions. By using the technique of linking data to propositions/assumptions these relations could be shown. Since the research has its focus on how technological nature could affect the technology transfer process, the technique of linking data to propositions/assumptions can be used to discover causal relations between the typology of technology and the concepts that are found in the literature.

The data, that was gathered throughout conducting the interviews at the TTO's, was sufficient for answering the different research questions. Therefore, the interesting pieces of information from the interviews were extracted from the transcripts. When analyzing the interviews, the different extracted pieces of data were grouped according to the concepts that were found in literature, like licensing or creation of spin-offs. By linking the pieces of data to these concepts for the propositions/assumptions, it could be seen as to how TTO's thought about these concepts and whether the propositions/assumptions were confirmed or falsified. By linking the data to the concepts and propositions/assumptions, conclusions could be made on these concepts and the data of the TTO's could be compared to each other, to see if different TTO's had different ideas on the organization of the technology transfer process.

Next to the concepts on which the assumptions are based, the flow-chart of Siegel et al. (2004) has some other interesting concepts for the process of technology transfer, like the kind of contracts that are closed and how the payment for the transfer technology is arranged. However, the desk research did not give clear leads for assumptions that describe relations between these concepts and the typology of technology. But the interviews might shed some new light on these concepts and if they are affected by the typology of technology that is presented in this research. These concepts are also taken into consideration when conducting the interviews. Linking data to propositions will also be a useful approach for finding information that could match with these concepts, so that it can be shown if these concepts could be affected by the typology of technology.

4. Background Information

For this research four TTO's were contacted to see if they had time for an interview on the overall process of technology transfer and if this process was affected by different technological natures, namely discrete vs. complex technologies. The information that is presented in the first part of this chapter comes mostly from the websites of the TTO's. The information revolves more around what the different TTO's aim to do. The descriptions are presented hereafter:

- **VU&VUmc Amsterdam:** The TTO at the VU & VUmc is founded in 2006 and is therefore, relatively young. Despite its young age, the TTO has already brought several opportunities to the market. Each year several spin-outs are founded, between 10 and 20 patents are filed and there are multiple collaboration deals with the industry and other users (TTO VU&VUmc, 2012).

  The TTO is there to manage the intellectual property (IP) portfolio for the VU and the VUmc. Futhermore, the TTO sets up spin-off companies and performs the negotiations for the university-industry collaborations that could be set-up. In order to make sure that this goes the way as it should, the personnel that is working at the TTO is a mixture of business developers and legal and patent experts.

  Global competition becomes much more important, so the TTO has to make sure that the industry knows ways to find the TTO and the VU and VUmc as a rich source of innovation. To make sure that these partnerships work, the TTO has to provide the best supportive structure to manage these partnerships. Furthermore, the TTO has to convince the public and private partners that the collective scientific innovation of the VU and VUmc, indeed finds its way to patients and society.

- **Leiden – LURIS:** The role of the TTO LURIS in Leiden can be summarized by the following quote: "*LURIS's technology transfer role aims to promote the transfer of University of Leiden technology for the use and benefit of society while generating income to support the University's main mission of research and education"* (LURIS - Leiden, 2012).

  Among the tasks of LURIS, is the task to manage the intellectual property of the University of Leiden and to help them turn these scientific inventions into tangible products. In order to do this, enthusiasm from the research community is necessary, but there must also be a willingness to invest by industry partners. The process involves that inventions from employees are disclosed to the TTO. These disclosures are evaluated for the commercial possibilities and when possible these inventions are licensed to industry partners. The financial gains that these license agreements develop are shared with the inventors and the appropriate department.

  In cases were IP plays a role, LURIS' advice and support will be required. For this, LURIS is active and has knowhow on: i) knowledge exploitation; ii) knowledge protection; and iii) public-private research collaboration. In this cases LURIS has a role as advisor. Beside this role LURIS is also mandated to a certain level in negotiations and agreements with 3rd parties where IP is involved (LURIS - Leiden, 2012).

- **Erasmus MC Rotterdam**: The role or vision of the TTO of the Erasmus MC in Rotterdam can be summarized by the following quote: "*It is our mission to create value by facilitating the transfer of our research results and technologies into useful products and services for society's benefit in general and in health care in particular, while generating unrestricted income to support research education and patient care*" (Erasmus MC Year report 2011, 2012).

  The TTO takes the mission seriously and works hard to accomplish it. But it is not always easy to identify the right opportunity. This ability comes with experience, judgment, improvisation and sometimes a bit of luck. In order to find the right opportunities, the TTO sorts through the science that researchers of the Erasmus MC produce. This is done on a daily basis. This is all done in order to accomplish the vision that is set out for the TTO (Erasmus MC Year report 2011, 2012).

- **Utrecht Holdings – Utrecht:** The TTO Utrecht Holdings was founded in 1998 and since then many companies were founded and patents licensed to industry partners. Utrecht Holdings manages and exploits all the patents of the Utrecht University and the UMC Utrecht. The TTO Utrecht Holdings is there to make optimal use of the medical and scientific knowledge that is developed in the University and in the UMC. Furthermore, they endorse the importance of strengthening, broadening and intensifying co-operation with their partners, whether it be organizations or governments. The vision of the TTO is that the added value, which is the generated knowledge from the university and the UMC and which is shared and transferred with other organizations, becomes more tangible and visible (Utrecht Holdings, 2012).

The information that is presented here is more general information. The TTO's that were interviewed for this research mentioned that as of this year there is Dutch technology transfer association, which is called the "*Technology Transfer Professionals (TTP)"* (Rotterdam, 2012). However, since a report for this association could not be found, the general information on the different TTO's that is presented above is the background information that could be presented.

After the short descriptions of the aim of the TTO's that were contacted, other background information will be given. This additional information came forth out of the interviews that were held at the TTO's. Most of the information is information that shows why the TTO's make certain decisions in their process.

4.1 Mission

The TTO's have as a mission or as a goal that they want to disperse knowledge and technology to society, inventions are a by-product of doing science, and they want this by-product to be properly used, so that society can benefit from these inventions. Therefore, they want to develop and disperse the technologies to as many possible players in the world, so that it can be used for as many applications as possible. For this reason the TTO's opt for non-exclusive licensing agreements when they negotiate the transfer of technology. Therefore, for both discrete and complex technologies the TTO's will opt for non-exclusive licensing agreements (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012) .

However, this will not always be possible since certain technologies will needs substantial amounts of resources to be developed further, the company that will sign a license agreement for this technology would also want the guarantee that he will be sole user of this technology, because the company will not be pushing resources in the development of the technology when his competitors are also able to develop the same promising technology (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012). This will most likely be the case for bigger complex technologies or fundamental/core-IP technologies. When conducting the interviews, some TTO's use the term complex technology to describe technologies that will need investments for further development and are therefore, mostly licensed on an exclusive basis, where other TTO's use the terms fundamental technology/core-IP to describe such technologies in their examples. Therefore, the examples for complex technologies will be grouped and presented in the analysis as bigger complex/fundamental/core-IP technologies. This could also show that the theoretical typology that was initially chosen for this research, cannot be that easily translated to a practical situation. This issue will be elaborated upon in the discussion.

4.2 Structure

TTO's in the Netherlands are still young, in comparison to other countries, which means that the capacity in terms of employees is also a bit scarce. Which was stated by multiple TTO's that were interviewed. Their structure is therefore not that different from each other. They have a director. Furthermore, they have business developers that really drive the process of technology transfer, in terms of screening, scouting and business cases etc. Then they have lawyers, who handle the license and the legal documents and they have employees who handle the finance of the TTO.

4.3 3RD PARTY IP

The TTO's that I contacted are not busy with acquiring 3rd party IP, to develop the bigger complex technologies, like semiconductors or radio equipment within a university. Acquiring 3rd party IP is too cost intensive and universities do not have the financial assets, capacity and expertise to take these risks, because more than not these projects do not even make it. Since universities are working with public funding they cannot take these risks, to lose substantial amounts of money on such projects. Companies can more easily take these risks, since they work with venture capital or loans (Amsterdam, 2012; Utrecht; 2012). So if relevant 3rd party IP exists, it will be the responsibility of the licensee to acquire it. Simply said, the TTO's do not have the funds to acquire 3rd party IP. There are some instances in which a TTO can acquire 3rd party IP, but that is then a natural consequence of researchers relocating to the university of the TTO from elsewhere (Leiden, 2012).

5. ANALYSIS

The analysis section is based on the interviews that were held at the technology transfer offices in Utrecht (Utrecht Holdings), Rotterdam (Erasmus MC), Amsterdam (VU&VUmc) and Leiden (LURIS). The analysis is structured around the sub-questions, that are stated in the introduction section of this research paper, and the assumptions that were formed throughout a literature search, which can be found in the theory section of the research paper. These assumptions will be shortly addressed at the concepts they were based on.

5.1 THE GENERAL PROCESS OF TECHNOLOGY TRANSFER FROM RESEARCHER TO LICENSING/SPIN-OFF

The general process of technology transfer from the invention of the scientist/researcher to finding a partner in society and licensing it to that partner seems straightforward, in terms that there are some sequential steps that are taken in the process, but as was shown in the theory section there are multiple decision moments and dilemmas throughout the process. The process of technology transfer starts with one of these two scenarios: i) The TTO discovers that there is some interesting research done by the researchers within the university; ii) Or the researchers reports their findings to the TTO (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). Furthermore, the researchers are required, throughout their CAO, to report a possible invention to the TTO (Utrecht, 2012).

The next step in the process is that the researchers are subjected to a structured interview, through an Invention Disclosure Form (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). Within this form there are several questions that all relate to the possible invention that have to be answered, but also on possible funding that they have worked with and on agreements that they could have made with third parties, concerning the technology (Utrecht, 2012). On the base of the Invention Disclosure Form, the researchers are invited for an in-take meeting. This meeting is there to verify certain things, and for them to give an oral explanation on the invention.

In the mean time a business case is being built by the TTO's, to see if there are commercial interesting aspects to the technology, and to look at what the best possible strategy is for the technology (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). In the case that a IP is developed where a company in society has a privilege in use for, the TTO's should first try to offer it to that particular existing company. If that is not the case, or the company declines the offer of using the technology, the TTO's are free to do what they want with the technology (Amsterdam, 2012). Furthermore, the TTO's are also busy with analyzing if the invention could be protected, through patents, because it could be that there is not a possibility to file for a patent, for several reasons (not new enough, not inventive etc.) (Utrecht, 2012; Leiden, 2012). Or the patent is too expensive, based on the indication for market potential (Rotterdam, 2012). But if there is a business case for the technology and it is commercial viable, so that the TTO's can offer the technology/invention to a company without filing for a patent, then TTO's will also continue the process with the technology and the researchers (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). However, when there is no commercial viability for the technology and the technology cannot be protected by patents, the technology transfer process will be terminated by the TTO's, which gives the researchers the opportunity to freely publish their findings (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012).

When the analysis of the TTO's has a positive outcome for the technology, because there is commercial potential for the technology, the technology can be licensed to industry partners. When TTO's decide that they want to license the technologies there are two routes the TTO's could take to establish such license agreements. The two routes are i) Licensing it to an existing company or; ii) Licensing it to a spin-off (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). There is a preference for licensing it to existing companies, but if that is not possible, because the technology was assessed and it was too early for the technology, the TTO could opt for a spin-off (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012).

By analyzing the first route, licensing the technology to an existing company. The TTO is further complicated by the fact that most of the inventions that come from the universities are very early stage, so they will need partners that can take the technology further (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). This will not necessarily have to be the end-users of the technology, because the end-users are often not really interested in the embryonic technologies, they would like to take up the technology further down in the development cycle, when the technologies are matured. Intermediate companies are therefore, also approached (Leiden, 2012). The Life Sciences sector is rather well structured in finding partners in society (Amsterdam, 2012; Leiden; 2012). As the TTO in Leiden states in the interview that was held in Leiden:

"B*ecause that is effectively what the biotech industry does, they will either develop or add value (validate) the promising technology up to a point that is then both commercially and technically valuable and really worth something"* (Leiden, 2012).

These intermediate companies are then the companies that could be targeted for license deals, to see if they believe in the technology and if they have, and would like to devote the necessary resources to take it further (Leiden, 2012). The TTO's aim to have a proper picture of the companies that they could license to as soon as possible. However, when possible partners cannot be found, but there is potential for market use and application, route 2, licensing to a spin-off, comes in as the second possibility for diffusing the technologies into society. Therefore, investors are contacted rather early on in the process. A spin-off should only be an option if the researchers really want to participate in doing the spin-off (Amsterdam, 2012; Utrecht, 2012). Next to this the IP has to be a good IP, which means that the IP is autonomous and valuable, so that the invention can be developed as a technology that could compete with existing technologies. Incremental innovations are therefore, not for spin-offs (Amsterdam, 2012).

However, if the researchers do not want to set up a spin-off company, then the TTO should not pursue this route either. But if the researchers really want to set up a spin-off, the TTO's could more easily agree on a spin-off. If there is still doubt on whether licensing to a spin-off could be an option, the enthusiastic attitude of the researchers could be decisive (Amsterdam, 2012). But a spin-off is a last case scenario, licensing to an existing company is mostly the preferred way (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). More on whether or not the TTO's choose for licensing to existing companies or licensing to a spin-off can be found later on.

Up to this point the technology transfer process seems rather straightforward, there are subsequent steps that are taken after each other in a linear path. However, there are some loops within the process, because most of the inventions that are reported at the TTO's are very early stage, since the science that is done on universities is mostly fundamental and curiosity driven and cannot be that easily translated to practical uses (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). There is not always a possibility to find potential partners in the society. It could be that that there is commercial potential, but that it is just too early to file for a patent. More work needs to be done, but there is also no option of finding intermediate partners. In this scenario, there could be a loop back in the process, where the researcher goes back to his research and tries to take the technology a step further. This does not always have to be the initial researcher, it could also be someone else in the university who is able to take the next step, this is what the TTO's call bundling forces (Leiden, 2012). This loop back is more likely to be the case for bigger complex/fundamental/core-IP technologies, since these are the technologies that are often in an embryonic state (Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). Discrete technologies are often more developed and do not necessarily need more work (Leiden, 2012; Rotterdam, 2012). In order to support the researchers with their research, the TTO could help the researchers apply for different kinds of funding (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). This could be a critical step in the process, because some experiments do not have enough power, companies want to see solid statistics. And further experiments can have these statistics as possible outcome, which can be added to the initial research (Amsterdam, 2012).

However, as stated earlier, when all the questions in the process are answered with NO, there is no way to file for a patent, there is no commercial value and partners could not be found in society, the whole process will stop and the scientist/researcher will be able to freely publish his findings. The complete process can be seen in figure 3:

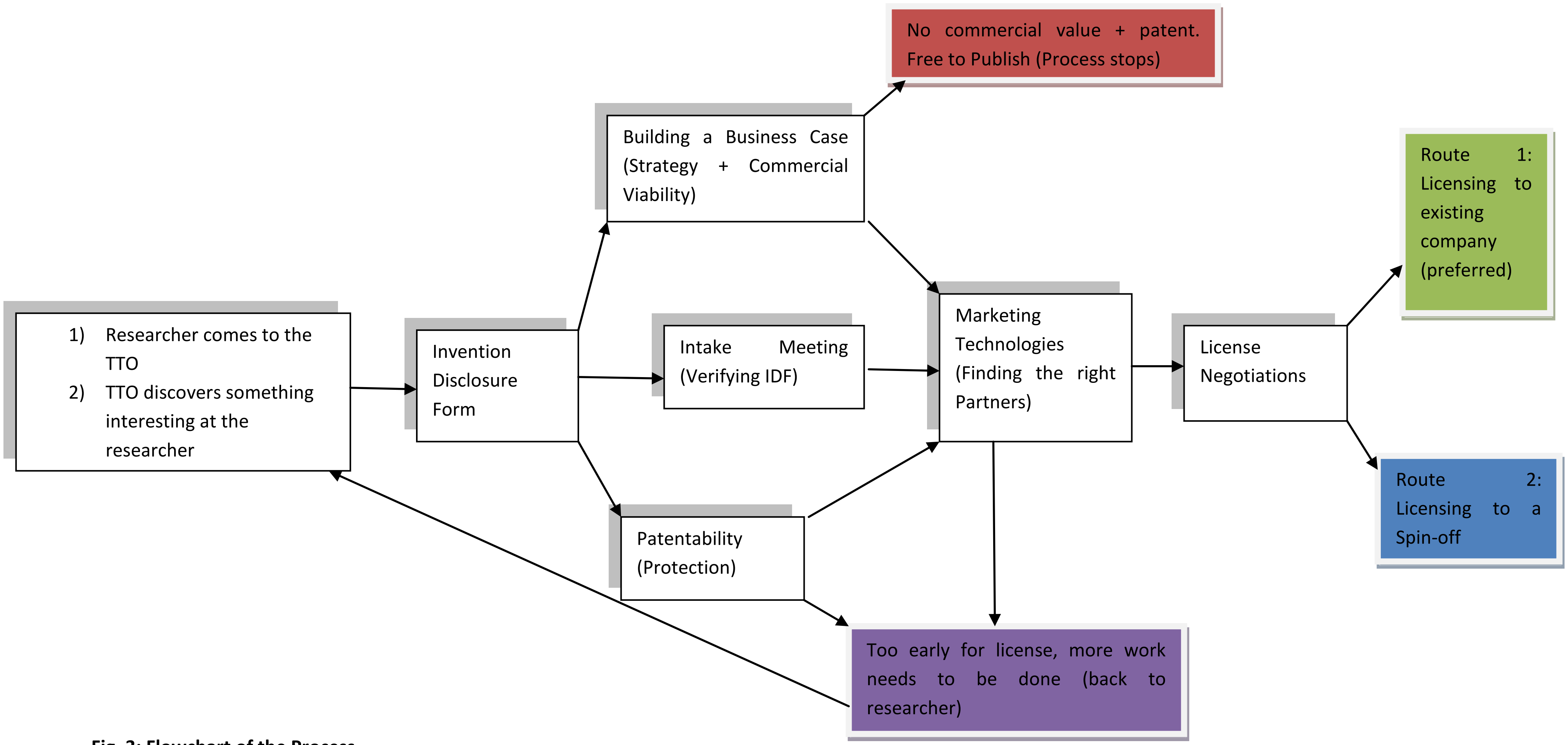

Fig. 3: Flowchart of the Process

Next to this general process, some of the TTO's stated that discrete technologies could be handled a little bit different than bigger complex/fundamental/core-IP technologies. A couple of discrete technologies, like cell lines or anti-bodies, could be bundled to get a critical mass. So that a couple of discrete technologies are bundled that are all different from each other, but are the same type of technology. These technologies could then be licensed as a bundle to an organization that is in the business of marketing these cell lines for example. This could be practical for a TTO, so that not for every cell line, a new license agreement have to filed (Leiden, 2012). Next to this, in Leiden they gave another example, since discrete technologies are often tools that were developed by the researchers, not because they like to develop these tools, but because they were necessary for the experiments and the research they were conducting. These tools could be made available for others to use. So they have developed a standard template agreement, were interested partners could fill in the blanks and for what they want to use the technology. So that there is a bit of control of to whom gets to use the technology, because researchers may not want everybody to use the tools and technologies that they have developed. Especially in the academic environment these transfers are almost always costless. In that sense these kinds of transfers could be seen as the purest form of technology transfer, in a sense that it is clearly about making things available that can be useful to other people (Leiden, 2012).

The overall process for the transfer of the technology stays the same, but it seems that there are more opportunities for the simpler discrete technologies to be licensed.

5.2 Licensing or Spin-off

The Technology Transfer Offices that were approached for this research all state that licensing is their preferred way to deal with technology transfer. This is mainly based on the principles of one invention is not an invention to base a business on (Rotterdam, 2012; Utrecht, 2012). Furthermore, as explained before, a business cannot be based on an incremental innovation, it has to be a good IP (Amsterdam, 2012). All of the TTO's speak of the process of technology transfer, in that they first set up a business case and try to license the technology to existing partners. But if they cannot find existing partners in society the TTO's will look at the opportunity of setting up a spin-off for the technology (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). The TTO's also state that setting up a spin-off is definitely not based on whether the nature of the technology is discrete or complex. Or as the TTO in Utrecht (2012) at Utrecht Holdings states it:

"*Setting up a spin-off has nothing to do with the distinction between a simple discrete technology or a complex technology. That is also easy to understand, because it is complex to make a perpetuum mobile, but I would not set up a company around it*".

Licensing to existing companies is also seen as less risky, less labour-intensive and less maintenance. It is easier to license to an existing partner, because then the TTO's should only have to negotiate one license deal and negotiate on the development terms. The TTO's have to check the progress and cash some royalties when the technology gets to the market (Amsterdam, 2012). In order to set-up a proper spin-off, the technology will need a good position to base the business on, and then TTO's, in cooperation with the researchers can set-up a business. As of this point, the work starts, a proper business plan surrounding your business to attract the necessary investments will be needed. Entrepreneurs that want to set-up a company are needed, who will have to work for the spin-off. Furthermore, the researchers have to take risks, which the researchers sometimes do not want to take. Therefore, the researchers themselves should be very motivated to take the leap in setting up a spin-off, when the initial researchers are not enthusiastic, the spin-off cannot be generated (Amsterdam, 2012; Rotterdam, 2012). Next to this the TTO in the Netherlands are quite young, so capacity and expertise are scarce, which also holds for the money that universities have, more on that can be read in the background information section of this research paper. So it is not really possible to set up a lot of different spin-offs. Because the people that are then going away to set-up a business need to be replaced, you have to train these new people yourself, which is costly and time consuming (Amsterdam, 2012). These factors help explain why

TTO's prefer license deals to exiting partners in society and opt for spin-offs in the later stages, for all types of technologies.

So in short, setting up a spin-off company by TTO's is not based on the distinction between technologies in the case of discrete vs. complex technologies. Therefore, the assumptions that were formed in the theory chapter for this concept are falsified. The outcome is based on the value of the invention, the risk the TTO and the researchers in question are willing to take, how motivated they are and if the risks are acceptable. It is difficult to set up a company based on one invention, a platform technology/core-IP could more easily be placed in a spin-off (Hoppel, 2012).

5.3 Exclusive vs. Non-Exclusive Licensing

The biggest challenge for bigger complex/fundamental/core-IP technologies, it that they are often very early stage, and it needs to be patented for people to invest. Furthermore, the TTO's will need to give a company an exclusive license, so that these companies have the freedom to let them develop the technology in whatever way possible (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012). However, the TTO's need to take measures for the technology, so that they can re-evaluate the licensing agreements. For example, when a technology is licensed to a company that are developing and using it for one type of application, but another field of application opens up for the same technology, there must be ways to make the technology active in that field, because the TTO's vision is that they want to disperse and develop the technologies so that they can be used for as much applications as possible (Leiden, 2012; Rotterdam, 2012). An example of such a case was given by the TTO in Leiden:

"In Leiden they were developing a cream, something chemical, that could be used on humans for a new way of skin absorption. And because it was very early stage they had to license it exclusively to a company, that would develop that technology further. However, when the company that had an exclusive license deal for the technology was optimizing the platform technology, the TTO of Leiden received a phone call of a veterinarian company in Belgium. As it turns out, they really liked the technology for their pigs, because it helps them to give the pigs pills and such. At that moment they had two different fields of application, humans and pigs, for the same technology and had to revise their license agreement, since the company that they were licensing it to was not exploiting the other field of application" (Leiden, 2012).

Some discrete technologies like cell-lines or research tools, are usually technologies that are accessible to use, and usually of interest to multiple users. So they are by definition much more likely to be non-exclusive licensed(Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). This is also the case for improvements that are made on certain existing complex technologies that are used by multiple partners in society. These are also licensed non-exclusively, since the improvement could then be licensed to every partner that is using that technology on which the improvement was made. TTO's could also have other mechanisms in place to ensure that a technology that is developed within a university gets further developed and finds its way to as much users as possible. in Leiden for example, the TTO gives companies over the world, on different continents exclusive rights for a certain discrete technology, but they can only have this exclusive license deal if they themselves license the technology to other parties in the world who want to use the discrete technologies. If the companies deny access to this technology to parties who want to use it, the license deals fails and the TTO gets the technology back. So in this case the technology will reach a great number of companies in the world by doing some geographical exclusive deals. However, since the companies that obtain a geographical exclusive deal are obliged to diffuse the technology to other interested parties, it is ensured that the discrete technologies will still be licensed non-exclusively (Leiden, 2012).

However, sometimes there are no other options than to license it exclusively, for example; when you improve a part of some technology, like a medical device, for which the rights are with company X in society, than the only option for the TTO is to license the improvement to that company, because the whole research on that part of a technology is based on a technology that, in its whole, belongs to another company. At the TTO in Utrecht they gave an example for this type of exclusive licensing:

"*When you would make an improvement for the dosage of medicine X, for which the rights are with Genencor, it would not make sense to offer it as a general technology to a company called Roche, because the whole research and the underlying results were devoted for the medicine of Genencor*" (Utrecht, 2012).

All TTO's also state that they rather not want to sell their technologies to companies. The reason for this is that they want to know what the technology is doing and if the technology is really being used. If they sell the rights of the technology to an interested company, the company could shelve the technology and then the technology would not be used. The TTO would make money, but that is not the primary goal of the TTO, they want to disperse and see the technology being developed as good as possible, so that it can be used for as many applications as possible. Therefore, the TTO's do not want to sell the technologies, they only want to license the technologies (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). In that case, when the licensee goes bankrupt they will get the license back and can license the technology to someone else. They can also exert pressure that the technology is really used, otherwise the licensee will have to give the rights of the technology back to the TTO. This are all mechanisms to ensure the proper usage of the technologies that come out of the university, and they have to be incorporated in the license agreements (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012).

5.4 Involvement of the researcher

All of the approached TTO's state that the involvement of the researcher in the process is very important, there is always a body of knowledge that surrounds the given technology. Whether it is a bigger complex/fundamental/core-IP technology, a discrete technology or an incremental improvement. For example, when you only have an anti-body that needs to be transferred, there is always the knowhow of the researchers that surrounds this anti-body. The researchers have done years of research with this anti-body and knows what can and cannot be done. This is the reason that when the TTO's are negotiating a license agreement, that there will always be a piece of knowhow incorporated in the deal. Furthermore, the TTO's also find it unprofessional to sign license deals without incorporating the knowhow of the researchers that surrounds the technology (Amsterdam, 2012). Because knowhow is a necessary piece of the puzzle to develop and use the technology. In order to transfer the knowhow of the researchers, the duties of the researchers have to be incorporated in the license deal, because they are the driving force behind the transfer of the necessary knowhow (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). A good example of why the transfer of the knowhow of the scientists/researcher is important for the proper usage of the licensed technology was given at the TTO in Amsterdam:

"In Amsterdam they had a case where a company only wanted a license deal on the patent, and did not want the necessary knowhow. But now they see that the company that only wanted a license deal is struggling with the use of the patent. So that is why they always want to incorporate a piece of knowhow into the license deal, to make proper use of the technology" (Amsterdam, 2012).

However, the transfer of the knowhow of the researchers will only work if the researchers are motivated about their own technological invention, because they have to stay involved in the process in order to transfer their necessary knowhow. Sometimes researchers think that the only thing they have to do is report the invention to the TTO's and that will be it. But they have to realize that when the technology and the license deal becomes successful, that they are involved in the process for longer periods of time (Leiden, 2012; Utrecht, 2012). This sort of issues must all be addressed in the license negotiations, so that the researchers know what is expected from them and how they have to stay involved in the process.

Bigger complex/fundamental/core-IP technologies are most of the time in an earlier stage of development, so when a license deal is likely to be set-up, the TTO's have to come up with a development plan for the technology, in cooperation with the licensee. To see how the technology is being developed and what is needed from the researchers in question. This means that researchers are more actively involved in the later stages for bigger complex/fundamental/core-IP technologies (Leiden, 2012; Rotterdam, 2012).

After the initial transfer of knowhow for the discrete technologies the researchers are less involved in the process, because a discrete technology, like cell-lines or anti-bodies, could for example be sent by mail after the initial knowhow transfer, because these kind of technologies are more like ready-made packages and are often in a more mature state than bigger complex/fundamental/core-IP technologies and are therefore readily usable (Leiden, 2012; Rotterdam, 2012).

As was stated before, it can always happen that a technology cannot be protected by patents for several different reasons, but that it is still commercially attractive to transfer the technology to companies. When this is the case the TTO's try to license these technologies on the basis of trade secrets or knowhow licenses. In this case the transfer is entirely based on the knowhow of the researchers that were involved with the technology. There are no ready-made packages, like patents, to license. The deals are all based on the knowhow and expertise of the researchers. Therefore, the researchers have to be involved for a long time. This is mostly the case for bigger complex/fundamental/core-IP technologies, that are all based on secrecy as their main advantage. For these type of technologies without a patent, the negotiations will strongly be focused on the duties of the researchers in the subsequent steps in the process, because their knowhow and expertise is what drives the transfer (Amsterdam, 2012; Leiden, 2012).

For discrete technologies, like research tools or cell-lines that researchers have developed or used for their research, there is less knowhow involved and are therefore, more easily distributable between parties who want to use it (Leiden, 2012; Rotterdam, 2012).

To conclude, the assumptions that were based on the involvement of the researcher can be confirmed. However, with every piece of technology that will be transferred the involvement of the researchers will be necessary. With bigger complex/fundamental/core-IP technologies the researchers will be involved for longer periods of time, since a development plan has to be set up, so that the technology will have the best chance to come to frutition. The involvement of the researchers is limited for discrete technologies in comparison to bigger complex/fundamental/core-IP technologies, but the involvement, especially in the early stages of the process, is always there and necessary.

5.5 Contracts (Payments/Royalties)

When there are negotiations for contracts for technologies, the negotiations tend to take longer for complex/fundamental/core-IP technologies in comparison to discrete technologies. When looking at complex/fundamental/core-IP or bigger technologies, they will need more development when they are licensed to a licensee. Because of this, the negotiations are not only based on the technology in question that should be licensed, but also on the next steps in the development of the technology and on the necessary knowhow of the researchers in question that is necessary to take this next step towards a final product (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). What happens in the process of negotiating on license deal, is that most of the times a collaboration agreement will be agreed upon. In this agreement there will be conditions on the licensing of the technology and there will also be a well defined research plan (Amsterdam, 2012; Utrecht, 2012). So that it is clear in which direction the technology is going and how it is fruitful for both parties, in terms of product development for the company and in terms of scientifical relevance for the researchers. The TTO's do not just give their knowledge away, so if the companies want certain knowhow or expertise from the researchers, the companies will need to give a proper compensation. This means, that when a license deal has been set up, there will be a commitment for both parties for a given period of time, which is fairly standard in the Life Sciences (Amsterdam, 2012). After signing of the license deals, the TTO's cannot rest, they need to have a system to see how the technology is developing, if certain milestones are met and how they are paying the TTO's, if they are obliged to pay. So the TTO's also stay involved in the whole process, not just at the negotiating stage (Leiden, 2012).

The transfer of technology is not only based on the technology itself, there are always people involved in the technology transfer process. So in contract negotiations and in the further process of technology transfer, it will be very hard to predict everything, the whole process remains really speculative. If the people do not connect for the transfer, in terms of the researchers connecting to the licensee, the process could stop. In such cases it does not matter how good the technology is and how much potential it has (Leiden, 2012). So that is also a reason why certain transfers can fail to happen.

As is stated before, the TTO's believe a transfer can only occur when the researchers are very motivated and enthusiastic about their technology and are motivated in bringing the technology as far as they can take it. They do not really believe in pushing the researchers, the transfer can only happen if they are motivated and enthusiastic about the technology, this is the case for both discrete and bigger complex/fundamental/core-IP technologies (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). So when researchers are very keen to do things and are very eager to assist in the process of technology transfer, and give the TTO's permission to just give the licensee everything that they want, the researchers could be the TTO's most powerful ally. But if they are more hesitant and less motivated, it could make the process of negotiating for a license contract more difficult (Leiden, 2012). This is not only the case for more complex technologies, but also for the discrete ones, because the researchers need to understand in what parts of the process they have to stay involved. And they have to be on board with that (Leiden, 2012).

The researchers are not really motivated by the financial gain they could have when the technology becomes a success, they just want to bring their invention as far they could possible take it (Amsterdam, 2012; Leiden, 2012; Rotterdam, 2012). Therefore, the TTO's did not have arguments with the researchers on financial issues, like that they do not get enough money from the invention. The researchers who come to the TTO's with their technological inventions are motivated by the fact that they want to see that their technology gets out there, the financial assets that could be gained from such a technology transfer are a bonus (Leiden, 2012; Rotterdam, 2012; Utrecht, 2012). From that point of view, the view of the researchers is quite the same as that of the TTO's, who are also there to disperse and develop as much technologies, to help solve societal problems so that people or society can benefit from research that is done in universities.

5.6 Partners in Society

It can occur that partners come to the TTO's to ask if there are developments in specific fields. However, most of the times the TTO's need to look for partners in society. Finding partners is thus most of the times done through desktop research, looking at what companies are working within the field, and which of them or possible interested in what the TTO's have on offer. The next step is writing and calling these companies, until the TTO, hopefully, finds a business that is interested in the technology and wants to license it (Utrecht, 2012). However, finding partners is difficult, because there are a lot of companies in society that *could* take your invention, on paper. It is difficult to find the right entrance. The Life Sciences sector is one of the most organized sectors in comparison to others. The companies have scouts, that search for new technologies and these companies will show on their websites in which kind of technologies they are interested (Amsterdam, 2012; Leiden, 2012). Furthermore, there is an office where you can report your findings (Amsterdam, 2012). However, these companies get a lot of technologies offered to them and most of these technologies are in a embryonic state. Which means, that if they are interested, the companies may have difficulties to see what they can do with the technologies and what the real commercial value is of the technologies.

Another way, to find partners in society, is establishing or entering public-private research consortia, where multiple TTO's and businesses are represented, so that certain technologies can more easily find the right businesses. Furthermore, in order to find proper candidates that could take the technologies, the networks of the researcher, department and TTO are important (Rotterdam, 2012; Utrecht, 2012). Over the course of years, a proper network has been established by these actors, which helps in finding the right partners. Networks like the *Medical Delta* and the *Business 2 Science Portal* are also very interesting for TTO's to find the right partners in society (Rotterdam, 2012).

5.7 Overall remarks on the process

Some TTO's state that private-public cooperation models, next to the scouting, patenting, licensing model (what has been researched in this paper), are becoming more important for the universities, because that is where the real money is. That money is necessary so that researchers can have the financial assets to pursue their curiosity driven research. Financial assets are declining for universities, so that is why the TTO's and the researchers should also focus on these kind of models. Just like in foreign countries, like Belgium (Leuven) and the Great Britain (Oxford). However, technology transfer in universities in the Netherlands is in their start-up phase, as can be read in the background chapter, in comparison to these examples. But the TTO's in the Netherlands are working towards that goal, so that they have a more bilateral focus. Scouting, patenting, licensing can be seen as technology transfer 1.0, which is very important and the TTO's are good at that in the Netherlands in terms of getting the patented technologies developed and dispersed into society, but the cooperation with industry partners is as important as that to get financial assets (Amsterdam, 2012).

6. Discussion

This part of the research paper reflects on the findings that were done in the analysis part of the paper and also reflects on some of the decisions that were made throughout the overall process of constructing the research. The first section is reserved for the technology typology that was used within this paper. The second part is a short reflection on why the overall general process looks the way that it is presented here within the approached universities, and the last part reflects on certain choices that were made for this research.

6.1 Discrete vs. Complex in the context of universities

Three out of the Four TTO's that were approached for this research paper, talked about discrete and complex technologies in one way or the other. But one did not use the terminology of discrete vs. complex. But focused more on fundamental technologies, or core-IP and incremental inventions. The way the TTO described core-IP, resembles the way the other TTO's describe complex technologies. Core-IP is then the same as the bigger complex technologies that need a lot of resources to be developed and on what companies can be based upon. Incremental innovations are minor inventions, improvements on what is already out there and are therefore licensed to all parties who want and can use these technologies. Furthermore, the fact that the TTO's also stated that universities do not build complex technologies by themselves, because it is very risky and cost intensive, and the universities do not have the financial assets to do so, because a lot of 3rd party IP needs to be licensed in, since complex technologies are build up from earlier knowledge and earlier IP. As was stated by the TTO's, this is mainly the area for companies acting in the private sector. Therefore, I think that the interviews in which complex technologies were named as technologies that need a lot of investment in order to be developed and are therefore exclusively licensed, are closely related to core-IP, platform or fundamental technologies. This is also based on the examples that were given throughout the interviews, like the value of the technology and the way these technologies were autonomous and could compete with existing technologies.

For the clear examples that were given as complex technologies, especially in Leiden, they talked about certain vaccines and technologies for genetic deceases, these technologies were new and very risky. Therefore, these technologies needed a substantial amount of resources for further development. For this reason, these technologies were licensed exclusively to existing companies. These technologies could then be further developed so that they could compete with existing technologies (Leiden, 2012). These technologies were indeed very complex and contained a lot of knowhow. But the description of how these technologies need further development and how they could change the field, closely resembles as to how at the VU&VUmc Amsterdam, fundamental technologies or core-IP technologies were presented. So maybe it is just what kind of label you put on these technologies, since they both are very complex, but these technologies are also drastically changing technologies, on which a platform could be created. These technologies were also examples of technologies that were autonomous, independent technologies that could be released and implemented in competition with existing technologies. So they did not depend that much on prior knowledge. By contacting the university of Leiden, it was verified that the examples that were given on the vaccines and the genetic deceases, were indeed technologies that were intended to be platform/fundamental technologies (Leiden, 2012).

So maybe, in terms of typology that is used, complex vs. discrete technologies, which is presented in the theory section (a lot of patents vs. less patents for protection), the typology cannot be that easily used for the universities and their technologies. The typology may be a good distinction when you only talk about patent databases, patents and in how many patents a technology needs. The way the typology, discrete vs. complex is used in the theory is also more applicable in a theoretical sense, since the only difference that is really given by scholars that use the typology of discrete vs. complex technologies is the amount of patents for given technologies and how these patents are used in doing business (Hall & Ziedonis, 2001; Hall, 2004; Cohen et al., 2001; Reitzig, 2004). When translating this theoretical viewpoint to a practical setting, as is done in this research, one can see that the transfer does not only entail patents, but there is more focus on the process, the resources in terms of knowhow and the subsequent development of the technologies. There is more to it then the interplay of patents when looking at technologies, which makes the typology that can be used in a theoretical perspective not so applicable to a practical setting. This also relates to the way Teece (1977) and Maskus (2004) present technology transfer, as can be read in the theory section. There is an embodied part of the technology (patents, blueprints etc.) and a disembodied part (knowhow, tacit knowledge). The latter is crucial to understanding and using the technology (Teece, 1977; Maskus, 2004). By using the typology of discrete vs. complex technologies, as presented in the theory, the latter part of the technology transfer is forgotten, and the focus will be more on the embodied part. But as Teece (1977), Maskus (2004) and the TTO's state, the disembodied part is of significant importance in the transfer.

Instead of using the typology of discrete vs. complex technologies, when looking at the process of technology transfer at universities, a better typology could be product vs. platform technologies. The typology of product vs. platform technologies revolves around the development of these given technologies. Furthermore, as can be seen in the analysis section, the development of the technologies has a high priority to the TTO's. In this research the term product would relate more to the simpler technologies that TTO's mentioned in their interviews, since these technologies were more developed, readily usable and are often applications that can be used for a single purpose. Furthermore, The platform technologies relate to the bigger complex/fundamental/core-IP technologies that were mentioned by the TTO's, the technologies that need to be licensed exclusively since the technologies will need a substantial amount of resources to be further developed. These technologies could be platform technologies, so that other products can be developed within the same framework of that platform. Furthermore, as the TTO's described, these kind of technologies could also be used to set up new businesses or business frameworks, since they are autonomous, which could compete with existing technologies. The examples that were given by the TTO's relate to the theory on platform technologies and how the subsequent development steps are important for technologies, since the theory states that a platform is a technological trajectory on which subsequent technologies can be developed (Meyer, 1997; Muffatto & Roveda, 1999). Therefore, this typology is more relatable for TTO's, since they state that not patents play the biggest role in the process, but mostly the subsequent development steps that need to be taken to ensure that the technology will reach the market and can be used in society.

6.2 Process of technology transfer in Universities

The different TTO's state that they have a general plan or structure for the whole technology transfer process, which can be seen in figure 3 in the analysis section, so that is also the general picture that was given within this research paper, this general process is similar to what other scholars have found when identifying the overall structure of the technology transfer process (Siegel et al., 2004). Furthermore, the TTO's also state that no predetermined plan can cope with all the variables that are present within the process of technology transfer (ex: people in the process, state of the technology, parties involved, technologies, patentability etc.) There are always loops, holes and surprising actions within the process. But the general description is what is given above, therefore there is no real difference in the process as to how they start and as to how the TTO's think subsequent steps will be taken. Furthermore, if the predetermined plan does not cope with the variables and circumstances that surface in the transfer for a given technology they will adept to these circumstances while handling the process off technology transfer.

The fact that the overall process stays the same for different technological natures, could also be related to organizational characteristics, since the TTO's stated that most of the TTO's do not have that much personnel, most of the TTO's are not that old and that they do not have the resources to work with every technology that comes in. These characteristics could help understand why the process is more or less streamlined and not focused on different technological natures, since the TTO's may not have the manpower or resources to incorporate different processes for different technological natures for their technology transfer. However, this research focused on the effect of technological nature on the process. In order to see, if these characteristics could indeed have an effect on the organization off the process, more research will be needed on the effect that organizational characteristics could have on the process.

6.3 General Remarks

The TTO's that were contacted for this research all shared a similar approach as to how they tackle the process of technology transfer. They had the same way of working, they "steal" each other' employees, they work and speak with each other and the TTO's also stated that they were not that big. Some of the TTO's also stated that technology transfer offices at technical universities, like at the university of Delft or Twente, the process could be different. But since I did not contact these universities, they had no time or did not respond to my e-mails, which also could be caused by the fact that TTO's are not that big and employees are scarce. Therefore, I could not check whether this is true or not. However, the process being the same, has also something to do with the field that these TTO's are working in and on the field that my research is focused on, which is Life Sciences. In Life Science they always need to be busy with medical examinations and clinical trials, which takes a long time. That is not really the case with technological innovations, they will need CE (quality) labels, but the trajectory is most of the times shorter (Rotterdam, 2012). Which could affect the process of the technology transfer in some way or another. This could be interesting to look at, when someone would take this research a step further.

The fact that these TTO's stated that there process of technology transfer did not differ from each other, is in terms of looking if technological nature could affect the underlying process of technology transfer, which was the goal of this research, a good point. By approaching several TTO's that handle the transfer of technology in the same way, that variable was kept the same and if differences could be seen in the process, these differences could be seen as the effect that technological nature has on the process.

The first idea for the interviews was to contact the managers of the different TTO's at the universities, as is described in the methodology section, but this was not always possible. Therefore, I did not always talk to the managers in the TTO's, but most of the times to the business developers. However, the business developers are very important in the process of technology transfer, and have a good grasp on the overall process and thus should have sufficient knowledge for this research. As was stated several times in the interviews, the business developers are the employees in the TTO's that really drive the process of technology transfer. The business developers are the employees that select the good inventions, they accompany the researchers, they look for interested market parties and they negotiate the license deals. This shows that they are important throughout the process and are therefore the right persons for the interviews. Since TTO's are still a young business in the Netherlands, they are not that big, and therefore did not have that much manpower. But the people I interviewed had a lot of knowledge on the subject and could give me clear answers to the problem that I was researching.

7. CONCLUSION

The aim of this paper was to find out if technological nature could affect the technology transfer process, from universities, through TTO's to society. The typology that is used within this paper is the typology of discrete technologies vs. complex technologies. In order to keep as much variables the same in the research, examples for technologies were chosen. As example for a discrete technology, pharmaceutical inventions were chosen, like cell lines or anti-bodies. As example for complex technologies, bio-technologies were chosen. Both are in the Life Science sector, which keeps the trajectory that both kind of technologies have to take to come to frutition and to the market the same, in terms of clinical tests and such.

For this research four TTO's were approached for interviews, this were the TTO's in Amsterdam (VU), Leiden (LURIS), Rotterdam (Erasmus MC) and Utrecht (Utrecht Holdings). The duration of the interviews ranged from 30 minutes to 1 hour and 30 minutes, with an average of 50 minutes. The interviews were based on the assumptions that came forth out of the theory that was used for the research and on the research questions. All with the overall goal to answer the following research questions.

7.1 SUB-RQ 1: WHICH TECHNOLOGICAL FEATURES OF DISCRETE AND COMPLEX TECHNOLOGIES SHAPE THE ORGANIZATION OF THE PROCESS?

By analyzing the different interviews several features that shape the process of technology transfer arose. However, these features cannot be placed within the typology of technology that is used in this research paper. These features are more general, that hold for every type of technology. Some are more in place when you talk about bigger complex/fundamental/core-IP technologies. But all these features are in place for the transfer and are of importance for every type of technology. The five features are listed below:

- Amount of knowhow
- Involvement of the researcher
- State of the technology (embryonic or well developed)
- Motivation of the researcher (willingness to cooperate)
- Patents (in a lesser manner)

At the start of the process, when the researchers comes to report their invention, the state of the technology and the motivation of the researcher are very important. The state of the technology is interesting, because further developed technologies could be more easily licensed to companies, since it is more clear as to how they could be beneficial for the licensee. Motivation of the researcher is also very important from the start, because the researcher needs to be involved in the further process and if he/she thinks that his/her role is played out after reporting his/her initial invention, the TTO cannot go further with the technology, because the knowhow of the researchers is important in the ongoing process. This directly brings up a subsequent point, the knowhow. The TTO's state that there is always a certain transaction of knowhow, no matter what kind of technology. Since the researchers are working for longer periods of time with the technologies, and the knowhow and expertise have to transferred as well for the proper use or further development of the technology. This means that the involvement of the researcher also shapes the process, for complex/fundamental/core-IP technologies the involvement of the researcher is very important for the further development of the technology, this relates to the theory of Teece (1977) and Maskus (2004), because the transfer of the necessary knowhow can be seen as a crucial step in the process. The involvement of the researcher will therefore also be incorporated in the negotiations of the license contracts with industrial partners, so that it is clear as to what is expected of both parties in the transfer. The involvement of the researcher is also very closely related to the motivation of the researchers, because they will have to want to be involved. The TTO's state that you cannot force the researchers, they will have to have that intrinsic motivation, otherwise there cannot be a proper transfer. The motivation of the researcher is thus an important factor throughout the whole process.

Patents that are filed for the technologies are of less importance in the process, since most technologies are patented in the Life Sciences. Therefore, most transfers entails the negotiations on patents. Researchers are then always present in the following steps, because a patent is a legal document, the inventors of the technology will always have to sign and confirm certain actions, when something needs to be done with the technology. When there is no patent, technologies could be licensed on a knowhow or trade secrets basis. In that case the other four factors (knowhow, involvement of the researcher, state of the technology and motivation) are equally important as in the process of transferring a technology with a patent

7.2 SUB-RQ 2: HOW IS THE GENERAL TECHNOLOGY TRANSFER PROCESS IN UNIVERSITIES THE NETHERLANDS ORGANIZED?

According to the different TTO's that were approached for this research, the overall process of technology transfer does not differ across the universities, in terms of how the process is organized. The general outlay of the process remains the same when the process of technology transfer is started. However, as can be read in the analysis section, the TTO's cannot predict how the process will evolve, since every transfer of technology depends on different variables. Therefore, the process could change, or the TTO's could adapt to changing circumstances.

The general organization of the process of technology transfer in the Netherlands is presented hereafter, with a short legend on the steps that are taken within the process.

1. Starting point: Either the researcher comes to the TTO with a possible invention or the TTO discovers that researcher are doing interesting research
2. The scientists/researchers needs to fill an Invention Disclosure Form
3. i) The researchers are invited for an intake meeting; ii) a business case is build for the technology; and iii) the patentability of the invention is checked
4. i) The technology could be ready to be licensed, because there is commercial value and/or the technology can be protected by patents. Therefore, licensee partners are sought in society; ii) or, there is no commercial value and no patent (Red box). Therefore the process stops and the scientists/researchers are free to publish; iii) or, the technology is in such an early state, that no companies can be found to license the technology too (Purple Box). Therefore, there is a loop back to the scientists/researchers, so that more research can be done on the technology.
5. When parties in society are found, the negotiations on a license deal will start
6. There are two routes for licensing i) Route 1 (Green Box) is licensing to existing companies in society, which is the preferred route for the TTO's; ii) Route 2 (Blue Box) is licensing to a spin-off. When a technology is licensed, either to a existing company or to a spin-off, the process is finished.

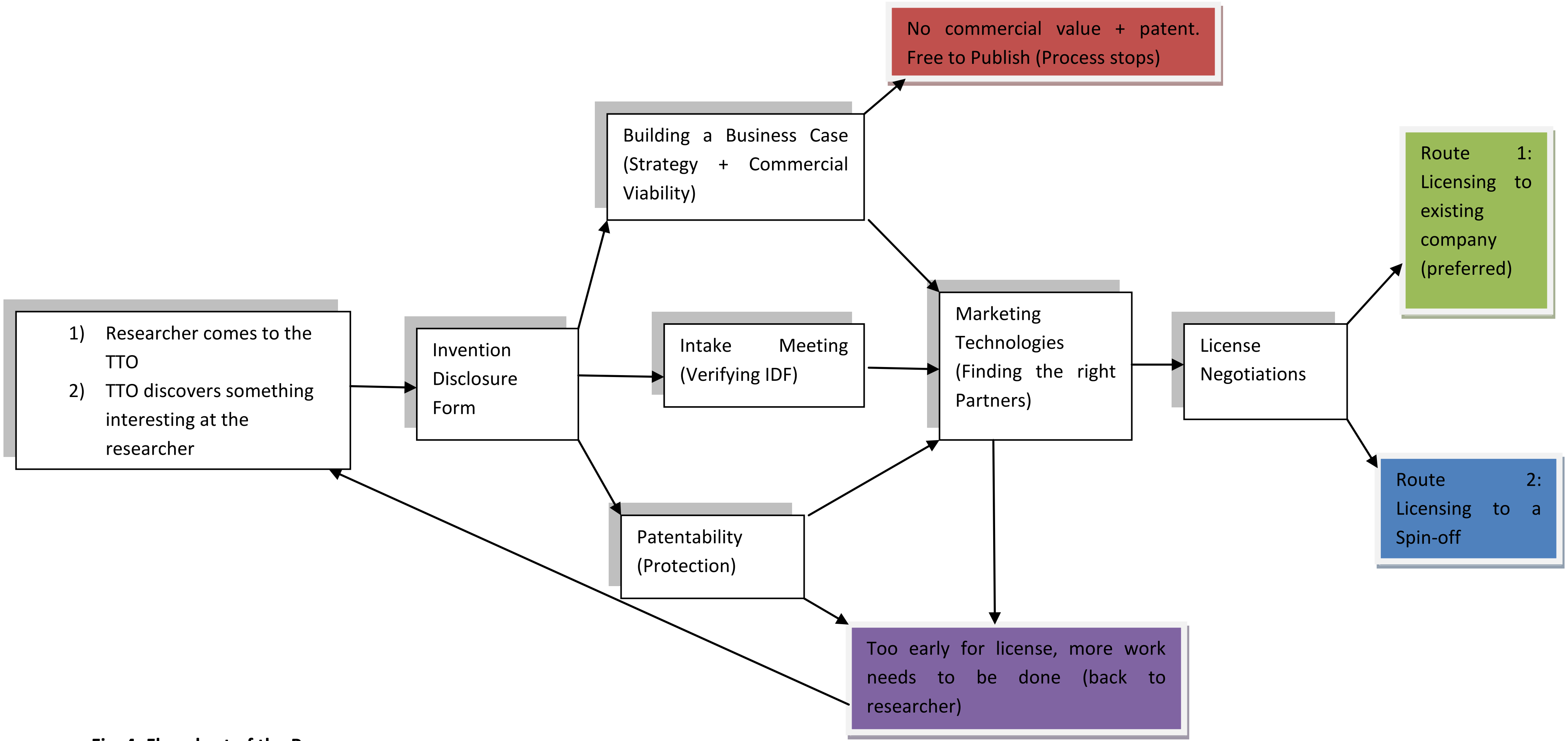

Fig. 4: Flowchart of the Process

7.3 SUB-RQ 3: WHAT ARE THE DIFFERENCES IN THE TECHNOLOGY TRANSFER PROCESS BETWEEN COMPLEX AND DISCRETE TECHNOLOGIES

The TTO's state that there are not that many differences between discrete and complex technologies in the technology transfer process and how the process is organized, because it is a general process. For bigger complex/fundamental/Core-IP technologies there will be need for more in-depth negotiations on the license contracts and the duties that have to be fulfilled by both parties to get a proper end-product. So development time after disclosure will be longer than for discrete technologies. This is the case, as is stated many times before, because bigger complex/fundamental/core-IP are in earlier state of development and thus need more work to be done after the initial disclosure of the technology.

Discrete technologies can be more easily distributed directly to the end users, because they are more full-fledged than complex/fundamental/Core-IP technologies, and they can be more easily used from the time of disclosure. Therefore, the negotiations for a license deal tend to be shorter for a discrete technology. However, in Leiden they gave a couple of examples of how they transfer discrete technologies like anti-bodies and cell-lines, which can be found in the analysis section on the process of technology transfer. These examples show that there are multiple ways to contact interested parties for simpler smaller technologies. The process did not change, but the licensing could be handled in several ways.

As described in the analysis section and in the discussion section, the TTO's do not really distinguish between discrete and complex technologies in general. The bigger technologies, that were described as complex technologies, are described by others as fundamental/core-IP/platform technologies. But they all stated that the process did not differ that much for different kinds of technologies within their offices.

7.4 HOW IS THE TECHNOLOGY TRANSFER PROCESS FROM DUTCH UNIVERSITIES TO SOCIETY INFLUENCED BY THE NATURE OF THE TRANSFERRED TECHNOLOGY?

The general description of the process that is given within this conclusion can be seen as a good description as to how the TTO's organize their technology transfer process. They do not really distinguish between different natures of technology. As can be seen from the above mentioned sub-questions, the overall process is the same for the different kinds of technology.

The differences that could be found when looking at different technologies are minimal. Incremental improvements on existing technologies or simpler discrete technologies, like anti-bodies, cell lines or research tools, tend to be always licensed to existing companies in society. Because these technologies are not valuable enough to base a business around. They are almost always licensed non-exclusively, since a lot of parties in society could take these kind of technologies. Incremental improvements on existing technologies, like medical devices for example, tend to be also licensed non-exclusively. However, when the technology belongs to one company, the improvement on that technology will, logically, be licensed exclusively to that company.

For bigger complex/fundamental/core-IP technologies, TTO's are often obliged to license the technology exclusively to interested parties. The TTO's would like to license every type of technology non-exclusively, because the TTO's want that as much people as possible can benefit from a given technology. But in the case of the bigger complex/fundamental/core-IP technologies, the technologies themselves are often in such an embryonic state, that the company who is interested in the technology wants an exclusive license, since the company is the one that takes the next step and does the development and therefore, does not want other parties to profit from their development and research efforts. In such cases, the TTO's are obliged to give out an exclusive license deal. In such licensee deals, the negotiations also tend to take longer. As can be read in the analysis section, there is a lot more to discuss for bigger complex/fundamental/core-IP technologies in comparison to simpler discrete technologies, in terms of development plans etc.

Another small difference in the outcome of the process, is that the bigger complex/fundamental/core-IP technologies are seen as technologies that are autonomous technologies that could compete with existing technologies in the market. Therefore, they have more value and could be used to base a business around. It could be a platform for other technologies.

The small differences that could be seen in the process, are not really differences in the process. The outcomes could be different and the negotiations tend to take longer when licensing a bigger complex/fundamental/core-IP technology. A discrete or a complex nature has therefore little to no influence on the process of technology transfer, as is also stated by the TTO's. As is described in the discussion section, the typology of product vs. platform technologies can better be used when discussing the technology transfer process from universities through TTO's to society, since the typology product vs. platform is focused around the development of the technologies and how they could be implemented in businesses. Furthermore, as can be seen in the analysis section, the TTO's are concerned with the development of the technologies, which makes the typology, product vs. platform, more suitable for TTO's and the technology transfer process. However, The process still stays the same when incorporating this typology, since it is a very general description of the process. The differences or adaptations on the process can only seen case by case, since every case of technology transfer is different.

Therefore, to sum up. The process of technology transfer is not influenced in a major way by the different natures of technology. Every transfer of technology goes through the same steps. The overall process stays the same, with little nuances in the steps that are followed, in terms of involvement of the researcher and the subsequent development of the technology, that were discussed in the analysis section and the previous paragraphs. The influence of technological nature on the technology transfer process from Dutch universities to society is therefore minimal.

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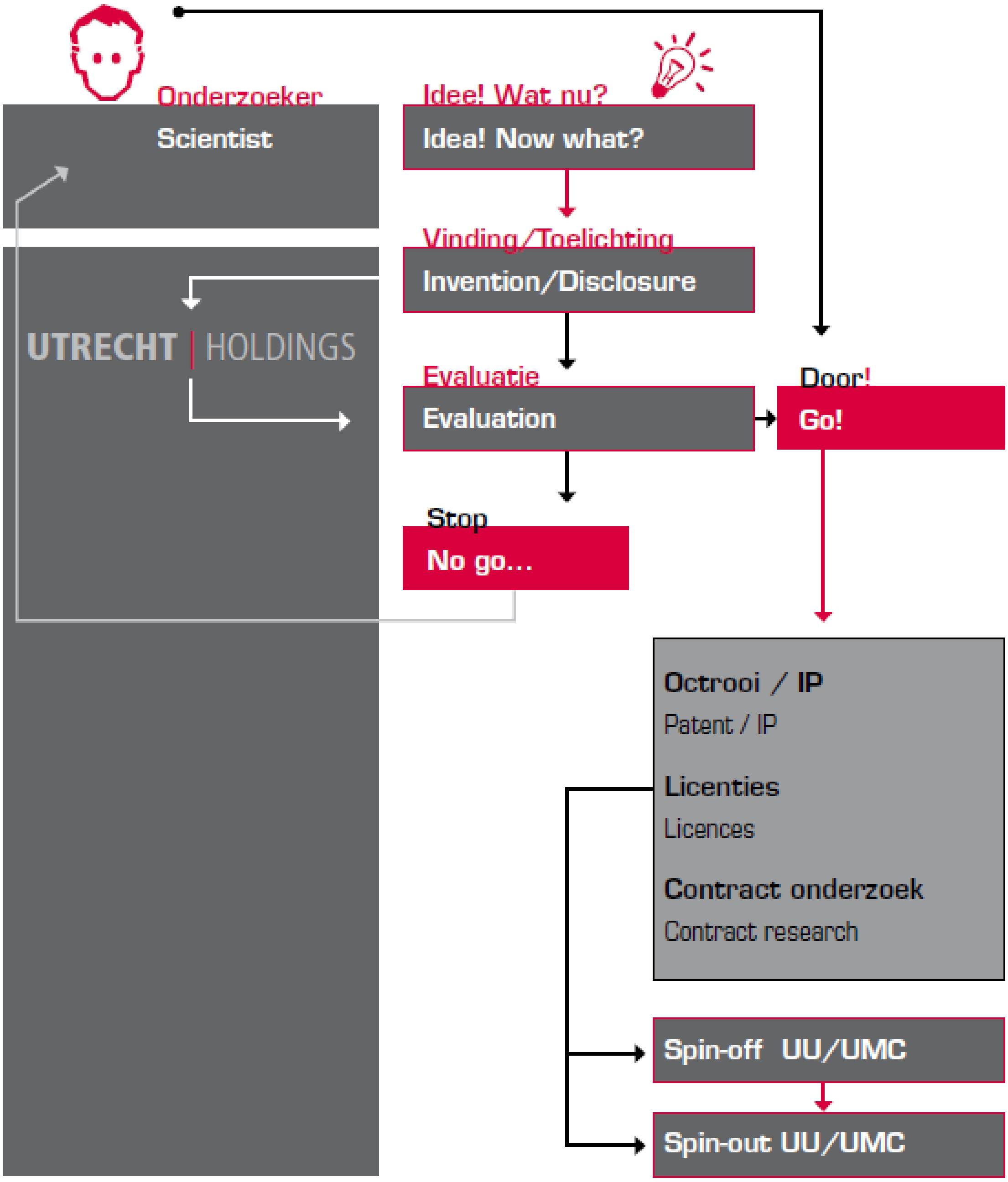
APPENDIX

A – UTRECHT HOLDINGS STRUCTURE



APPENDIX A: UTRECHT HOLDINGS

B – INTERVIEW

THE EFFECT OF TECHNOLOGICAL NATURE ON THE DUTCH UNIVERSITY TECHNOLOGY TRANSFER PROCESS

Interview

Science and Innovation Management (SIM)

Master's Thesis (GEO4-2239) 45 ECTS

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INTERVIEW

1) *Wat is uw naam?*

2) *Wat is uw functie in het TTO?*

3) *Wat heeft het TTO voor specifieke functie voor de universiteit?*

4) *Hoe is het transfer proces georganiseerd in het TTO? Dus wat zijn de verschillende stappen die ondernomen worden als er een onderzoeker van de universiteit bij het TTO komt met een onderzoek?*

Mijn onderzoek voor mijn master thesis focust zich op de invloed die verschillende soorten technologie kunnen hebben op het transfer proces. Voor mijn onderzoek heb ik onderscheidt gemaakt tussen discrete en complexe technologieën. Het verschil zit hem voornamelijk in het feit dat er voor discrete technologieën minder patenten nodig zijn om het uiteindelijke product te beschermen dan bij complexe technologieën, waarbij er vaak voor alle verschillende onderdelen van het product patenten nodig zijn om het te beschermen. In mijn onderzoek vallen technologieën uit de farmaceutische/chemische hoek onder de discrete technologieën (vb: antilichamen/stoffen) en vallen innovaties uit de biotechnologie onder de categorie complex. Zodat beide technologieën onder de noemer "life sciences" vallen, een tak waar veel universiteiten zich mee bezig houden. Bij complexe technologieën en het transfereren ervan komt vaak ook meer "tacit knowledge" kijken, wat het transfer proces kan beïnvloeden.

Een korte rondvraag heeft al opgeleverd dat veel universiteiten zich niet bezig houden met complexe technologieën in zijn puurste vorm, dus het opbouwen van een complexe technologie vanaf de grond, omdat er dan heel veel IP in-gelicenseerd moet worden. Complexe technologieën kunnen dus ook voor universiteiten worden gezien als (incrementele) verbeteringen die worden aangebracht aan bestaande technologieën uit de biotech tak.

De volgende vragen gaan dan dus ook over het feit of verschillende aspecten van de soorten technologie het transfer proces kunnen beïnvloeden. De concepten waar de vragen over gaan, komen uit de literatuur over "technology transfer", waarbij er volgens mij mogelijkheden liggen waar de soort technologie (discreet vs. Complex) invloed kan hebben op het proces en de keuzes die gemaakt moeten worden.

Om een zo puur mogelijk beeld krijgen van de keuzes die TTO's moeten maken, zal de laatste vraag van dit interview, vragen naar aspecten die volgens u belangrijk zijn in het gehele proces, waar met behulp van de onderstaande vragen nog niet bij is stil gestaan.

---

5) Is het makkelijk om partners te vinden in de samenleving voor de aangeboden technologieën? Is er verschil voor de soorten technologie (discreet vs. Complex)?

6) *Zijn er verschillen in de uitkomst van het transfer proces tussen discrete en complexe technologieën, qua gebruik van business models voor bepaalde technologieën? Is het bijvoorbeeld gebruikelijker dat er voor discrete technologieën bedrijven worden opgestart en dat complexe technologieën vaker worden gelicenseerd aan bestaande bedrijven of worden doorontwikkeld met behulp van het bedrijfsleven? Of heeft de soort technologie hier geen invloed op?*

6b) *Als er verschillen zijn, wat is dan de reden voor deze verschillen in uitkomsten van transfer proces, welke aspecten van de technologieën spelen hierbij een grote rol? Als er geen echte verschillen zijn tussen de uitkomst en de soort technologie, waardoor wordt er dan wel voor verschillende business modellen gekozen?*

7) *Als technologieën worden gelicenseerd aan bestaande bedrijven, zit hier dan nog verschil tussen de twee soorten (discreet vs. Complex) technologieën? Dus wordt de ene soort technologie bijvoorbeeld vooral exclusief gelicenseerd, waarbij de onder aan meerdere bedrijven wordt gelicenseerd (non-exclusive)?*

7b) *Welke aspecten van de verschillende technologieën zijn de oorzaak voor deze verschillen? Of waardoor zijn zulke verschillen juist niet aanwezig?*

8) *Zijn er verschillen bij het transfer proces in hoeverre de onderzoeker(s) die de vinding hebben gedaan betrokken blijven bij het transfer proces? Dus hangt het van de soort technologie (discreet vs. Complex) of de invloed van de onderzoeker(s) gelimiteerd is, of dat hij bij het hele proces betrokken blijft?*

8b) *Als er verschillen zijn tussen de betrokkenheid van de onderzoeker en het feit of het over een discrete of complexe technologie gaat, waar komen deze verschillen dan vandaan? Door welke aspecten van de technologie worden deze verschillen gecreëerd?*

9) *In wat voor stadium worden onderzoeken/innovaties bij het TTO aangeleverd? Zijn ze vaak nog in de eerste fase van ontwikkeling of al in een ver gevorderd stadium en zit hier nog verschil in tussen de twee soorten technologie (discreet vs. Complex)?*

9b) *In hoeverre is de commerciële waarde van onderzoek/innovatie te schatten als hij binnenkomt bij het TTO en zit hier nog verschil in tussen de twee soorten technologie (discreet vs. Complex)?*

10) *Als onderzoeken/innovaties in een te vroeg stadium binnen komen om hun waarde goed te kunnen schatten kan extra tijd om de innovatie door te ontwikkelen nodig zijn om het onderzoek op waarde te schatten. Komt dit vaak voor dat dit nodig is?*

10b) *Komen zulke gevallen vaker voor discrete of complexe technologieën of is er geen verschil? Dus welke soort technologie heeft meer behoefte aan meer ontwikkelingstijd en door welke aspecten ontstaan deze verschillen?*

11) *Bij het transfereren van technologieën worden er contracten afgesloten over hoe de technologie wordt getransfereerd? Zijn er verschillende soorten contracten en is er hier verschil in contracten tussen de verschillende soorten technologieën (discreet vs. Complex)?*

11b) *Als er verschillen zijn in de contracten die worden afgesloten voor de verschillende technologieën, aan welke aspecten van de technologieën kunnen deze verschillen gekoppeld worden?*

12) *Er zijn bij het transfereren van technologieën ook meer opties om te betalingen te voldoen, zoals betalingen op basis van, bijvoorbeeld: royalties, gesponserd vervolgonderzoek of betaling van het gehele bedrag in één keer. Heeft het soort technologie (discreet vs. Complex) invloed op hoe betalingsregelingen worden getroffen?*

12b) *Als er verschillen zijn in betalingsregelingen die worden getroffen voor de verschillende technologieën, welke aspecten van de technologieën zorgen dan voor deze verschillen?*

12c) *Worden verschillende betalingsregelingen ook ingezet om onderzoekers te stimuleren om ze meer betrokken te houden bij het transfereren van de innovatie?*

12d) *Als de soort technologie geen invloed heeft op de vorm van betalingsregeling en het ook niet gebruikt wordt om onderzoekers te stimuleren, op basis van welke informatie wordt er dan voor een bepaalde betalingsregeling gekozen?*

13) *Zijn er nog belangrijke aspecten, volgens u, in het transfer proces die tot op dit moment over het hoofd zijn gezien? Keuzes die het proces kunnen maken of breken, waar de soort technologie invloed op kan hebben?*

Dit is het einde van het interview, bij deze wil ik u bedanken voor de tijd die u heeft genomen om de vragen te beantwoorden die mij verder zullen helpen bij mijn onderzoek naar technology transfer offices in Nederland.

Bedankt en met vriendelijke groet,

Dik Kruis
