Master's thesis

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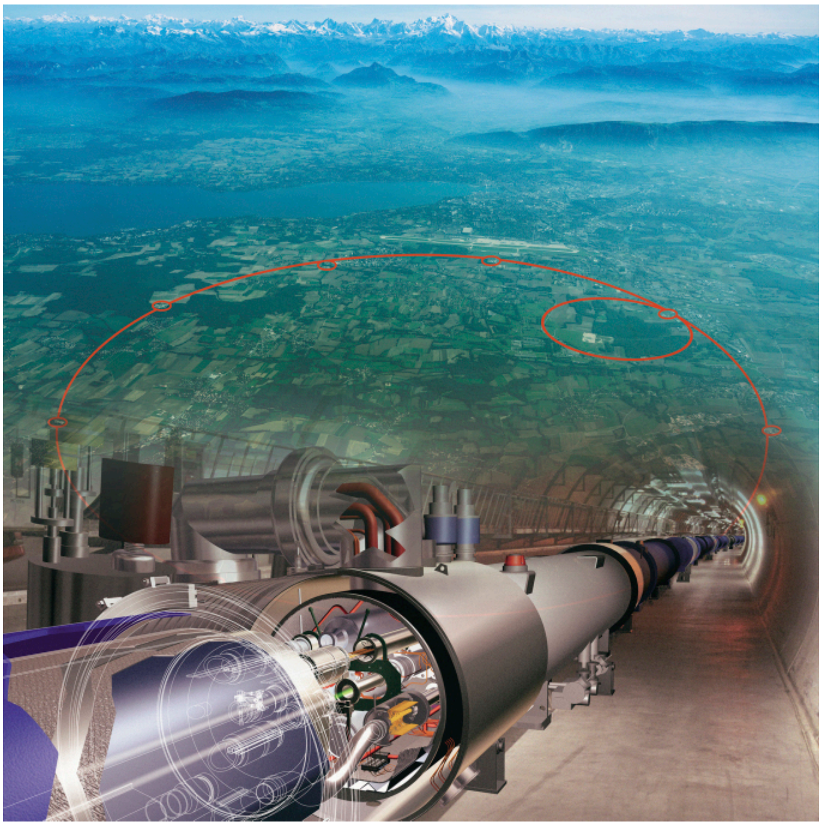
Pricing of Licenses on CERN Technology

Trondheim November 2006

NTNU
Norwegian University of Science and Technology
Factulty for Social Sciences and Technology Management
Department of Industrial Economics and Technology Management



NTNU
Innovation and Creativity

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Abstract

This Master thesis develops a framework for the pricing of licenses on technology, suitable for a Technology Transfer (TT) context that is characterized by a goal of dissemination, early-stage technologies, limited market information, and great variations between technologies. The chosen context is defined by comparing the policy and the specificity of the initial recipient, CERN, to other public research institutions, thereby aiming at the development of a general framework.

A conceptual model of the framework is thereafter developed to accommodate considerations of all the indicated characteristics through three main subparts: 1) the target price, 2) the walk-away point, and 3) the royalty structure. For estimation of a suitable target price, valuation methodologies from academic and business literature are reviewed and discussed with regard to their suitability for the chosen TT context, thus selecting six methods of different approaches and varying information dependency. A method for quantifying the appraiser's qualitative judgment of a technology's potential profitability and associated risk, termed technology utility, is subsequently developed and integrated across the selected methods. Moreover, through an analysis of walk-away point and royalty structure, the dissemination perspective is given due consideration and some practical guidelines are suggested.

Lastly in the development, a pricing process for employing the framework is presented, indicating the different steps involved and the considerations necessary. A case implementation on a CERN technology is thereafter provided, together with a thorough sensitivity analysis and discussion of the thesis.

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List of Abbreviations

BATNA	Best Alternative To Negotiated Agreement
CCA	Contingent Claim Analysis
CERN	Conseil Européen pour la Recherche Nucléaire but also The European Organization for Nuclear Research
CERN TT	CERN Technology Transfer Group (CERN's OTT)
COGS	Cost Of Goods Sold
DCF	Discounted Cash Flow
GEM	Gas Electron Multiplier
HEP	High-Energy Physics
IP	Intellectual Property
IPR	Intellectual Property Rights
LEP	Large Electron-Positron (collider)
LHC	Large Hadron Collidor
MC	Monte Carlo
MRC	Modified Replacement Cost
NEG	Non Evaporable Getter
NPV	Net Present Value
OTT	Office of Technolgy Transfer
SG&A	Sales, General, and Administrative (expenses)
TT	Technology Transfer
TUR	Technology Utility Rating
WACC	Weighted Average Cost of Capital
WWW	World Wide Web
ZOPA	Zone Of Possible Agreements

Preface

This document is our Master thesis at the Department of Industrial Economics and Technology Management (IØT), Norwegian University of Science and Technology (NTNU). The thesis was written through the Technical Student Programme at CERN, the European Organization for Nuclear Research, in Geneva, Switzerland, from April to November 2006. The topic was provided by the Technology Transfer (TT) Group at CERN, as they have long felt the need for a coherent methodology for the pricing of licenses. The public version of the thesis will furthermore by published at CERN CDS server under the number CERN-THESIS-2006-060, and an extract will be submitted for publication in the business journal Les Nouvelles.

Firstly, we would like to express our thanks to our supervisor at NTNU, Alexei Gaivoronski, for supporting our stay at CERN and for valuable guidance throughout the process. Secondly, we sincerely thank Henning Huuse, Marilena Streit-Bianchi, and Jean-Marie Le Goff at the TT Group for our educating discussions and their *priceless* support. Without their interaction and guidance, this thesis would have been a different and far less pleasurable adventure. Furthermore, the entire TT Group deserves our gratitude for accommodating us and teaching us the field of Technology Transfer. The knowledge and experience gained through our operational work at the group has been crucial in developing a practical framework, and we hope the result of this thesis will live up to their expectations. We also would like to thank Larry Plonsker and Sindre-Jacob Bostad of the Licensing Executives Society (LES) for giving us free access to the LES journal, Les Nouvelles, which carry so much knowledge from real-world pricing experience. Equally grateful are we to the personnel of the CERN Library, who have impressed us with their speed and ability to dig up every book requested, although our topic is clearly untraditional at CERN. Last but not least, we thank the academic staff of the IØT Department at NTNU for 5 years of exceptional education and the department's management for their support of our stay at CERN.

All errors and omissions in this thesis are the sole responsibility of the two authors.

Geneva, November 19th 2006,

Vidar Eide　　　　Andrzej Golebiowski

In every phenomenon the beginning remains always the most notable moment.

Thomas Carlyle, Scottish writer (1795-1881)

Introduction

The origin of this thesis was that the Technology Transfer Group at CERN (CERN TT) felt a strong need for streamlining their pricing approach to technology licenses. There was a strong feeling that CERN's nature and policy made it so particular that no methods proposed by academia or business literature could fully accommodate their specific needs. Thus, when we arrived, the following purpose for this thesis was formulated: *"Establish a pricing framework for licenses on CERN Technology, accommodating the specificity of CERN's policy for Technology Transfer."* However, in order to deduce a clear problem formulation, further discussion is needed and it will be the topic of the first section. The last section will then briefly outline the structure of the thesis.

Problem formulation

So what makes CERN's policy for Technology Transfer so specific that they have difficulties using standard pricing methods? CERN is an international organization funded by 20 different countries, called Member States. Thus, when giving licenses on technologies developed with public resources, CERN has other considerations than a private profit-maximising company, since its stakeholders are different. The main goal of CERN's Technology Transfer activities is namely to *"maximize the technological return to the Member States"* [CERN Technology Transfer Group, 2006]. How the pricing policy should reflect such a superior goal is a subject of great controversy, also at other public research institutions in similar situations and in academia. Answering it would demand an analysis into the field of welfare economics, searching for an answer to the question: *What price would maximise the social welfare of Member States?* This thesis will not enter that debate but remain on a microeconomic level and take an approved pricing policy for granted. Most OTTs are given the mandate to prioritize dissemination rather than profit from their governing authorities. Moreover, what CERN TT needs is not a discussion of its current pricing policy but a framework that implements it:

"CERN will seek to obtain a price for the licensing of its technology reflecting, as much as possible, the market value of the technology. CERN will, however, favour pricing approaches that are deemed to maximise the dissemination as opposed to maximising the income."

In the formulation of this thesis, we also stated that we would develop "a pricing framework that is suitable in the Technology Transfer context at CERN." This means that not only do we have to develop a framework that has a sound academic foundation, but it should also be fitted for implementation at CERN TT. Therefore, we need to analyze the context of CERN TT and deduce the inherent characteristics that the pricing framework has to account for.

However, we quickly realized that the preceding concerns are not unique to CERN TT, but are shared by other Offices of Technology Transfer (OTTs) at public research institutions. Both the policies of such OTTs and their context are closely comparable to that of CERN TT. We will therefore aim at developing a general pricing framework for OTTs at public research institutions, something which might increase the academic interest and reach of this thesis. The specific TT context for which the framework is developed will be defined early and our general approach will also be validated by comparing CERN TT to other OTTs.

This discussion leaves us with the following general problem formulation:

The purpose of this thesis is to establish a pricing framework for licenses on technology developed at public research institutions, accommodating the specificity of an OTT's policy for Technology Transfer. Thus, the pricing framework will seek to obtain, as much as possible, the market value of the technology, but will favour pricing approaches that are deemed to maximise the dissemination of the technology as opposed to maximising the income. Furthermore, the thesis will develop a framework that is suitable for implementation in the Technology Transfer context.

Structure of further analysis

Part I will present the Technology Transfer context and analyze in detail the resulting characteristics a pricing framework should accommodate. *Chapter 1* will depart with an introduction to CERN and the innovation taking place there, followed by *Chapter 2* which will compare the policy and context of CERN TT to other OTTs, thereby validating our general problem formulation and defining our TT context. *Chapter 3* will proceed with a thorough analysis of the challenges of pricing of licences in this TT context, while *Chapter 4* will summarize the discussion of Part I.

Part II will build on the analysis of part I and develop the pricing framework. *Chapter 5* will start by presenting a conceptual model of the framework, while *chapter 6* will study IP valuation literature and evaluate which methods are suitable in the chosen TT context. *Chapter 7* will then develop a methodology for quantifying an appraiser's qualitative judgment of a technology's risk and profitability. *Chapter 8* will proceed to develop the main part of the pricing framework by integrating this methodology across the valuation methods chosen in Chapter 6. *Chapter 9* will then provide a complementary discussion of the remaining parts of the conceptual model. Lastly in this part, *Chapter 10* will summarize the pricing framework and outline a pricing process describing the necessary steps involved.

Part III consists solely of *Chapter 11*, which will implement the pricing framework for a licensing case from CERN. This will provide a first test of the general framework, enabling us to discuss its suitability for CERN TT and perform a sensitivity analysis of the modelling approach.

Lastly, a chapter will summarize the whole thesis, before we conclude and suggest directions for further work.

Part I

Analysis of background & context

Chapter 1

CERN... where the web was born!

> *In physics, you don't have to go around making trouble for yourself - nature does it for you.*
>
> Frank Wilczek, American physicist (1951-)

CERN, the world's largest particle physics laboratory located at the Swiss-French border near Geneva, was created to promote European science after the Second World War by gathering the best scientists from all sides of the conflict. During the post-war nuclear arms race, it united research communities from both the East and the West; its research has led to three Nobel prizes; it is also the birthplace of the invention that has changed everyday life in the industrialized world, the World Wide Web. It still attracts thousands of people from all around the globe to solve the puzzles of the universe, and it has even been popularized by Dan Brown in his mass-selling blockbuster *"Angels and Demons"*[1]. Dan Brown's version of CERN offered little reality and a lot of (science) fiction, but the true story about CERN is almost as fascinating as the fictive one. This chapter will take a closer look at CERN's history, mission and current endeavours, emphasizing how the research drives innovation and gives continuous birth to new technologies. It is precisely when licensing such technologies that there is a need for a coherent pricing framework.

1.1 Background

CERN, the European Organization for Nuclear Research[2], was created in 1954 by 11 European governments with the mission of undertaking fundamental research in particle physics, also known as High-Energy Physics (HEP). America had at this point in time taken over Europe's leading role in science, and the financial investments involved in HEP projects was beyond the means of any single European country.

[1] For CERN's own comments on Dan Brown's literary work, please see the following website: http://press.web.cern.ch/public/Content/Chapters/Spotlight/SpotlightAandD-en.html

[2] The acronym CERN stands for *Conseil Européen pour la Recherche Nucléaire*, which was a council of representatives from the original Member States. It was this body, founded in 1953, that ordered the building of the laboratory and named it the European Organization for Nuclear Research. However, the original acronym has stuck to the organization ever since. This section is based on CERN's own accounts its history[Hurter, 2004]

This forced Europe to unite and pool its efforts to get science on the old continent back on its feet. Later, more countries joined the organization, and there are now 20 European Member States officially funding the budget, while countries from all over the world are involved through various research contributions.

The field of High-Energy Physics studies the smallest particles of our world, the particles that are the building blocks of our Universe. Many of these particles may not exist under normal circumstances in nature or are not visible. They therefore have to be created during collisions with other particles, as is done in so-called *particle accelerators*. Particles are accelerated to almost the speed of light, whereupon they are collided with each other, causing new particles with extremely short lifetime to be created. Using very sophisticated instruments, these short-lived particles can be detected and analyzed. The detection of such particles can help the scientific community explaining phenomena such as the Big Bang and gravitation.

The great barrier to advancing research in the HEP domain is related to the energy contained by the particles at impact. Following Einstein's relativity theory, the energy is directly linked to the velocity of the particles, the ultimate limiting velocity being the speed of light. More powerful accelerators can accelerate particles closer to this limit, enabling scientist to make further progress in fundamental research: the higher the energy in collisions, the smaller are the particles that are created. The most important function of CERN has therefore always been to provide the scientific community with such facilities, repeatedly building particle accelerators that are bigger, more powerful, more complex, *and* more expensive than previous ones. The biggest accelerator built so far is the Large Electron-Positron collider (LEP), which was constructed as a gigantic ring with a circumference of 27 km, located between 50 to 175 meters below the earth's surface, and operated between 1989 and 2000.

About 3500 people work at CERN, representing a wide range of skills: physicists, engineers, technicians, scientific fellows, students, craftsmen, administrators, secretaries, and workmen. The scientific and technical staff designs and builds the intricate machinery and ensures its smooth operation. It also helps prepare, run, analyze, and interpret the complex scientific experiments. In addition, some 6500 visiting scientists, half of the world's particle physicists, come to CERN to perform their research experiments. They represent 500 universities and over 80 nationalities.

Major achievements at CERN include the discovery of the W and Z boson, for which Carlo Rubbia and Simon van der Meer were awarded the Noble Prize in 1984; and an important breakthrough in the field of particle detectors, later resulting in a medical application. The invention of this detector, called the multi-wire proportional chamber, earned Georges Charpak a Noble Prize in 1992. Today CERN's main focus is on the construction of the next accelerator, the Large Hadron Collider (LHC)[3].

1.2 The Large Hadron Collider

The LHC will be the largest and most powerful particle accelerator ever built, the cost of the actual installations itself amounting to almost 9 billion euros[4]. In addition

[3]For an in-depth study of these discoveries, please take a look at the homepage of the Nobel Prize: http://nobelprize.org/nobel_prizes/physics

[4]This section is entirely based on information from CERN's website web.cern.ch

to this, thousands of researchers are working to prepare the experiments that will use the LHC, and many more will work with the final analysis. In pursuit of some of the most fundamental questions about how the physical world works, the LHC has pushed the boundaries of technology and the scale of science experiments to new extremes.

When the LHC starts operating in 2007, complex radio frequency power will accelerate particles to 0.999999991 times the speed of light. In order to keep the particles on track, over 9000 magnets will create a magnetic field 200,000 times stronger than the earth's own magnetic field. To produce such an extreme field, the magnets will be cooled down to a temperature of -271 degrees Celsius, thereby making the LHC the coldest locality in the Universe.

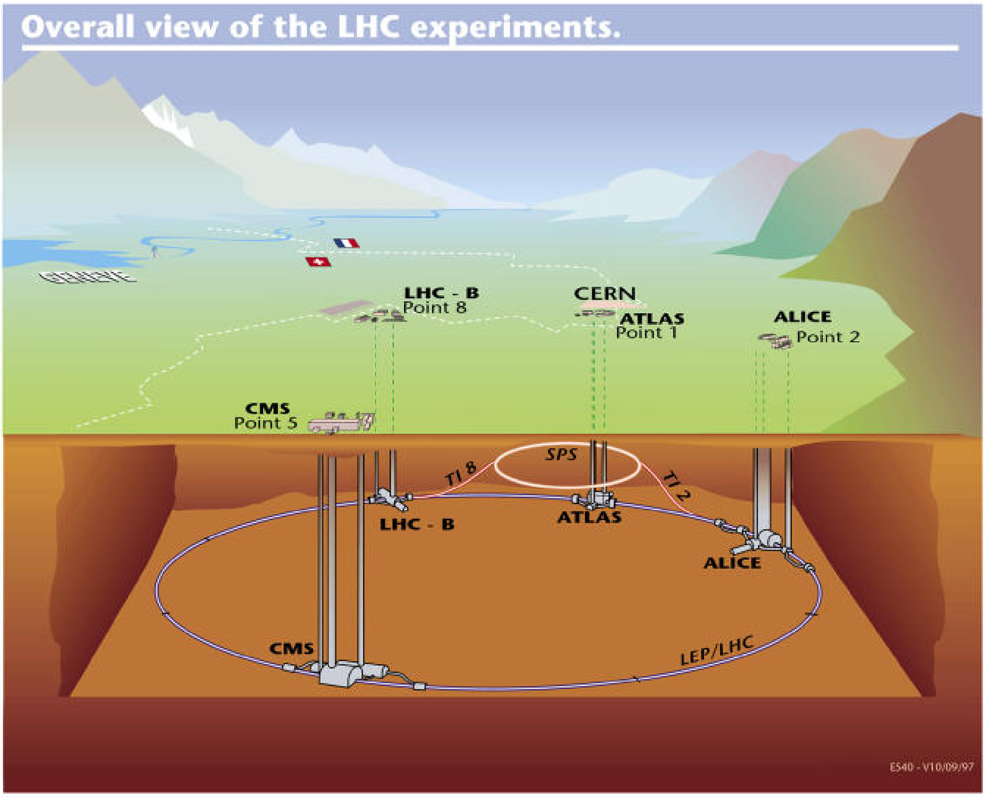


Figure 1.1: Illustration of the LHC and CERN

The LHC is already under construction in the same tunnel that was created for the previous accelerator, the LEP. Each particle will travel around the 27-kilometer ring 11,000 times per second, and collisions will occur up to one billion times a second. This accelerator will generate colossal quantities of computer data, amounting to 10,000 Britannica Encyclopaedias per second. This has forced CERN to look for innovative ways of organizing the data processing, effectively solved by connecting the resources of many computing centres through the Internet. This computing *Grid* ultimately aims at turning the global network of computers into one vast computational resource.

The physics behind what researchers hope to accomplish with the LHC are extremely complex, conveying important questions like: why particles have mass; why the mass we can observe only accounts for 4% of the total mass in the Universe; why our Universe is made of matter and not of antimatter; and what occurred during the first milliseconds of Big Bang. This thesis will not dwell much on this academic field. However, it is important to understand that in the quest for answer to these questions, vast resources, both man-hours and money, are laid down to create one of the modern world's most advanced and sophisticated instruments. The construction of such instruments would never be possible without significant engineering innovations.

1.3 Innovation at CERN

Research includes all activities aiming at invention, thereby discovering *"new means for achieving some function not obvious beforehand to someone skilled in the prior art"* [Kline and Rosenberg, 1986]. According to Mansfield [1971], research can be divided in two broad categories: *fundamental research*, which is an original investigation into scientific knowledge, having no specific commercial objectives; and *applied research*, which is directed towards using scientific knowledge for practical applications.

This way of viewing research is especially relevant for CERN, as the Organization's original mission is vested entirely in the field of fundamental research. Progress in the discipline is directly related to the performance of its experimental facilities, that in turn are determined by the state-of-the-art of the underlying technologies [Barbalat, 1997]. As shown in the previous sections, new experimental facilities, as the LHC, require substantial practical innovations that fall into the category of applied research. Following this, it is obvious that both fundamental and applied research are necessary to fulfil the original mission. Thus, the building of the accelerators occupy most of the scientific and engineering staff working at CERN, in addition to employing a wide network of industrial partners all over Europe. Together, they face construction demands that you find no equivalent to, forcing them to acquire new know-how by collaborating and innovating, thereby pushing the state-of-the-art of current technologies to new levels. It is clear that the technologies developed may have potential applications elsewhere and transferring them from CERN to the public domain has become an integral part of CERN's mission. The next section will introduce how CERN has worked in bringing its technologies to a wider application.

1.4 Bringing CERN's technologies to society

Although fundamental research may eventually prove to have commercial applications [Howells, 1984], it is the applied research at CERN that has stood for most of the innovations with practical impact. For the society to benefit from this activity, CERN needs an active approach towards disseminating the knowledge and innovations it creates. CERN has long been aware of this responsibility and organized, already in 1974, a meeting and an exhibition on the technologies arising from High Energy Physics [Barbalat, 1994]. Moreover, in 1975, it even conducted a study on the economic benefit of its aforementioned procurement contracts with industry, and similar studies has been repeated twice over the years [Schmied, 1975; Bianchi Streit et al., 1984; Nordberg, 1994]. In general, the studies showed an economic return to the companies of three times the original procurement contract, originating from the increased know-how and skills after working with CERN. Similar results have been found at the European Space Agency (ESA), the National Aeronautics and Space Administration (NASA), and at Fermilab: the American equivalent to CERN. Economic turnover for a company is one thing; the training effect of CERN welcoming thousands of visiting scientists is even greater [Bressan, 2004].

The area of technological domains that have benefited from CERN's research is wide indeed, including computer technology, electromechanical engineering, mechanical engineering, material science, superconductivity, cryogenic technology, ultra-high vacuum, and electronics. Today, the story of the World Wide Web (WWW) is the prime example of how the research at CERN has led to practical innovation. The WWW was originally developed at CERN in the late 1980s to provide a common and effective method for the distribution of information between scientists collaborating in physics research. The use of WWW as a way of communicating through the Internet quickly took off without any dissemination effort from CERN, and today it is changing life and cultures all over the world. Other examples of CERN inventions include: innovative vacuum technology that has been used to create more effective solar panels; advanced particle detectors that have been used in the medical imaging application called PET (Positron Emission Tomography); and electronics designs used in laboratory analysis equipment[5]. CERN has also made its GRID resources available for the noble cause of fighting malaria, providing software and free computing power to analyze possible strategies for eradication of the disease.

Chapter summary There is an increasing emphasis on the role of technology in our society and in our economy. Research institutes like CERN experience this trend as governments increasingly want to see and measure the results from putting money into research. Although CERN has long had a clear policy of sharing the knowledge it creates and of publishing all of its results, its member states wanted a more proactive approach in the late 1990s. As a result, a separate unit, the Technology Transfer Group (CERN TT), was set up in 1999 to further formalize the dissemination of technologies from CERN. The next chapter will discuss the concept of Technology Transfer, and compare CERN TT with other Offices of Technology Transfer (OTT).

[5]For a complete account of technologies developed at CERN, please see: http://cern.ch/technologytransfer

Chapter 2

Technology Transfer

In general, the process of commercializing technology is very complex, highly risky, takes a long time, cost much more than you think it will, and usually fails.

U.S. Congress Comitee on Science and Technology, 1985

Technology Transfer (TT) is defined as *"the movement of know-how, technical knowledge, or technology from one organizational setting to another"* [Roessner, 2000]. The proactive TT policy introduced by CERN in 1999 was aimed at *"making known and available to third parties, under agreed conditions, technical developments achieved in fulfilling the laboratory's mission in fundamental research"* [CERN Technology Transfer Group, 2006]. The formation of CERN TT coincided with a wider trend of surging interest in TT, both among academia and policy-makers. Through the comparison of CERN TT with other OTTs at public research institutions, this chapter will validate the approach of developing a general pricing framework.

2.1 What is Technology Transfer?

Bozeman [2000] claims that TT can be understood in terms of: who is doing the transfer, what is being transferred, to whom, and how they are doing it. This broad definition of TT includes not only commercialization of technologies, but also TT between companies, TT between research institutions; essentially all dissemination of knowledge and technology. Moreover, Bozeman creates a model of TT based on his understanding: *The transfer agent* is thus the institution or organization doing the transfer; *the transfer object* is the content of what is being transferred, ranging from scientific knowledge to a specific invention; *the transfer recipient* is the target of what is transferred; while *the transfer medium* is the vehicle used to transfer the technology. The next sections will take a closer look on each of these four dimensions.

2.2 The transfer agent

One of the roots of the surging TT trend, was the enactment of the Bayh-Dole act in the United States in 1980 [U.S. Council on Governmental Relations, 1993]. This act transferred the ownership rights of technology and knowledge generated under federal grants from the funding agencies to the universities, thus providing the latter with opportunities to exploit research results commercially. The act was an acknowledgment of the growing importance of knowledge and Intellectual Property (IP) in the economy. The rationale was that a stronger protection of publicly funded research would lead to a faster and wider transfer of technology, because companies need ownership rights to pick up and commercialize the results of university research[1]. Following the act, most American universities formulated TT policies in the 1980s, succeeded by European institutions about one decade later. A recent study by Carlsson and Fridh [2002] examines the role of offices in charge of implementing such policies, the OTTs, at 12 leading US universities. The study states that all of these have a primary purpose in *"assisting the institution, on behalf of its faculty and inventors, in the dissemination of research results for the public good."* Furthermore, in the words of Smith and Parr [2000], the priorities of most OTTs are: *1) to benefit society, and 2) to make some money*. Clearly, the TT policies at other OTTs have evident similarities with that of CERN TT, characterized by a fundamental trade-off between dissemination and profit-maximisation. Recalling the discussion in our problem formulation, it is a subject of great controversy to decide how the pricing should reflect such a superior goal. However, we will assume that a policy similar to that of CERN, *"aim for market value but favour dissemination"*, sufficiently characterizes the implementation of other OTTs. This latter interpretation is an important part of the TT context chosen for the general pricing framework.

2.3 The transfer object and recipient

The transfer object can take a number of different contents and forms. Normally, a technology is the object of transfer and can, according to Razgaitis [2002*b*], be the basis for a new product or service, provide an enhancement to an existing product or service, or result in cost savings. In addition, due to the fundamental nature of much public research, the transfer object is often scientific knowledge with no immediate commercial potential. This is especially true for CERN, whose original mission is entirely placed in fundamental research. Although this is probably an important difference between CERN and other public research institutions, the focus of this thesis is licensing of technology with an economic benefit for a licensee. For such technology, the transfer recipients can broadly be grouped in two: other research institutions and commercial companies. The scientific community is not only the recipients of purely scientific knowledge: CERN's innovations also have clear value for similar institutions building smaller accelerators. This could also be true for other OTTs, although the massive cost of infrastructure in High-Energy Physics makes this field a somewhat extraordinary example. However, in this case, CERN has a clear policy of making technology easily available, asking only a price that covers transfer costs. In CERN's case there is therefore no need for a pricing framework for such licenses. On the other hand, the pricing framework would be equally applicable for OTTs that do aim at market value in such situations. Nevertheless, in this thesis the focus is on technologies with a clear commercial potential. In this regard, there is no particular difference between CERN TT and other OTTs.

[1]For a deeper discussion of the importance of Intellectual Property Rights in the modern *knowledge economy*, please see Appendix A.

2.4 The transfer medium

According to [Bozeman, 2000], there are 3 main vehicles used by public research institutions when commercializing their technologies:

- *Cooperative R&D agreements* between the public research institution and an industrial partner aim at developing a technology into a commercially viable project. Such agreements can be especially important because the research institution can offer unique research facilities and know-how. The agreements clearly stipulate the conditions of exploitation of IP developed in such a partnership. At CERN, such agreements are widely used because further development is often required.
- *R&D consortia* are in some ways similar to cooperative R&D agreements but are more formalized, generally involving many different institutes, universities, and industrial partners. The research undertaken by such consortia has a high profile, often aiming at domains of great social importance, and is in CERN's case often funded by the European Union or other public funding institutions in its Member States.
- *Licensing* of IP is one of the most common approaches employed in the quest to disseminate knowledge and technologies. The technology in question is typically more mature than in R&D agreements and has a clear market potential. Such agreements normally include technical consultancy in order to facilitate the effective transfer to the industrial partner.

Besides these three groups, we should point out a few others. *Contract research* agreements are used when the industrial partner pays to have a research project performed. They are generally used by institutions that rely on private funding for their existence, and are thus not used at CERN. In addition, CERN occasionally engages in direct *technology supply* agreements on a temporary basis when no industrial partner is able or willing to produce CERN-developed technology. In this case, CERN can sell products to commercial and scientific customers on a small scale, however it prefers to avoid this supply role. It is not clear to us how common such a practice is at other research institutions. Finally, an important vehicle used by many OTTs, is to establish and finance separate *start-ups* to commercialize some promising technology. CERN's mandate does not allow it to take such an active role in industrial development, hence this vehicle has never been used by CERN TT. Other TT vehicles also exist, but they have less importance in the process of commercializing technology.

The analysis in this section illustrates that CERN employs many of the same transfer media as other research institutions, although some different practices are clearly present. However, in this thesis, the focus is purely on the licensing of technology, for which no fundamental difference between CERN TT and other OTTs exist. The next section will now describe the work process most OTTs follow when commercializing technology through the medium of licensing.

2.5 The commercialization process

In general, OTTs at public research institutions have very similar work processes. An analysis of such processes used by leading universities [MIT TLO, 2006; Stanford OTL, 2006; Berkeley TTD, 2006], in addition to those outlined by academia [Smith and Parr, 2005; Carlsson and Fridh, 2002], broadly indicate seven different phases in the commercialization process, illustrated by figure 2.1.

Figure 2.1: The licensing/commercialization process

All processes start with the *research* performed by the institutions, often leading to some invention perceived as valuable to entities outside the institution. *Invention disclosure* is the written notice of such an invention to the OTT, which is the starting point of the formal TT process. This document explains the main characteristics of the invention, so that personnel working at the OTT can learn about the technology. *Assessment* is the period during which the OTT reviews the invention, conducts patent searches, and analyzes the market and alternative technologies to determine the invention's commercialization potential. The information gathered during this assessment is a basis for sound decisions in following steps. *Protection* is pursued to encourage third party interest in commercialization. Normally this will lead to patent protection if a commercial potential can be expected. *Marketing* consists of the identification of candidate companies that have the expertise and resources necessary to bring the technology to market. If an interested company is found, the actual transfer between the agent and the interested company takes place in the *licensing* phase. The recipient is thus ascribed certain rights to use the technology through a license agreement. The *follow-up* of such license agreements may require further development, during which support and training of the recipient may be necessary, as well as follow up on the financial conditions laid down in the agreement.

The commercialization process used by CERN TT is based on the same approach and builds on the experience reported by other OTTs. Although taxonomy may vary somewhat, it more or less follows the same steps as described above. Figure 2.2 shows a conceptual model of the main steps in this process, while Appendix B details all these steps with the relevant sub processes.

Figure 2.2: CERN's goal directed TT process

As can be seen, CERN TT splits the assessment phase into a *Technology Assessment* phase and a *Market Analysis & Technology Pricing* phase. The rationale for such a split is that the former is an initial assessment leading to the formulation of an IP strategy, which is then followed by a more thorough assessment of market and value of the technology. The *transfer* phase corresponds to the licensing phase, while the other phases are identical to the ones described above.

Chapter summary This chapter has compared CERN TT with other OTTs through the analytical model of Bozeman, giving due consideration to aspects concerning the transfer agent, transfer medium, transfer object and transfer recipient. While the discussion reveals that there are some differences, the chapter precisely defined the TT context chosen for this thesis, summarized by figure 2.3. The discussion showed that for this context, CERN TT and other OTTs are very similar indeed, validating the approach of developing a general pricing framework. Next chapter will proceed with an analysis of what characterises pricing in such a context.

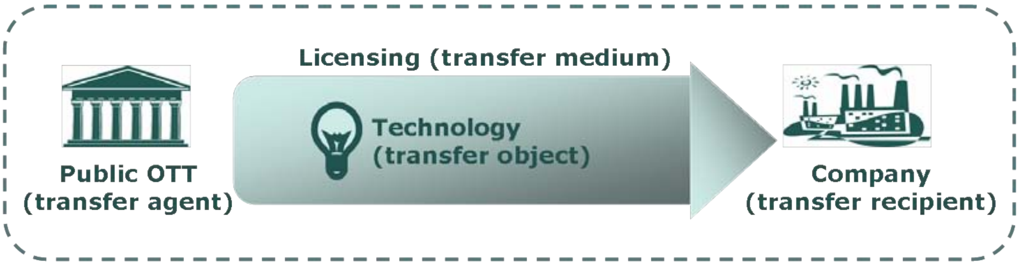


Figure 2.3: The chosen TT context

Chapter 3

Analyzing the chosen TT context

Before I came here I was confused about this subject. Having listened to your lecture I am still confused. But on a higher level.
Enrico Fermi, Italian physicist (1901-1954)

Following the two previous chapters, any confusion about the context in which we will develop a pricing framework should be cleared away. Consequently, we hope that it is the understanding of the subject that has been brought to a higher level. This chapter will continue the analysis by outlining the characteristics of pricing in the chosen TT context. It will also present examples from CERN's licensing practice that illustrate the analysis. Hopefully, this will further clear away all remaining confusion about which challenges we are facing when developing the pricing framework.

3.1 Pricing characteristics

TT policy Clearly, the most important characteristic of the chosen TT context is the pricing policy, which chapter 2 summarized as: *aim for market value but favour dissemination.* This policy was the origin for writing this thesis, and has been duly discussed, both in the introduction, and in the previous chapter. Nevertheless, let us repeat ourselves one more time: *the pricing framework has to implement the indicated TT policy.*

Technology licensing Since the purpose of this thesis is to establish a framework for the pricing of licenses, there are some terms that deserve a clearer definition: Licensing can be defined as *"the granting to others the right to use Intellectual Property in association with a particular product or service, for a given period of time, in a specific geographic territory"* [Anson and Suchy, 2005]. Moreover, in a license agreement, the owner of the IP is called the *licensor*, while the recipient is called the *licensee.* The licensee clearly expects to create some value with the acquired IP, and the licensor normally claims a royalty on this value. Royalty is therefore defined by the American Heritage Dictionary as *"a share in the proceeds paid to an inventor or a proprietor for the right to use his or her invention or services."* Such royalty payments may take several forms. Briefly, the most common structure is one where parts of the licensor's royalty are paid as lump-sums, either up-front or at some specified time, and parts are paid as a running percentage of revenue. We will call such a series of royalty payments as *royalty structure*, and it is effectively the price of the license agreement. Hence, in order to be suitable in the chosen TT context, *the pricing framework has to integrate considerations of an appropriate royalty structure.*

Negotiation setting Furthermore, the negotiation setting is inseparable to licensing. Since the licensing object normally is more complex than standardized off-the-shelf products, an initial price proposal is seldom accepted without discussion. Moreover, there is potentially information asymmetry between the parties regarding technical details and market outlook. Negotiations are a way of solving that issue by building trust and sharing information, especially important since licensee agreements normally are long-term arrangements. During such negotiations, the price will inherently change: from the initial price proposal, through counterproposals, till the final price is agreed upon. To get the best deal possible, it is vital to spend time and resources on a preparation phase, estimating both the highest price one think one may get from the licensee, and the lowest price one is willing to accept. This means pricing of licenses is more than the pure exercise of calculation but rather a long and complex process of: gathering and assessing information, preparing for negotiations, but also revaluate one's pricing during negotiations. *The pricing framework should thus accommodate that pricing is a process.*

Non-/Exclusivity The next characteristic is that of exclusivity. In line with their goal of dissemination, most OTTs would like to avoid awarding exclusivity in market domains or geographical coverage [Smith and Parr, 2000]. Since they are funded by public money, they feel that several companies should benefit from the technology in question, and, in some cases, that makes perfectly sense. In this regard, Katz and Shapiro [1986] analyze in a game-theoretic model under which circumstances a research institution will give away too few licenses. Their results show that this will happen when a technology is a cost-reducing process, because in this case, social welfare is maximized when everybody has access to the technology. However, as section 2.2 pointed out, companies do prefer to either own or have exclusivity in IP rights when commercializing risky technologies. Thus, when the only viable path to successful commercialization seems to require the protection from competition that exclusivity gives, most OTTs are ready to award exclusivity[1]. We will not discuss the rationale for their approach, neither from a micro economical nor a welfare economical perspective, but take for granted that *the pricing framework should distinguish and support both exclusive and non-exclusive licenses.*

Early-stage technologies A further complicating aspect for pricing in the chosen TT context, is the early-stage nature of an OTT's technologies. However, we are not talking about commercializing scientific knowledge, as this might have a time perspective of several decades. Rather, the OTT's technologies normally derive from the operational activities related to its research. For instance at CERN, exploring truly fundamental matters, most technologies result from the development of increasingly sophisticated equipment for measuring and performing the experiments

[1]For CERN, its international nature further complicates this, as all funding countries want a fair return from CERN's technology transfer activities. For this reason, CERN TT has the principle of Equal Opportunities; specific routines for informing national representatives and giving equal access to picking up the technologies developed. Exclusivity may still be given for specific domains when deemed necessary for a successful commercialization or when the technology is the result of a partnership.

and not from the fundamental research itself. These technologies are already applied in some sense and working prototypes exists, but further development is still needed to get a commercially viable product. This clearly affects the pricing framework, as *it needs to assess the stage of development and determine the resulting impact on a suitable price.*

Limited market information Related to the early-stage nature of an OTT's technologies is the aspect of limited market information. Since the technologies normally are quite immature and require further development, it may not be clear to the OTT which markets that are attractive. Earlier in the commercialization process, this may cause difficulty in promoting the technologies to industry, and in the licensing phase it will make the pricing exercise harder. When it is unclear how the licensee intends to use the technology, what the potential market size is, or how profitable the agreement will be, estimating the market value of a technology will be very hard indeed. It is however likely that different methods for estimating market value will vary in their dependency on information. *The pricing framework should thus include and employ several methods to ensure that it can cope with limited market information.*

Variations in technology utility Lastly, as the two previous characteristics implicitly show, there may be great variations between technologies. This variation regards several aspects of the transfer: the technical uncertainty of further development, the market uncertainty of customer adoption, the strength of Intellectual Property Rights, the competitiveness of the technology, the licensee's profit margins, and many more. All these aspects represent, in one way or another, either the potential profitability of the license agreement or the associated risk. Bundled together, we will call them of *a technology's utility.* However, it may be hard to judge the impact of technology utility on the market value, especially for TT professionals at an OTT, who often have limited background and experience from finance. *The pricing framework should therefore employ a coherent approach to risk and profitability across all methods.*

This chapter has so far highlighted the characteristics of pricing licenses in the chosen TT context, summarized by table 3.1. The next section will provide some examples from CERN that illustrate these points. This information is confidential, however, and not available in the public version of the thesis.

Characteristics	Effect on pricing framework
TT policy	Aim for market value but favour dissemination
Technology licensing	Integrate royalty structure considerations
Negotiation setting	Accommodate that pricing is a process
Non-/Exclusivity	Distinguish and support both
Early-stage technologies	Assess stage of development
Limited market information	Include and employ several methods
Variations in technology utility	Coherent approach to risk & profitability

Table 3.1: Characteristics of pricing in the chosen TT context

Chapter 4

Summary of Part I

Everything that can be invented has already been invented.
Charles H. Duell, Commissioner, US Office of Patents, 1899

Since its creation in 1954, CERN's mission has been to build and operate particle accelerators for research on the fundamental building blocks of our Universe. **Chapter 1** presented a brief introduction to the institution and its achievements. The current project, the Large Hadron Collidor, is uniting scientists from all over the world in building the most advanced and powerful accelerator to date. In this process, CERN generates new scientific knowledge and *inventive* technologies with a wider potential to society. The World Wide Web is the prime example of a spin-off from particle physics that has had the most far-reaching consequences for our daily life. There is clearly a potential for companies in different industries to benefit from the technologies developed through CERN's activities, and CERN has long been conscious of its responsibility for sharing its knowledge and technologies.

An active policy for Technology Transfer (TT) was introduced at CERN in 1999, with the creation of the Technology Transfer Group (CERN TT). **Chapter 2** analyzed the concept of TT and defined the TT context chosen for this thesis. It did so by discussing the four dimensions of TT: *The transfer agent* is an OTT of a public research institution; *the transfer object* is a technology that can be the basis for a new product/service, provide an enhancement to an existing product/service, or result in cost savings; *the transfer recipient* is a commercial company, seeking an economic benefit through the deal; and finally, the transfer medium is licensing. Furthermore, a comparison of CERN TT with other OTTs was provided throughout the chapter, concluding that for the TT context chosen, no fundamental differences exist. Hence, the chapter validated the approach of developing a general pricing framework.

Chapter 3 continued with an analysis of the characteristics of pricing licenses: the TT policy of aiming for market value but favouring dissemination; the royalty structure consideration necessary when licensing; the fact that pricing is a complex process; the difference between non/-exclusive licenses; the early-stage nature of technologies spinning out from public research; the limited market information normally available; and the large variations in technology utility. Table 3.1 summarized these findings which will be considered when developing the pricing framework in part II. The chapter also provided an empirical study of three licensing cases from CERN TT that illustrated these pricing characteristics.

Part II

A framework for pricing of technology licenses

Chapter 5

A conceptual model

Beginning is easy - continuing hard.

Japanese proverb

Part I laid the foundation for the pricing framework through the analysis of relevant pricing characteristics, and part II will now *continue* to develop the framework. This chapter starts the development by presenting a conceptual model, directly accommodating the three most essential characteristics discussed by part I: the goal of dissemination, the negotiation setting, and the technology licensing situation. The chapter will also outline the structure of further analysis, at the same time introducing how we will take care of the remaining pricing characteristics.

5.1 Building the model

The pricing of licenses in the chosen TT context is inherently linked to the negotiation setting. For a structured analysis of such a setting, we will introduce the ZOPA model (zone of possible agreements) from standard negotiation literature [see for example Thompson, 2001]. The higher value on the deal line in the model represents the value to the licensor, see figure 5.1[1].

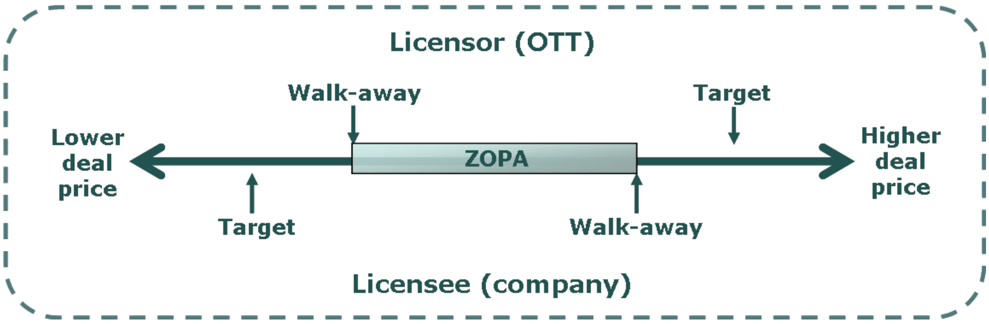


Figure 5.1: The ZOPA model (zone of possible agreements)

[1]Several other authors have analyzed licensing using such a model [see for example: Neil, 1997; Degnan, 1998; Megantz, 2002; Paulsen, 1997].

In its simplest form, the model is a one-dimensional way of viewing the value accruing to each of the two parties involved in the negotiations. Clearly, there are other considerations in negotiations than the pure monetary terms, but in this thesis we focus only on the pricing aspects of licensing. Consequently, for the chosen TT context the model is a representation of the negotiation of an appropriate price. We see that the licensor, an OTT, and the licensee both have a target price and a walk-away point along the line. The ZOPA is then the area between the two parties' walk-away points. Obviously, in an extreme case, there could be no ZOPA, and the negotiations would end quickly. It is also important to note that the model represents the view of the all-seeing observer, since no party is likely to know the other's walk-away point, nor target. The walk-away point is also referred to as best alternative to negotiated agreement (BATNA).

The model also visualizes the long and complex process involved in the pricing of licenses. As outlined by chapter 3, the preparations previous to negotiations involve both the gathering and assessing of information, forming the basis for *estimating an appropriate target price*, in addition to *consideration of a suitable walk-away point*. However, negotiations consist of several rounds of proposals and counterproposals to probe the opponent, causing the need to revaluate one's pricing. The process starts by one party quoting a price, potentially well above the actual target in order to anchor the following negotiations, and the final price can vary greatly depending on the negotiation styles and stances of the parties involved. This dynamic situation can be quite intriguing, but a study thereof is clearly out-of-scope for this thesis. Thus, we will make the simplified assumption that the *initial price quoted by the licensor is equal to target price* in the model. We will also *focus solely on the part of the pricing process that takes place before the negotiations start*, essentially the preparations to the negotiations.

However, in technology licensing a single value on the transfer, as represented by this one-dimensional model, is quite unusual. It would represent a license agreement paid fully upfront, which may happen, but is rare. Rather, as emphasized in section 3.1, *the royalty structure is effectively the price of the license.*

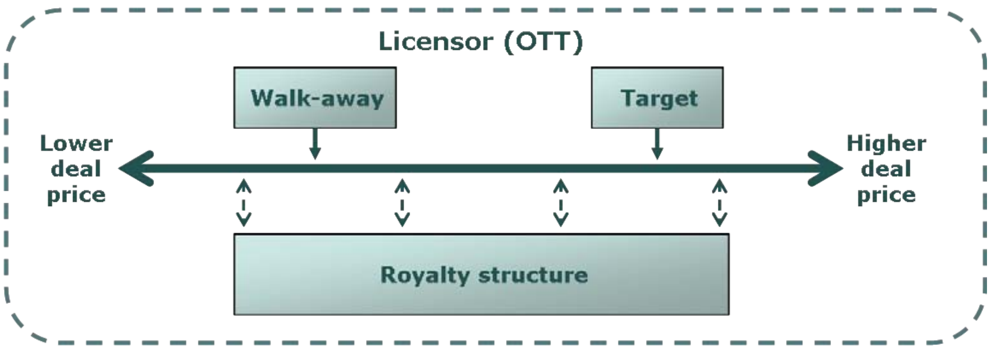


Figure 5.2: The extended ZOPA model

This analysis leaves us with three fundamental aspects of the pricing framework, 1) The target price, 2) The royalty structure, and 3) The walk-away point, as illustrated by figure 5.2. We will now analyze this extended ZOPA model in relation to the most important pricing characteristic, the TT policy, thereby transforming the ZOPA model to the conceptual model of the pricing framework.

Clearly, aiming for market value means that the OTT should base the target price on a market value. However, the exact relation might not appear to be so clear immediately. For a private company, it would make sense to set a target well above the market value in order to attain the highest possible final price. Although this might scare away some licensees, it might still be an optimal strategy over time. However, for a public OTT, this would necessarily be sup-optimal: The OTT is required to favour dissemination, hence any advance that could compromise the deal should, if possible, be avoided. On the other hand, any target price below the market value would not be compatible with the policy of aiming for market value. We will therefore claim that the only approach consistent with the TT policy is to *set the target price equal to the market value.* Furthermore, the walk-away part of the framework will analyze *how far an OTT should stretch in order to favour dissemination.* To some extent, the largest impact of this dissemination perspective is exactly on the walk-away point. Lastly, several combinations of lump-sums and running royalties correspond to the same value, but these different royalty structures may be very different in terms of how they facilitate dissemination. Hence, the third conceptual part of the framework will analyze *what kind of royalty structure favours dissemination.* Conceptually, this is equally relevant along the entire deal line of the model, but it is of course most relevant for to the translation of market value into an appropriate royalty structure.

This concludes our discussion of the pricing framework on a conceptual level. Nevertheless, this section has emphasized a *cardinal* point of this thesis, namely how the pricing framework will accommodate the TT policy, the most important pricing characteristic of the chosen TT context, and, furthermore, the origin for writing this master thesis. The conceptual framework is summarized figure 5.3, which also outlines the structure of further analysis.

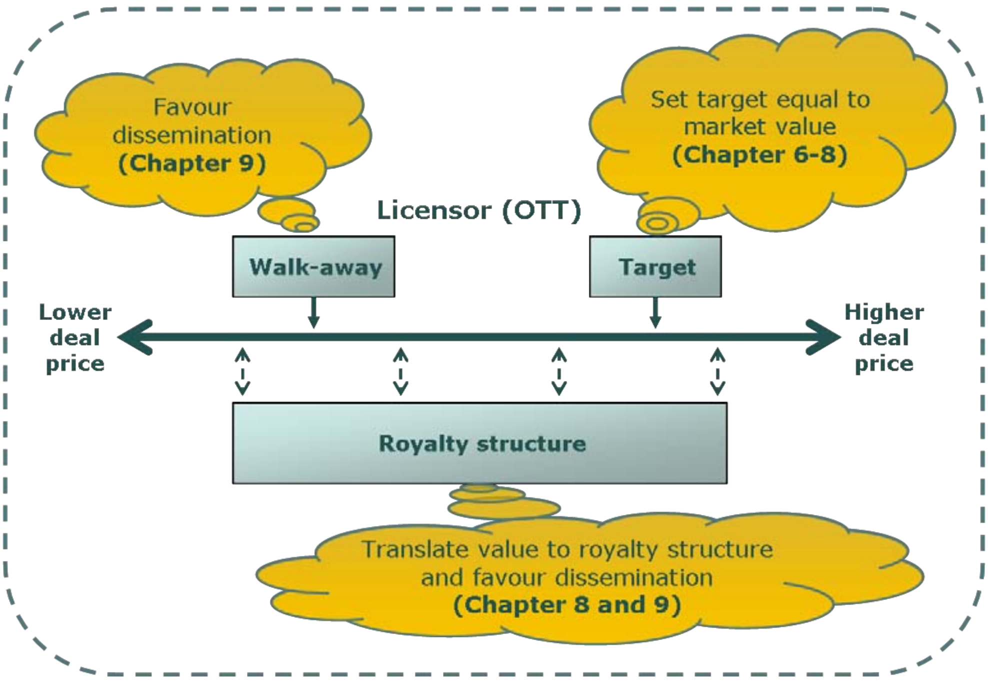


Figure 5.3: Conceptual model of the pricing framework

5.2 Structure of further analysis

In order to deduce the target price, the framework has to estimate the *fair market value* of the technology. From licensing literature, such a value is often defined as: *"the amount at which a property would exchange between a willing buyer and a willing seller, neither being under compulsion, each having full knowledge of all relevant facts* [Smith and Parr, 2000]. Different valuation methods used for finding this market value will therefore be the foundation of the pricing framework, and the main part of the further analysis. Chapter 6 will start by discussing the most commonly used methods for valuation of Intellectual Property and choose those that can be used in the chosen TT context, characterised by early-stage technologies and limited market information. Chapter 7 will then discuss how to assess variations in technology utility, while chapter 8 will describe the proposed pricing framework in detail. The chapter will furthermore leverage the results of chapter 7 to create a coherent approach to risk & profitability, at the same time relating the framework to both exclusive and non-exclusive licenses. For each of the valuation methods, we will also present how to translate the estimate of value to a corresponding royalty structure. However, the general analysis of what royalty structure that will favour dissemination will not be performed until chapter 9. That chapter will also present an analysis of how to evaluate an appropriate walk-away point. Finally, chapter 10 will summarize the entire framework by describing how to use it, effectively outlining the process of pricing.

Chapter summary This chapter has presented the conceptual model of the pricing framework, giving due consideration to how it will account for all of the pricing characteristics laid down by part I. We have shown how pricing can be viewed as three complementary aspects: the target price, the royalty structure, and the walk-away point. The next chapter will begin the analysis of what will be the main focus of the remaining chapters; the estimation of a fair market value.

Chapter 6

Choosing suitable valuation methods

Valuation methodologies can be compared to Grandmother's chicken soup. Everybody has a recipe, but no one agrees on what to put in.
Anson and Suchy [2005]

The previous chapter presented our conceptual model of the framework and outlined the structure of our further analysis. Furthermore, it explained why valuation should be the basis in setting a target price, even for OTTs with a dissemination perspective. This chapter will focus on how that underlying valuation can be performed by studying the literature on Intellectual Property (IP) valuation and by evaluating which valuation methods are suitable to the chosen TT context. The discussion will not go into detail on the calculations of each method, but remain on a more abstract level. For those interested, we refer to the seminal work of Smith and Parr [2000] and Samuelson [1964].

6.1 The main valuation approaches

The literature generally groups IP valuation methods in three main approaches: cost, market, and income [Smith and Parr, 2000; Razgaitis, 2002*b*; Anson and Suchy, 2005; Reilly, 1995].

Cost The cost approach gives an indication of a technology's value by considering the costs involved in its development. It is based upon the economic principle of substitution, assuming that *"an investor will pay no more for an investments than the cost to obtain an investment of equal utility"* [Reilly, 1995]. However, much of the literature criticizes this approach: *"What is the true cost? A negligible cost of a moments insight or the sum total cost of the educational and experience of a lifetime?"* [Anson and Suchy, 2005]. Although some authors dismiss all cost measures, there is a general consensus that the cost approach is more than just merely adding up all the receipts associated with the R&D and that it may give some indication of a licensee's willingness-to-pay. It may thus be justifiable in combination with other approaches, even though it contains some severe limitations. Most importantly, it does not consider a technology's profitability or risk.

Market In the market approach, indications of value are developed by considering the price at which property with similar technologies have exchanged in arms-length transactions [Parr and Smith, 1987]. The term "arms-length" relates to transactions where the parties are either unrelated or conduct the deal as if they were unrelated, so that there is no question of a conflict of interest[1]. However, the technology's risk and profitability are only indirectly reflected in the valuation. Thus, one can only assume that such factors were estimated by the market in previous exchanges. The market approach is very useful if the asset in question is commonly traded and market data is available, like the case is for commodities as stocks, cars, etc., but also for IP assets as trademarks and brands. In this case, the market has determined the value and one can easily use this to value the asset.

Income The income approach is based on the economic principle of anticipation, or expectation, [Reilly, 1995], meaning that all methods in this group base their value on an estimation of the expected income. While the simpler methods only consider the potential profitability of the technology, the more advanced methods also account for its associated risk through discount rates and probability distributions. The latter are also the most academically sound methods available, but they require a considerable amount of information, and may thus not be appropriate for all license agreements.

6.2 Cost approach

6.2.1 Historical cost

The historical cost method basically aggregates all of the receipts for expenditures associated with the R&D. This cost measure has been used in licensing as a measure for value as the licensor naturally would like to be compensated for all costs born.

The method is seen as a bad proxy for value by all relevant literature. There is no linkage between the R&D expenditure used to develop a technology and the potential economic value it may have for a third-party. This is especially true for research institutions with a mission of fundamental research like CERN. The aggregated R&D costs in such institutions are massive, and practical innovations derived from this research are just by-products. In such cases, it is extremely difficult to decide which costs that were actually relevant to the development and which that were not. The selection of relevant costs may be easier in an institution with applied research as its mission, but, in any case, such costs can be largely out-of-date. In addition, this method does not account for the utility of the technology, neither risk, nor profitability.

The above discussion indicates that the historical cost method is not a suitable for the valuation of IP in any situation, and especially not in the chosen TT context.

[1] This is similar to the definition of value in the previous chapter 5

We will therefore not include it in the pricing framework.

6.2.2 Replacement cost

The *replacement cost* method measures the cost necessary to develop any asset with similar utility to the technology in question. When one can assume that candidates for substitution exist, meaning candidates with similar utility, the replacement cost method may give some indication of economic value. However, the method is quite complex: all aspects of obsolescence need to be addressed since better technologies may have been developed; opportunity costs related to faster or delayed market entry need to be included; and some consideration of the probability of success must be made. If all such elements are taken into consideration, the exercise does in fact aim at determining the value of the IP in the marketplace. The problem, however, is the economic principle of substitution underpinning the method. For most innovative technologies, candidates for substitution rarely exist, and thus the validity of this method is questionable. Still, a cost approach is often seen as useful for early-stage technologies, precisely because no specific market application can be identified [Anson and Suchy, 2005; Drews, 2001]. In such cases, the replacement cost approach has often been seen as a valuable method.

In a licensing situation, of which negotiations are an important part, replacement cost may give valuable insight into the position of the licensee. However, we should discuss the *modified replacement cost* (MRC) method, as it simplifies the necessary calculations.

6.2.3 Modified replacement cost

Betten [2000] offers an attractive modification of the standard replacement cost method. In this method, the inventor is asked to estimate how much time and equipment he would need to recreate the technology in question if he would have changed job. Let us take a closer look at what such a method implies.

Although the standard replacement cost method is sound in certain situations, and can be useful for an OTT, great difficulties will still remain in deciding what costs to include. It may pose serious challenges to account only for the costs strictly relevant to the development of the technology, not to say accounting for the effect of obsolescence and quantifying the opportunity cost. The danger remains that too many irrelevant costs will be accounted instead of the most important ones. By using the modified replacement cost (MRC) method, a cost estimate will inherently take into account the technical improvements made and how much more efficient the research community has become. By focusing on the minimum costs necessary to replace the technology, it should be easier to employ cost as a benchmark for value. In any case, whatever cost approach ones chooses, it will still remain a severely limited way of valuing a technology, as it does not consider the economic benefit of the technology.

Based on the above discussion, we feel that the modified replacement cost method should be included in the framework, bearing in mind its limitations. It should, in fact, never be used alone, but rather as a complement to other methods. We further feel that the MRC method can be included at the expense of the standard replacement cost, mainly for two reasons: firstly, the modified method provides a practical way of estimating the cost; secondly, it is better to be prudent when including costs, considering the general drawback of the cost approach. The MRC method is basically a conservative way of quantifying the effort in developing a technology, and the assumption is that the level of this effort could indicate how much a licensee is willing to pay.

6.3 Market approach

6.3.1 Market comparables

The basic idea of this method is to find a historical market transaction that is comparable to the one currently being valued. The assumption is that the price of the comparable transaction represents a valuation, and therefore the present technology should have roughly the same value.

The first problem with this type of valuation is that you can never be sure if the price of the comparable transaction actually reflects market value. Many other considerations, hidden to us, could have influenced the transaction price. Nevertheless, being aware of this weakness, the method does provide a benchmark. However, market comparables rarely exists for the innovative and early-stage technologies spinning out from research institutions. Furthermore, if such deals exist, information about them is normally not publicly available.

For the aforementioned reasons, we conclude that the market comparables method is difficult to use in the chosen TT context and will therefore not be included in the pricing framework.

6.3.2 Paradigm licensing

Paradigm licensing is in many ways a variation of the market comparables method. Instead of searching for a single comparable deal, the appraiser classifies the technology in an industry, whereupon he uses the existing *royalty rate paradigm*, the standard royalty rate used by professionals working in the industry, to perform the valuation.

Several studies have confirmed that there seems to exist such paradigms [Sullivan, 1994; McGavock et al., 1992; Degnan and Horton, 1997; Razgaitis, 2003*b*]. However, they all conclude that there tend to be a wide spread around the average royalty rate. Thus, when using the paradigm licensing method for valuing a technology, only a *royalty range* common for similar technologies can be reasonably established, leaving it up to the judgment of the appraiser to decide where in that range one should aim. There are several highly recognized books published every year, presenting updated data on royalty rates in different domains [Grimes and Battersby, 2004; Parr et al., 2004]. However, some authors have pointed out the limitations of the method [see for example Parr, 1990], highlighting that it omits considerations of the technology's potential profitability and associated risk, in addition to neglecting a changing economic environment which could alter reasonable paradigms through time. Nevertheless, it still remains a widely used method in cases where limited information makes more advanced methods unfeasible.

Considering the chosen TT context, where limited market information often is the case, we conclude that the method should be included in the pricing framework, since it actually requires so little of it.

6.3.3 Auctions

Auctions have been used since ancient times to determine the value of goods offered for sale. It is essentially a market approach, as the price is determined directly by the market, the difference from other market approaches being that the auction method uses pending offers for precisely the IP in question, thus giving a direct valuation.

In principle, this method is excellent, but it does necessitate an important presumption: The licensor must enjoy a certain bargaining power on interested licensees [Razgaitis, 2002*b*]. Such a bargaining power normally means having several interested companies that may be played up against each other. For most of an OTT's technologies, this is hardly ever the case. The technologies are of an early-stage nature, and a lot of marketing effort needs to be performed to attract some third-party interest. This means that only for the most attractive technologies does it make sense to apply the auction method. Moreover, the method is best suited for exclusive licenses, since for non-exclusive licenses, no bidder has the incentive to "win." Furthermore, for a sound application of the auction method, the bidders should have access to detailed information about the asset, allowing them to price it accordingly. Again, for the early-stage technologies of the chosen TT context, this extent of information is seldom available.

Based on the above discussion, we will not include the auction method in the pricing framework, but we do suggest it be considered for exclusive licenses on very attractive technologies. However, its application no longer involves a pricing exercise, since the OTT only need to facilitate the process.

6.4 Income approach

6.4.1 Profit sharing analysis

Profit sharing analysis values the IP based on a reasonable split of the licensee's expected profits from employing the IP. The *25% rule* is the most known subset of this method, suggesting that the reasonable split between licensee and licensor is 75-25. This rule has also been called the *"most famous rule-of-thumb for license valuation"* [Razgaitis, 2002*b*]. The underlying argument for that exact split is the amount of risk taken by each party in a typical licensing deal.

There is broad historical evidence confirming that the 25% rule has been used for a long time both in licensing business [Davis, 1958] and in litigation law [U.S. Circuit Court of Appeals - 6th, 1938]. Numerous articles have been written about the factual underpinnings of the rule, most recently by Goldscheider et al. [2003]. The authors study industry statistics and conclude that the ratio of royalty rates over operating profits seem to be around 25% across different industries. Furthermore, they conclude that, rough as it is, the rule is a valuable tool when market information is limited. However, some authors disagree strongly and point out that the rule lacks explicit consideration of the technology's utility. Profitability is taken into account only partially through an analysis of the licensee's profit margin, while risk is treated implicitly through the profit split. Other authors suggest that rather than applying a precise rule, the utility characteristics of the technology should indicate the exact profit split within a reasonable range, typically in the order of about 10% to 40%, or even 50%, of operating profits.

Profit sharing analysis clearly offers insight into the profitability of the licensed technology and is applicable in the negotiation setting confronting an OTT. Although the method is simple, it is suitable in cases of limited market information and we will therefore include the method in the pricing framework.

6.4.2 Discounted cash flow

The discounted cash flow (DCF) method is one of the most academically robust valuation tools available, thoroughly explained and discussed by academia, and widely used in practice [for a thorough description, see Brealey and Myers, 2000]. The DCF method values a project by determining the *net present value* (NPV) of future cash flows, discounting such cash flows with a rate that reflects both: the *time value of money*, people prefer money sooner rather than later; and risk, people prefer certain cash flows to uncertain ones.

The DCF method is a very powerful and sound approach to license valuation, taking into account both the technology's expected profitability and its associated risk. The main drawback is that it requires information on cost structures and market prospects that can be difficult to get or estimate. The second problem is how to choose an appropriate discount rate based on a technology's risk profile. This is not easy, and much finance literature has criticized the DCF method for not dealing with risk in a consistent way [Fama, 1996], further discussed in chapter 8. Furthermore, since the commercialization of early-stage technologies is especially risky, a careful risk-adjustment is crucial to arrive at a sound valuation.

Although the application of the DCF method may be challenging in cases of limited information, it is clear that the method should be included in a pricing framework. It is the most promising method treated so far and a widely used valuation tool in industry.

6.4.3 The formula method

The formula method is frequently referred to in the literature and used by the US tax authorities for accounting purposes. It calculates the value of a company's intangibles by comparing its average profits with the average profits of the industry. A percentage return on the company's assets is typically determined by using a period of 5 years immediately prior to the valuation date. The average profits of the industry is then deducted from the company's return, and this excess return, if any, is considered to be the return relating to the intangible assets. The method then suggests finding the present value of a stream of such returns continuing infinitely. This is thus the value of the intangible assets of the company.

However, for valuing licenses on new technology, the method is clearly unsuitable, since it assumes a running business. The method is therefore discarded from the pricing framework.

6.4.4 Venture capital method

This method derives it name from the fact that venture capitalists employ it when valuing a start-up company, including its intangible assets and thus technologies. It starts by first setting a target for its value at a future point in time. Next, the current value is estimated by discounting this amount and taking into account future anticipated dilution. The venture capitalist then uses this value to estimate the amount they are willing to invest for a certain share of the company. Usually, discount rates used in this method are considerably higher than public stock return rates, illustrating that significant returns on investment must be achieved in order to compensate for the high risk of funding infantile companies.

Although attractive for IP valuation from the perspective of an investor in a start-up, the method has no immediate application in a technology licensing situation. We will therefore not include the method in the pricing framework.

6.4.5 Relief from royalty

The *relief from royalty* method is much referred to in the literature on IP valuation. It suggests valuing the technology of a company by calculating *"the present value of the royalties that the company is relieved from paying as a result of owning the assets"* [Anson and Suchy, 2005]. The underlying assumption is that if the company would not have owned the technology, it would have needed to license it, thereby forcing it to pay royalties on the income stream. The method is normally used to value the intangibles of a company for accounting purposes or to establish damages in litigation cases. In a licensing situation, this method offers no help at all, since it essentially works backward. If one knows the royalty rate that should be assigned to a given technology, one have already performed a major part of the valuation task.

Clearly, the method is only appropriate in different situation than the chosen TT context, and it will therefore not be included in the pricing framework.

6.4.6 Scenario analysis

In the simple DCF method outlined before in this section, the NPV is calculated using clearly defined inputs. Scenario analysis, however, defines different scenarios in which the inputs of the DCF model may vary. Often, one defines three scenarios with different levels of sales, costs, speed of technical development, etc., that form an optimistic, a realistic, and a pessimistic scenario. The NPV can then be calculated for each possible outcome, and if a specific probability is attributed to each scenario, a final expected NPV can also be calculated.

Such an analysis improves decision-making by allowing a more complete consideration of outcomes and their implications on market value. In this way the licensor will be able to better understand the uncertainty the licensee is facing. The different scenarios may also include some form of action or decision that the licensee may take, conditioned on a future event. One could for example assume that in the optimistic case scenario, sales are higher than expected so that the licensee can expand the business. In this case, scenario analysis embody some notion of *real options,* a concept that will be further discussed in section 6.4.8.

Scenario analysis will be included in the framework to better understand how uncertainty may affect the value to the licensee. This uncertainty should clearly affect the pricing of the technology.

6.4.7 Monte Carlo

The Monte Carlo (MC) method has a different approach to modelling uncertainty. It assigns probability distributions to the input variables rather than assuming discrete variables in a limited number of scenarios. Contingencies, or correlations, between input variables can also be introduced when the distribution of some variable depends on the outcome of others. A large number of simulations are then performed, repeatedly running the model by drawing random numbers for all the distributions. The final outcome is a distribution of NPV which effectively shows the uncertainty involved in the project.

Razgaitis [2003*a*] discusses how such an analysis is helpful in a deal-making situation, and Bratic et al. [1998] recommends the use of such a method when licensing, since it is *"enhancing accuracy by demonstrating the effect of uncertainty."* However, the main drawback of this analytical method is again the amount of information that it requires. Furthermore, considerable amount of time need to be devoted to develop sound probability distributions.

However, if this extent of information is readily available, Monte Carlo is a powerful tool for pricing licenses in the chosen TT context. We will therefore include the MC method in the pricing framework.

6.4.8 Contingent claim analysis

The discussion about scenario analysis introduced the concept of real options. Such options arise when future information can influence the outcome of future investment decisions. Real options analysis, or rather *contingent claim analysis* (CCA), is a methodology that employ financial option theory to value such real options. The methodology is particularly applicable when there is a high degree of uncertainty, some managerial flexibility, and when one can reasonably assume that new information will arrive.

Different sub methods of CCA have been suggested for valuing real options, including closed form solutions, partial differential equations and binomial lattices [for a thorough discussion of CCA'a advantages and drawbacks, see the seminal work of Trigeorgis, 1996]. Common for all of these methods is that they are based on advanced mathematics, require a deep understanding from the appraiser, and rely on extensive information. Conceptually CCA is the most academically sound valuation tools proposed by literature; however, many articles have discussed the practical problems of implementing the method. Pries et al. [2003] compare DCF against CCA for R&D valuation and conclude that *"we find that additional option valuation assumptions to reflect uncertainty bring little analytical advantage and great practical problems."* Given the information limitations dealing with early-stage technologies, an OTT will have clear problems using CCA methods. To put it in Razgaitis [2002*b*] words: *"The luxury of data is simply not available."* Another weakness is that it requires the OTT to estimate the strategic choices the licensee will face, which it is unlikely to have any indications of.

Although CCA would increase valuation accuracy by better accounting for managerial flexibility, we feel that the above discussion indicate the infeasibility of using CCA in the chosen TT context. The limited market information, and the advanced calculations and considerations necessary indicate that a resulting valuation is more likely to be flawed than sound. Therefore, we cannot propose the use of any real options analysis in this thesis.

6.4.9 Practitioners' methods

In addition to the aforementioned methods, the business journals refer to many different practitioners' methods. Generally speaking, they are all variations of the methods described above but with certain tweaks to create differentiated methodologies available for "consultancy and sale" [Poredda and Wildschutz, 2003; Khoury et al., 2001; Khoury, 2001; Bramson, 1999; Collette, 1989; Marlow, 1978]. Although, in principle, some seem to provide sound valuation approaches, there are essentially two main problems: Since they are proprietary methods, only quick introductions are publicly available; and, more importantly, none are developed for a TT context. For these two reasons, we do not find these methods appropriate for the pricing framework.

6.5 Suitable methods for the chosen TT context

Table 6.1 summarizes the analysis done so far in this chapter, providing a list of all methods discussed and a simple yes/no to whether the method is included in the pricing framework. The methods marked with yes will be further discussed in chapter 8. Due to their varying information dependency and in line with the analysis in chapter 3, we have included several methods. Moreover, since the selected methods also convey different valuation approaches, i.e. cost, market, or income, using several methods to value a single technology will give complementary views on the market value.

6.6 What about risk and profitability?

The discussion about potential valuation methods in this chapter has made it clear that no method is perfect, neither from an academic perspective nor for application in

Method	Included	Explanation
Historical cost	No	Does not reflect any economic value
Reproduction cost	No	Does not reflect any economic value
Replacement cost	No	Valuable benchmark if costs are treated carefully, but MRC is more attractive
Modified replacement cost	Yes	Offers a practical guideline on which costs to include
Market comparables	No	Comparable transaction rarely exist for early-stage technologies
Paradigm licensing	Yes	Crude but still useful in cases of limited information
Auctions	No	Not enough bargaining power or information; No active pricing
Profit sharing analysis	Yes	Crude but valuable method based on licensee's expected profit margin
Discounted cash flow	Yes	Academically sound method accounting for risk, time value of money, and expected economic benefit
The formula method	No	Not suitable for technology licensing
Venture capital method	No	Not suitable for technology licensing
Relief from royalty	No	Not suitable for technology licensing
Scenario analysis	Yes	Gives valuable insight into the uncertainty facing the licensee
Monte Carlo analysis	Yes	An advanced simulation method but requires considerable information
Contingent claim analysis	No	Necessitates too much information
Practitioners' methods	No	Not developed for a TT context, and little information about them is available

Table 6.1: Overview of selected valuation methods

the chosen TT context. Some do not account for the utility of the specific technology being valued, while others do so only indirectly: the MRC method and paradigm licensing does not relate to risk and profitability at all; profit sharing analysis does not perform any appropriate risk adjustment; while the DCF method and scenario analysis rely upon an appropriate discount rate to account for risk; risk adjustment in the MC method is a more complex issue that will be thoroughly discussed in chapter 8. Thus, there are large variations between the methods of how they account for a technology's utility, that is, its potential profitability and associated risk.

This means that the appraiser is left with considerable room for qualitative judgment. In case of the discount rate for the DCF method and scenario analysis, he needs to evaluate the technology's risk and translate this judgment into an exact discount rate. Similarly, for the ranges provided by paradigm licensing and profit sharing analysis, he needs to specify where in the range to aim based on some opinion of the technology's qualities. However, normally he does not possess any quantitative data to back up this professional judgment. The pricing framework thus needs to allow room for such qualitative judgment, but it should formalize it and base it on an assessment of the technology utility. Moreover, a vital characteristic of the chosen TT context is the variations in this utility between technologies, making a careful assessment more important. The pricing framework thus needs to implement a coherent approach to risk and profitability, the subparts of technology utility, across all the chosen valuation methods.

In this regard, the *concept of rating* has been suggested on many occasions [see for example Razgaitis, 2002*b*; Breese, 2002; Khoury, 2001] to standardize the assessment of a technology and is normally used in the TT context to rank different technologies for work prioritizing. When applied in this way, this concept involves: defining a set of factors, attributing a score to each, and calculating a total score that reflects how important a technology is. The rating method has also been used together with the market comparables method to adjust the value of the technology in comparison with the technology(ies) of the comparable transaction(s).

We will employ the rating method to provide a formalized assessment of technologies. Furthermore, by integrating such an assessment in a consistent and coherent way across all the chosen valuation methods, we will ensure that the pricing framework properly accounts for a technology's utility, i.e. its risk and profitability. The next chapter 7 will take a closer look at this issue and develop a rating system, which we will call the *Technology Utility Rating* (TUR) method. Afterwards, chapter 8 will show exactly how it will be integrated in each of the chosen methods.

Chapter 7

Accounting for a technology's utility

Nothing can have value without being an object of utility.
Karl Marx, German philsopher (1818-1883)

The previous chapter performed an analysis of the IP valuation literature, thereby selecting the methods that are suitable in the chosen TT context. It ended by emphasizing the problem of accounting for the great variations in risk and profitability. By turning to the licensing literature, this chapter will analyze the elements that are deemed important for the commercial success of the transferred object. Moreover, it will extract the factors that affect risk and profitability and develop a methodology for assessing these factors.

7.1 Building a factor system

The general licensing literature is crowded with surveys of which factors practitioners deem the most important when negotiating licenses. Though not claiming to have covered them all, a considerable number of surveys were reviewed. Thus, we deduced a consensus analysis of the most important factors that affect risk and profitability. To explain this analysis in detail would be very space consuming, without adding much substance to the overall analysis. Rather, the resulting factor system is shown in table 7.1, together with a representative sample of surveys for comparison.

The factor group expressing profitability includes: *competitiveness* compared to alternative solutions; *duration* of the license agreement; *profit margins* that the technology will provide; overall *market size* of the application domain; and finally, whether the license grants *exclusivity*. This last factor is perceived as especially important as it provides a limited monopoly to the licensee on the application of this technology, either in a specified domain or geographic territory. The factor group of risk includes: *technological uncertainty* of whether further development will be successful; *market uncertainty* concerning the final reception by customer; *IPR strength* reduces the risk of competition; *support and training* provided by the licensor will reduce the risk of failure; and *stage of development*. Similar to exclusivity, this last factor is deemed

Arnold and Headley [1987]	McGavock et al. [1992]	Zaharoff [2004]
- Intrinsic Quality - Protection - Market - Competition - Licensee values - Finances profit - Risk - Legal terms - Requisition	- Protection - Exclusivity - Utility - Commercial success - Refinement - Competition - Duration - Minimum royalties - Support/training - Licensor commitment - Enforcement burden - Foreign vs. domestic - Convoyed sales - Advice of Expert	- Importance - Uniqueness - Stage of development - Risk - Profit margins - Exclusivity - Advances - Transferability - Market scope - Territorial scope - Duration
Gibbs [2005]	Razgaitis [2002*b*]	**Our factor system**
- Enforceability - Novelty - Claim scope - Forward citation - Backward citation - Duration - Non obviousness - Difficulty in inventing around - Dependence on complementary assets	- Market size - Product margins - IP strength - IP breadth - Stage of development - Market environment	**Profitability** - Competitiveness - Duration - Profit margins - Market size - *Exclusivity* **Risk** - Tech. uncertainty - Market uncertainty - IPR strength - Support & training - *Stage of development*

Table 7.1: Consensus analysis of important factors in license agreements

very important by all sources reviewed, being the most important determinant of risk.

7.2 Rating the factors

There are four steps in applying the rating method [adapted from Razgaitis, 2002*b*]: 1) finding factors, 2) developing a scoring scale, 3) weighting the factors internally, and 4) developing a final assessment table. The first method element, *finding factors*, was given due consideration in the previous section. However, two of the factors found were deemed to be especially important: stage of development and exclusivity. In addition, already in part I did we outline these factors as critical pricing characteristics in the chosen TT context. The pricing framework should therefore allocate extra weight to them, hence we will not include these in a rating system as we will for the other factors, but rather assess them separately. For exclusivity this simply means deciding whether we are dealing with an exclusive or non-exclusive license. However, for the stage of development, this is somewhat more complicated.

Similar to Smith and Parr [2000], we will propose four development stages: 1) proof of *concept*, 2) *prototype*, 3) market *entry*, and 4) *mature* market. Table 7.2 provides a quick explanation of these stages.

Stage of development	Quick explanation
Concept	The technology is immature, exists on drawings, or is confirmed in small-scale experiment
Prototype	A working prototype illustrating the benefits of the technology has been produced
Entry	A marketable product has been developed, and entry into market is started or verging
Mature	The product has reached maturity, with stable cost structures and profits

Table 7.2: Chosen stages of development

There are several options on how to score the remaining factors [Razgaitis, 2002*b*]. In this thesis we will implement a scale from 1-to-5; however, using a non-numerical complement by attributing a "−−" to 1, "−" to 2, "=" to 3, "+" to 4, and "++" to 5. Although the factors could be weighted internally so that an average score would attribute more importance to some factors than others, we will choose not to perform such a weighting. The final assessment table, including all factors, the scoring scale, and a descriptive explanation of its use is illustrated in figure 7.1.

Technology Utility Rating - XVD inhibitor

Technology:	*The XVD inhibitor (fictive)*			
Licensee:	*ACME Corp.*			
Industry:	*Manufacturing - material science*			
Type of license:	**E**xclusive		**N**on-exclusive	
Stage of development:	**C**oncept	**P**rototype	**E**ntry	**M**ature

Factor rating	--	-	=	+	++	Invert (y/n)	Final score
Profitability - relative to exclusivity							*3.5*
Competitiveness				✓		n	4
Duration			✓			n	3
Profit margins					✓	n	5
Market size		✓				n	2
Risk - relative to technologies in the same stage of development							*3.25*
Technical uncertainty				✓		y	2
Market uncertainty				✓		y	2
IPR strength					✓	n	5
Support training				✓		n	4
Total utility score							***N/E-3.38***

Figure 7.1: Performing a Technology Utility Rating

To perform a rating of the given factors, we also need to specify what benchmark these factors should be rated relative to. In the chosen TT context, the natural benchmark should be *comparable licenses*. More specifically, the factors in the risk group should be scored relative to licenses on *technologies in the same stage of development*, as the stage already accounts for a big part of the risk. Similarly, the profitability factors should be rated relative to other exclusive licenses if one is rating an exclusive license, and correspondingly for non-exclusive licenses. This is illustrated in the figure as relative to *exclusivity*.

Looking closer at the risk factors, we also see that a high score on the first two, technical and market uncertainty, increases risk, while a high score on the last two, IPR strength and support&training, decreases risk. In our rating system we want to associate a high score with a higher technology utility, therefore we will need to *invert* the score of the first two risk factors before calculating the average risk score. Thus, a high score for a risk factor means low risk. This inversion is illustrated with a "y" in the column marked with "Invert (y/n)", while the column "Final score" shows the corresponding inverted score. For the profitability group, averaging the factors is easy as a high score on all four profitability factors indicates a higher utility. For all of these, and for the two risk factors that were not inverted, the column "final score" simply shows the original score. In order to arrive at a score for the technology's utility, we will again average the score of the two factor groups. An OTT may decide to allocate different weight to these two factor groups, but in this framework they will be given equal importance. This score will from now on be referred to as the *utility score*. In addition, the stage and exclusivity factors are each represented by their own letter, illustrated directly in front of the utility score in the assessment table. The table also shows the individual scores of the two factor groups.

Chapter summary This chapter has introduced a precise way of assessing the risk and profitability of a specific technology up for licensing. This has been done deliberately *before* we have detailed explained the six valuation methods, something that will be done in the next chapter. In this way, the next chapter may seek to integrate this TUR rating across all the valuation methods, coherently accounting for a technology's utility.

Chapter 8

Valuing a technology license

A cynic is a man who knows the price of everything and the value of nothing.

Oscar Wilde, Irish writer (1854-1900)

In the popular version of Oscar Wilde's quote, it is the *economist* that knows the price of everything and the value of nothing. Ironically, with the two previous chapters, we have laid the foundation for a pricing based excactly on value. Six methods were chosen for inclusion in the pricing framework, and then in detail we developed a complementary method for assessing a technology's utility, that is, its risk and profitability. The method developed was called the Technology Utility Rating (TUR) method. This chapter will take a closer look at each valuation method through 4 subparts: 1) specification of the method; 2) how to use it in the chosen TT context; 3) how the TUR method may be integrated to account for risk and profitability; and finally, 4) how to translate the resulting valuation into a specific royalty structure. The 6 chosen methods are shown in table 8.1.

Methods selected
Modified replacement cost
Paradigm licensing
Profit sharing analysis
Discounted cash flow
Scenario analysis
Monte Carlo analysis

Table 8.1: The selected valuation methods

8.1 Modified replacement cost

Specifications MRC is the method that requires the least amount of market information. In fact, it does not require any market information at all and gives thus in some way the crudest measure of value. The reason to include a cost approach method was that it can still provide a useful benchmark before negotiations, where the licensor needs to place himself in the position of the licensee and determine what he would need to spend if developing the technology on his own. This can say something about how much such a licensee would be willing to pay. Also, it should be noted that the MRC is a very prudent variant of the cost approach, providing a minimum inclusion of relevant costs due to the nature of how it is estimated: One actually ask the internal expert how much time and equipment it would take him to recreate the technology he himself has invented. This estimate will of course depend greatly on the nature the technology. If it is a concept born out of a moment's insight, it will have no cost at all; If it is a highly complex manufacturing technology, the cost estimate could be substantial. At this point it becomes especially clear that MRC omits any notion of the technology's utility. Even a very simple concept can prove to be extremely valuable for a licensee, while a complex technology may generate very little economic benefit. Nevertheless, quantifying the amount of effort that would be required for the recreation of the technology does provide insight into how much a licensee is willing to pay. Take the example of an extremely simple technology which provides substantial cost savings to the licensee. Such a concept would be valued very low using MRC method, and very high using the DCF method. Although few can argue against that DCF would be a far better approach for valuing the technology in such a case, they are still complementary methods. It is not sure that a licensee will be eager to pay a price that fully reflects the actual utility while knowing that it did not cost anything for the licensor to develop the technology.

How to perform it in practice As explained in the previous chapter, the MRC method asks the inventor to estimate the effort that would be required to recreate the technology from scratch if he changed job. More formally, two questions need to be asked:

- *Knowing what you know now, how much time would you need to rediscover or create this technology?*
- *What infrastructure and equipment would you need?*

The inventor has in this scenario no longer any access to protected information relating to the technology, only to the knowledge he has acquired through the work. Nor has he access to the infrastructure of the original employer. If the OTT and the inventor do possess some information about the potential licensee, the estimate can be made even more relevant by sketching a scenario where the inventor actually develops the technology for the licensee, using whatever resources they may possess.

Integration of TUR So how can the MRC method relate to the TUR? In fact it should not: the MRC is the only method where the TUR will have no direct influence. Rather, we will look at them as two complementary measures. The TUR assesses the risk and profitability of a technology, while the MRC focuses on the cost to develop it. There is therefore no direct link between these two. However, a high TUR does indicate a potentially important economic benefit for the licensee because of low risk and high profitability. Since MRC does not consider such aspects, one could claim that the higher the TUR, the more dangerous will it be to use MRC as a measure of value. In such a case the licensor will risk renouncing high royalties if setting a target based on MRC. Anyway, repeating ourselves one more time: MRC should always be used in combination with a market or income approach method.

Royalty structure How then to translate a cost estimate into a specific royalty structure? This is actually not possible without the use of any sales estimates. If such estimates do exist, it is easy to calculate the running royalty necessary that would equate expected royalties to MRC. It would also be very easy to introduce different levels of upfront fees, adjusting royalty rate either upwards or downwards accordingly. Of course, as the more sophisticated methods suggest, one should in theory account for the time value of money when dealing with future cash flows. But if one starts introducing discount rates reflecting time value of money or some risk adjustment, the exercise starts looking like a DCF model, and the appraiser should instead use this more advanced valuation method.

8.2 Paradigm licensing

Specifications The next method in sophistication is paradigm licensing. The industry royalty rate paradigms provide some useful indications of what a reasonable value for the technology might be. Typically, paradigms presented in literature are based on surveys done across different industries, asking companies about what royalty rates that were used when licensing. With a large number of answers, this creates a distribution of royalty rates in the given industry, thereby indicating a relevant range after discarding the extreme cases. However, two important aspects are rarely presented by such surveys: first, whether the royalty rates surveyed concern exclusive or non-exclusive licenses; second, what kind of upfront fees that accompanied the royalty rates. The former issue is quite severe as one might expect that the surveys cover a mixture of both exclusive and non-exclusive licenses. One needs thus evaluate the extent of this mixture and decide which parts are suitable for either type of licenses. We will suggest how to account for this in relation to the paragraph on the TUR method. The latter issue is also problematic as one would assume that in most cases the licensor will extract part of the value through an upfront fee. This will be discussed in more detail under the later paragraph dealing with royalty structure.

How to perform it in practice To use paradigm licensing as a valuation tool, an OTT needs to find information about relevant royalty rate paradigms. The natural place to start is to analyze which industries the OTT is working with, and then search for information related to each industry. Razgaitis [2002*b*] provides an overview of where to find such paradigms, and there books published each year [two of the most recognized are: Parr et al., 2004; Grimes and Battersby, 2004]. We recommend that an OTT buys such books if they want to use this method for valuation purposes. Other resources might be business societies, individuals working with licensing, business journals, published agreements and court cases.

Integration of TUR The only possibility for accounting for risk and profitability in the paradigm licensing method is through the paradigm royalty range. First and foremost, it will make the paradigm licensing method not only an industry standard, but also a valuation reflecting the risk and profitability characteristics of the technology, among them the aspects of exclusivity and stage of development. Secondly, it will give some indication of the precise royalty rate that the OTT should aim for.

The challenge is how to model the effect of the different factors of the TUR method on this range, and there are several possible approaches depending on your perspective and preference. First of all, one needs to develop two paradigm ranges, one for exclusive licenses and one for non-exclusive licenses. This can be done by assessing the mixture of exclusive and non-exclusive deals in the industry. If no information about this can be found, one may, for instance, assume a 50/50 mixture, but one also needs to assess how the two ranges overlap each other. Estimating this overlap should also be based on some indication of industry norm. However, if nothing can be found, we suggest assuming that the two types of licenses share the centre 25%, meaning that the lower 37.5% are for non-exclusive licenses only, the middle 25% are shared by both types of licenses, and the upper 37.5% should only be used for exclusive licenses. We will refer to such a structure as 37.5/25/37.5. This is just an example of such an analysis, and if information can be found, this modelling should of course be adjusted accordingly. To demonstrate our explanations, we will throughout this chapter refer to the fictive case of the XVD inhibitor, rated in the previous chapter to an overall score of N/E-3.38. Figure 8.1 shows the use of the paradigm licensing for this fictive technology. Thus, if the industry paradigm for material science is 5-15%, the corresponding non-exclusive part would be 5-11.25% if assuming a 37.5/25/37.5 mixture. This is illustrated in the upper right corner of the figure.

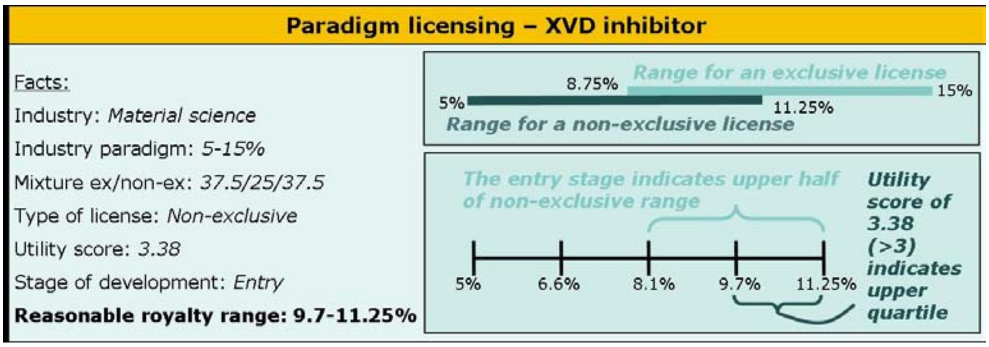


Figure 8.1: Integration of TUR for paradigm licensing

Thereafter, we proceed to modelling stage of development, and there are again many possible approaches. Having to choose one, we suggest splitting the resulting range in two, based on the stage structure of the TUR method: the lower half is used for technologies in stages 1) Concept and 2) Prototype; and the upper half is for technologies in stages 3) Entry and 4) Mature. This division reflect that of different risk, building upon the experience from practitioners that the biggest hurdle in commercialization is going from a prototype to a marketable product. As illustrated by figure 8.1, the Entry stage of the XVD inhibitor narrows the range to 8.1-11.25%.

The utility score is then used to define more exactly within each half to pick a royalty rate. Again there are several possibilities: one could use the factors to arrive at decimal number; however, we feel it is more appropriate to decide which of the two quartiles within the first half one end up; meaning that a score from 1-3 gives the lower quartile and a score from 3-5 gives the upper quartile. In this way, the overall royalty range is divided in four, and as such ranges normally span 8-10%, this would give each subpart 2-2.5% of span. A more detailed segmentation than that does not make much sense for a method that already is quite crude. For our fictive case with a utility score of 3.38, figure 8.1 suggests the suitable royalty range to be 9.7-11.25%.

The utility score of the TUR method expresses the appraiser's perceptions of the potential profitability and the associated risk of the technology. However, the fact that stage of development divides the range in half means that some risk inherent to the stage has been accounted for already. Still, risk is the single most important factor in technology commercialization, meaning that using both the stage of development and the utility score to account for risk does not necessarily mean a double-counting. On the other hand, profitability has also by some measure been accounted for, both by using a range specific to exclusivity and by demanding a royalty percentage of the sale price. The licensor should therefore already profit from higher sale price, larger volumes and longer duration. However, it is common practice to demand a higher royalty rate if the profitability is higher than normal. Thus, by rating the profitability group relative to exclusivity, such a comparison is achieved. Moreover, the more profitable a technology might be, the higher bargaining power the licensor will have over the licensee, since it is more likely that other companies also are interested. Hence, both factor groups are somewhat accounted for already, and since it would be hard to judge any superiority of one group to the other, we feel the equal weighting between them assumed in chapter 7 is reasonable.

Royalty structure After having valued the technology by determining a suitable royalty rate using the method in combination with TUR, what about the upfront fee? As stated before, the nature of paradigm licensing makes it impossible to know how high upfront fee accompanied the royalty rate, but it is likely that some part of the value was claimed upfront. The appraiser could thus undervalue a technology if only claiming a running royalty rate as payment for the technology. However, in most cases it is likely that upfront fees are relative small compared to expected running royalties. It would be far too risky for a licensee to pay too much of the expected royalties upfront. We will simplify the analysis by assuming that, in addition to the royalty rate indicated by the paradigm method, it is accompanied by an upfront fee covering the transfer costs of the licensor. Although there is little doubt that this is not generally the case, it would be impossible to give any answer to what the level of average industry upfront fees is. In addition, under the TT policy of favouring dissemination, it is better to be make a prudent valuation that can easily be justified in later negotiations. An OTT is of course fully entitled to ask for a larger upfront fee: In this case we advice that the appraiser adjusts the running royalty downwards. As for the case of MRC, no answer can be given to the exact nature of this trade off if one does not have information of expected sales. This trade-off therefore relies entirely on the professional judgment of the appraiser.

8.3 Profit sharing analysis

Specifications Profit sharing analysis is the first method that accounts for some of the potential profitability of the technology. In this respect it is a more sound method than MRC and paradigm licensing, but at the same time it is a little more information dependent. However, only very limited market information is needed as input, and it should therefore be applicable to most situations. Figure 8.2 shows an illustration of a complete profit sharing analysis for the XVD inhibitor. The top part of the figure includes the integration of the TUR method, which will be discussed later. First, we will start with the income statement, shown in the bottom part of the figure.

How to perform it in practice As can be seen, the appraiser needs to estimate a sales price, cost of goods sold, selling costs, and general & administrative costs. The natural place to start to get such information would be by asking the company for their business plan for the product or technology to be licensed. If they are not willing to pass on such information, or if the appraiser does not trust the information they provide, a simple market study is the answer. By reviewing the business and competitors, in addition to analyzing databases of industry statistics (see for example Reuters)[1], it should be possible to arrive at some rough estimates. The annual reports of the licensee would also be a useful source of information. If the OTT uses information provided by the licensee in the analysis, the resulting royalty rate may be understated, since the licensee has incentives to be conservative. However, for OTTs favouring dissemination, this will be less of an issue than in a transaction between two commercial parties. The valuation using the profit sharing analysis will still provide some estimation of market value. After estimation of the operating margin, the method applies a reasonable profit split to find what share should accrue to the licensor. This amount divided by the sales price thus gives the royalty rate indicated by profit sharing analysis.

Profit sharing analysis – XVD inhibitor

Facts:

Mixture ex/non-ex: *37.5/25/37.5*

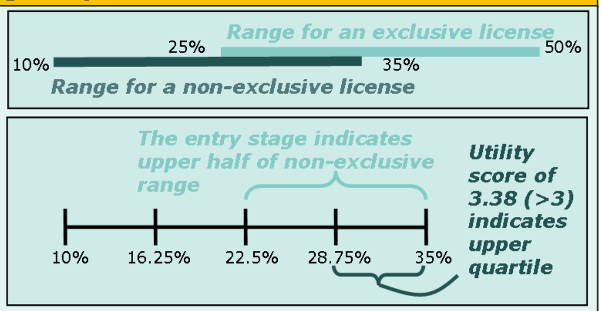
Type of license: *Non-exclusive*

Utility score: *3.38*

Stage of development: *Entry*

Reasonable profit split:

28.75%-35%



Income statement	
1. Sales price	120
2. Cost of Goods Sold (COGS)	60
3. Gross profits (1-2)	60
4/5. Sales, General & Administrative costs	24
6. Operating profits (3-4/5)	36
Royalty rate calculation	
7. Lower bound of royalty rate - (28.75 % * operating profit) / Sales	8.6%
8. Upper bound of royalty rate - (35 % * operating profit)/ Sales	10.5%

Figure 8.2: Integration of TUR for profit sharing analysis

[1]Reuters provides an extensive and free database online, containing detailed statistics for a wide range of different industries. This site is located at:
http://today.reuters.com/business/industryprofiles.aspx

Integration of TUR Since the method operates with a range for suitable profit sharing splits and the chosen profit split directly determines the appropriate royalty rate, it is possible to integrate the TUR method in a similar way as for the paradigm licensing method. However, we need first define two suitable ranges; one for exclusive and one for non-exclusive licenses. Chapter 6 indicated that an overall suitable range would be 10-50%, and similar to the analysis for paradigm licensing, this range may be divided according to exclusivity. Again, this should in principle be done based on the industry norm, but we have not found any information regarding such profit splits, and based on the general licensing norm, we therefore suggest using a range of 10-35% for non-exclusive licenses and a range of 25-50% for exclusive licenses. Thereafter, the resulting profit range will is divided in half according to stage of development, and the utility score decides in which of the two quartiles within that half to pick a suitable profit sharing split. Figure 8.2 gives an example of such a calculation for the fictive XVD inhibitor technology. It calculates the appropriate profit split to lie between 28.75% and 35%, suggesting the suitable royalty range to be 8.6%-10.5%.

In the case of profit sharing analysis, it is even clearer that some profitability is already accounted for in the analysis, as it is based on a snapshot of an income statement. However, it does so only in a simple way through the operating margin. No notion is made of other profitability factors such as market size and duration, and no adjustment for risk is made. Also, the negotiation argument for using the utility score that further accounts for profitability remains the same: a higher total profit should give a higher royalty rate because the licensor has increased bargaining power over the licensee. Thus, we are still comfortable with allocating equal weight to the factor groups of risk and profitability.

Royalty structure Regarding royalty structure, the method only estimates a reasonable running royalty rate. Matching our discussion regarding the paradigm method, we will assume it is plausible to accompany this measure with an upfront fee covering transfer costs, treating the two methods consistently. In any case, the transfer costs should be marginal relative to expected total royalties. The appraiser can introduce a higher level of upfront fee if at the same time adjusting the running royalty rate downward. As previously, if there is no estimate of total sales, this trade off is left to the judgment of the appraiser.

8.4 Discounted cash flow

Specifications The DCF method is the simplest of the more "advanced" methods in our framework, and a DCF model is actually part of all the three advanced methods. Thus it is an extremely important part of the framework, and the basis for an academically sound valuation. DCF is the most widely used tool in any valuation context in business [Albouy, 2003], and it is reasonable to expect that a licensee will do such an analysis when faced with a licensing agreement. At least they will normally be familiar with the concept.

We will not do a thorough explanation of the mathematics involved in a general DCF calculation in this thesis, for this purpose vast amounts of literature exist. Brealey and Myers [2000] does provide an introduction to both time value of money, risk, discount rates, cash flow statements etc. Figure 8.3 shows an illustration of a simple DCF model, again by using the fictive example of the XVD inhibitor. Free cash flows are estimated for each year of the technology's lifespan, and these are then discounted with an appropriate rate and summed to find total net present value (NPV). We will in this section make the discussion necessary to understand how to employ the DCF method in the chosen TT context.

DCF model for XVD inhibitor	Period 0	1	2	3	4	5
Inputs						
Capital investment	2 500					
Tax rate	30%					
Discount rate	0%	24%	24%	14%	14%	14%
(Discount factor)	1.00	1.24	1.55	1.77	2.03	2.32
Cash-flow analysis						
1. Sales	0	6 000	8 000	9 000	9 000	9 000
2. Cost of goods sold	0	3 000	4 000	4 500	4 500	4 500
3. Gross profit (1-2)	0	3 000	4 000	4 500	4 500	4 500
Other costs						
4. Sales costs	0	600	800	900	900	900
5. General & Administrative costs	0	600	800	900	900	900
6. Cash flow from operations (3-4-5)	0	1 800	2 400	2 700	2 700	2 700
7. Depreciation (20% - linear)	0	500	500	500	500	500
8. Pretax profit (6-7)	0	1 300	1 900	2 200	2 200	2 200
9. Tax (8 * tax rate)	0	390	570	660	660	660
10. Profit after tax (8-9)	0	910	1 330	1 540	1 540	1 540
11. Depreciation	0	500	500	500	500	500
12. Capital investment	2 500	0	0	0	0	0
13. Free cash flow (10+11-12)	-2 500	1 410	1 830	2 040	2 040	2 040
14. Discounted cash flow	-2 500	1 133	1 183	1 152	1 007	880
Total net present value	**2 856**					

Figure 8.3: Example of a discounted cash flow model

How to perform it in practice As can be seen from the figure, a large number of inputs need to be estimated to perform a DCF for the project where the licensee envisages to use the technology. Level of sales, sale price, investments, tax rates, cost of goods sold, selling and general & administrative expenses etc. Recalling the known principle "garbage in, garbage out", it is extremely important to make sound estimations if the DCF method shall give a reasonable valuation. When awarding exclusivity, one should furthermore estimate the licensee's increased market power, which may result in higher sale price and/or volume. The estimation should, first and foremost, be based on information provided by the licensee, preferably through a business plan detailing the commercialization plans. If the licensee cannot or will not provide information, it becomes difficult for an OTT to make use of the DCF method. A market survey can provide parts of the picture through industry statistics and general market knowledge, but to know how the licensee can perform in the market will be difficult without their input. However, a licensee may be positive to provide some business plan if they have one, since the OTT is not generally seen as a profit-maximizing entity. Estimates will of course tend to be understated, but they will in any case provide a sound starting point.

Integration of TUR - The discount rate The future cash flows are discounted in the DCF method to account for time value of money and project risk, so the discount rate used in the model greatly influences NPV. This makes the selection of an appropriate rate critical if a sound valuation is to be concluded. This section will therefore start with a theoretical discussion of how to estimate an appropriate rate, before presenting how our framework will solve it.

Literature in the field of Corporate Finance suggests [Brealey and Myers, 2000] that the discount rate used by firms in project valuation should reflect its cost of capital, typically referred to as the *weighted average cost of capital* (WACC). The capital structure of a firm comprises two main components, equity and debt, hence the WACC is calculated by weighting each component of the capital structure with its expected or appropriate return - return on equity (ROE) and return on debt (ROD).

Some of the most acknowledged finance papers of the 20th century have been written precisely on the subject of how to estimate appropriate returns on risky assets. Typically, the construction of such a discount rate will start with the *risk-free interest rate*, the percentage of return generated by investing in risk-free securities such as government bonds. A risk premium is then added to get the correct *risk-adjusted* discount rate. The Sharpe-Lintner-Black model [Sharpe, 1964; Lintner, 1965], usually called the *Capital-Asset Pricing Model* (CAPM) is widely used in finance, building on the earlier work of Harry Markowitz on diversification and modern portfolio theory [Markowitz, 1952]. It is used to find the rate of return for an asset that is to be added to an already well-diversified portfolio, given that asset's non-diversifiable risk. The CAPM formula takes into account the asset's sensitivity to non-diversifiable risk (beta), the expected return of the market and the expected return of a theoretical risk-free asset. Due to shortcomings in adequately explaining the variation in stock returns, other models building on the CAPM have later been introduced, The *Fama and French Three Factor Model* [Fama and French, 1993] and *Arbitrage Pricing Theory* [Ross, 1976] being the two most important concepts.

In the field of project valuation, academic circles have later criticized the asset-pricing models for their poor handling of project specific risk. This criticism states that a major error in valuing a project is to discount it with a WACC that applies to the entire firm on average. Such an approach is not appropriate when the risk of a particular project differs markedly from that of the firm's existing portfolio of assets. With asset-pricing models, this error is normally due to the use of the company's beta, calculated from the variation of the company's stock returns. Using such a beta, no regard is given to the specific risk characteristics of the project in question. It is possible to solve this by using a *project beta*, rather than a company beta, but this may turn out be very difficult to calculate in practice due to the lack of a tradable market for such risky projects. Hence, managers today end up doing a risk-adjustment of the discount rate, or WACC, mainly based on judgment. Another important point made out by critics is that risk is not static but may change significantly throughout the life of a project. It would be wrong to discount all future cash flows with the same rate in such a case.

In the chosen Technology Transfer context one can hardly expect the licensee's WACC to be good measure of the inherent risk of the technology. Neil [1997] clearly expresses this by stating that *"the use of a corporate cost of capital, handed down ex-cathedra for use as the discount rate, is clearly inappropriate in such circumstances."*

Weiler [2004]		Smith and Parr [2000]		**The chosen risk classes**	
Embryonic	50%	Start-up	50%	Concept	40-50%
Technology	25%	Prototype	40%	Prototype	30-40%
Pre-launch	15%	Early entry	30%	Entry (in market)	20-30%
Mature	10%	Fast growth	25%	Mature (market)	10-20%
Risk-free	3%				

Table 8.2: Consensus analysis of appropriate discount rates

It is thus extremely important that the pricing framework can handle an appropriate risk-adjustment of the discount rate, and this adjustment necessarily needs to be based on a qualitative but sound judgment. When it comes to changing risk throughout a project, it is clear that an early-stage technology will gradually become less and less risky as maturity develops. The technology becomes more certain, and market prospects can be better evaluated. This has also to be taken into account in the framework.

The risk-adjustments discussed in this section furthermore need to be dealt with consistently across different technologies. We will therefore claim that the TUR can be leveraged to achieve just that. However, the exclusivity aspect and the other profitability factors should have limited relevance for the DCF method, since it allows explicit considerations thereof through the DCF model. Therefore the integration of the TUR method is different, albeit only slightly: We will again use the stage of development as the initial factor of adjustment. This allows a discrete adjustment of the discount rate according to which stage the technology has evolved to. Such an adjustment is common in DCF literature [see for example Smith and Parr, 2000; Weiler, 2004]. The stages we have chosen to use in this thesis were defined in chapter 7, and a consensus analysis on the risk-adjusted discount rate relevant for each stage is shown in table 8.2. The different sources use different stage classifications, but still some consensus can be extracted. An OTT implementing the pricing framework should make their own reflections regarding this classification and associated risks.

For the selection of an exact discount rate within these ranges, it is no longer appropriate to use the total utility score as indicated above. However, we may still use the score of the risk factor group, as it expresses the appraiser's qualitative judgment of the technology's risk relative to its stage of development. According to the above discussion of finance literature, this is exactly what is needed, and the TUR method is furthermore a formalized approach to quantifying such a judgment. This results in the process illustrated by figure 8.4, that also illustrates the simple calculations involved in translating the risk score to an adjustment of the discount rate.

Royalty structure After estimating relevant inputs, the DCF model calculate a NPV as seen from the licensee if no royalties would need to be paid. Theoretically, if the model uses an appropriate risk-adjusted discount rate, this rate will reasonably compensate the licensee for all the risks involved in the project. His investment criterion should therefore be to accept the project if NPV is equal to or exceeds zero. Furthermore, if buying such an investment project, he should be willing to accept a price up this NPV, and the project would still be profitable since the discount rate compensates for all risks taken.

By using the sales numbers and the original NPV from the DCF model, one can

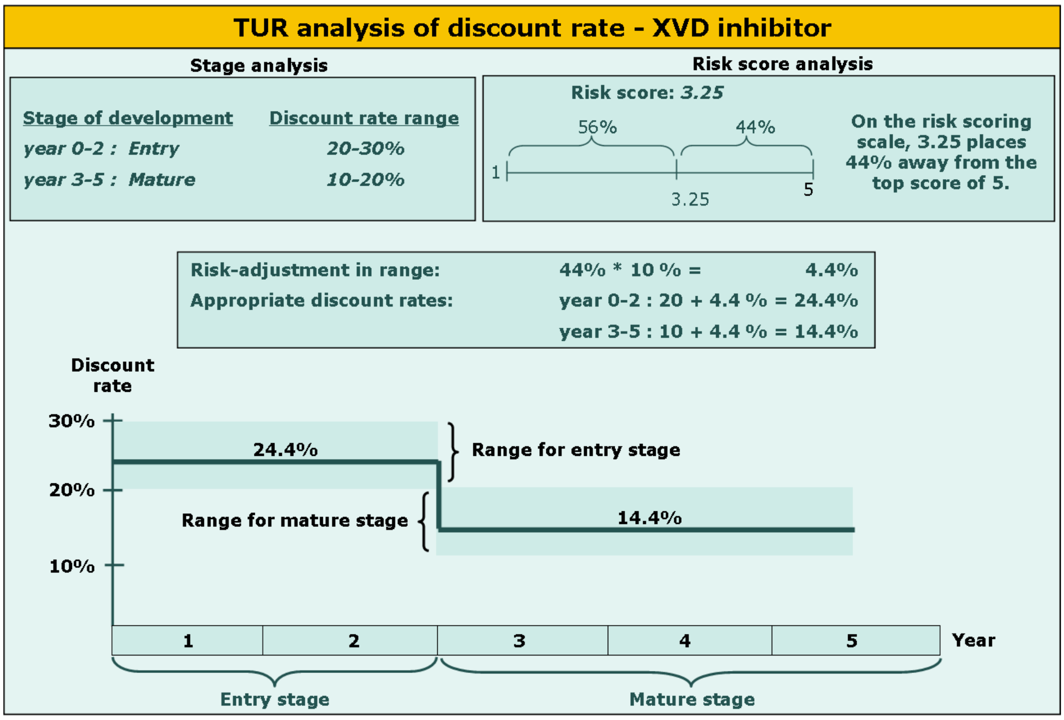


Figure 8.4: Integration of TUR for DCF - discount rate

calculate a royalty structure that equates to that NPV, essentially driving the licensee's NPV to zero. Figure 8.5 shows a module that performs such an exercise in Microsoft Excel. A level of upfront fee is assumed, and the remaining value is extracted through adjusting the royalty rate upwards from zero by using the Excel function called "Goal-Seek." This function automatically finds the running royalty rate that equates total discounted royalties to the original NPV. This is conceptually similar to reducing the NPV in the original DCF model to zero by introducing a royalty structure. The resulting royalty structure that will equate the licensee's NPV to zero will be an estimation of the market value of the technology, for which the pricing framework should aim. However, it will also be an estimation of the *licensee's* walk-away point and together with the *OTT's* own walk-away point, they

RS module - XVD inhibitor	Period 0	1	2	3	4	5
Input						
1. Upfront fee	100					
2. Running royalty rate	**11%**					
3. NPV from DCF model	2739					
4. (Discount factor)	1.00	1.24	1.55	1.77	2.03	2.32
Calculations						
5. Tax shield of royalties		190	253	284	284	284
6. Discounted tax shields of royalties		152	163	161	140	123
7. Total NPV to be extracted (3-1+sum6)	3 379					9 000
8. Sales		6 000	8 000	9 000	9 000	9 000
9. Running royalties		632	843	948	948	948
10. Discounted royalties		660	708	696	608	532
11. Total discounted royalties	**3 205**					
12. (Goal seek calculations (7-11)	174					

Figure 8.5: Example of royalty structure module for a DCF model

will define the ZOPA range in the conceptual model.

It is important to note that it does not make sense for the OTT to set its target any higher than this, since it might scare away the licensee, compromising the goal of favouring dissemination. Thus, recalling our integration of the TUR method, there is no room left for giving the aspect of exclusivity and the profitability score any larger influence, since we are already at the limit of the ZOPA range. The arguments for higher bargaining power due to higher profit range and the similar arguments was relevant for the two preceding methods, but when using the DCF method and the royalty structure module, the licensee's value is already driven down to his investment criterion, thereby eliminating the validity of such arguments. The outcome of the DCF method should also be compared to that of other methods, and it may be used as a correction for the simpler ones.

Furthermore, due to the royalty structure module, the appraiser can alter and play with this royalty structure depending on the level of the upfront fee. Hence, the DCF method provides an integrated tool for both valuing a license, and translating this value to a royalty structure. The benefit of such a method compared to the less sophisticated ones previously described is evident.

8.5 Scenario analysis

Specifications Scenario analysis is a direct extension of the simple DCF method, using the same DCF model developed but for three different scenarios: often an optimistic, a pessimistic and a realistic scenario. The inputs for the realistic scenario will typically be identical to the ones used in the simple DCF method, while the other scenarios need new estimations based on the appraiser's judgment. Inputs that vary can for instance be higher/lower market share, longer/shorter time-to-market due to uncertain technical development, higher/lower costs, higher/lower sales price due to competition, and other assumptions. Choosing which input to vary should be based on a combination of market knowledge and discussions with the licensee. Expected NPV can then be found by multiplying each scenario with the associated probability and summing up. Figure 8.6 is a simple illustration of a scenario analysis based on the DCF model presented in figure 8.3. Again the XVD inhibitor is used as an example, and only the level of sales, COGS and investments vary between the cases.

Integration of TUR The three scenarios may have widely differing assumptions relating to the stage of development, the technical development needed, market uncertainty, and the other factors of the risk group. Hence it would not be appropriate to use the same discount rate in all of the scenarios. We will therefore suggest to perform a TUR for each of the three scenarios, and use the same approach that was described in the simple DCF method to adjust the discount rate.

Royalty structure The scenario analysis will give three different NPV, and one expected NPV for the whole project. How then to translate these results into a meaningful royalty structure? There are several ways in which this can be done. The first possibility is to use the resulting expected NPV in combination with the

Scenario analysis – XVD inhibitor

Assumptions	Period 1	2	3	4	5
Pessimistic scenario					
Sales	4500	6000	6750	6750	6750
COGS	2700	3600	4050	4050	4050
Discount rate	26%	26%	16%	16%	16%
Realistic scenario					
Sales	6 000	8000	9000	9000	9000
COGS	3 000	4 000	4 500	4 500	4 500
Discount rate	24%	24%	14%	14%	14%
Optimistic scenario					
Sales	7500	10000	11250	11250	11250
COGS	3750	5000	5625	5625	5625
Discount rate	22%	22%	12%	12%	12%

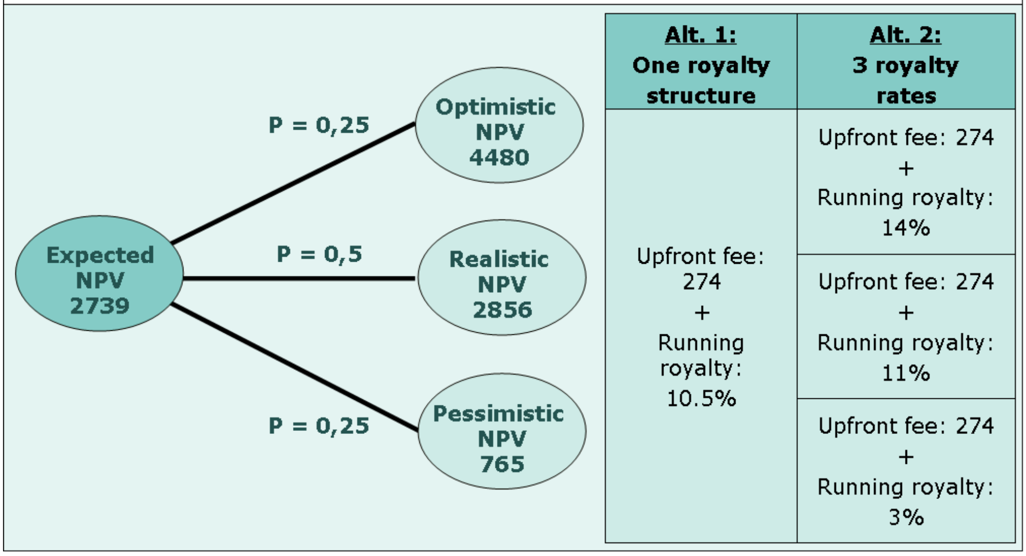


Figure 8.6: Example of scenario analysis

realistic scenario to adjust the royalty structure accordingly. This would mean using exactly the same royalty structure module as in the simple DCF method, as shown in figure 8.5. The only difference would be to use the expected NPV value of the scenario analysis as input to the royalty structure module, instead of the NPV value found by the realistic scenario. Depending on upsides and downsides modelled by the scenarios, total royalties in the new royalty structure will either be higher or lower that the one found by the simple DCF method. The result of such an analysis for the example case, the XVD inhibitor, is shown as "royalty structure alt 1" in figure 8.6. Furthermore, the same reasoning done for the simple DCF methods with regards to the exclusivity aspect, the profitability group, and the investment criterion is also valid here.

Another attractive idea is to calculate three different royalty structures, so that NPV equals zero in each of the scenarios. In this case the resulting royalty as percent of the profit will be higher in the optimistic scenario, and lower in the pessimistic. However, the upfront fee should clearly be the same for all royalty structures. If the NPV for the pessimistic is negative, as it often may be, the appropriate running royalty should be set to zero. Such a variable structure can then be suggested in negotiations, introducing an increased risk sharing between licensor and licensee that should benefit both parties. Such an alternative has also been calculated and is shown in figure 8.6 (alt 2). If such a variable royalty structure is seen as attractive by the licensee, the contract could stipulate specific conditions for introducing such a structure. These conditions should closely match the factors that make the three scenarios vary in NPV. This could be the level of sales, in which case one could propose that the running royalty increases as certain sales benchmarks are reached. However, such a structure would have to been thoroughly discussed in negotiations, as the licensee would need to understand the rationale for introducing such contingencies. They are after all meant to benefit the licensee. Therefore, to use scenario analysis in such a way, one should try to develop the three scenarios in cooperation so that both parties can trust the final results.

8.6 Monte Carlo analysis

Specifications Monte Carlo analysis is the most advanced method included in the pricing framework and will only be applicable in cases where extensive information is available or when the importance of the case does permit devoting considerable resources to the licensing process. Typically, this could be the case for licenses involving large expected revenues and thus high royalties. Razgaitis [2003*a*] gives an excellent introduction to the MC analysis, here we will only describe the main features necessary for employing the method in the chosen TT context.

How to perform it in practice The starting point for a MC analysis is a DCF model as the one shown in figure 8.3. But instead of prescribing a specific value for all inputs to this model, one assigns a probability distribution to each input to obtain a richer understanding of the NPV value to the license. This modelling is most easily performed by using a software program specializing in MC analysis, as *Crystal Ball*[2] or *@Risk*[3].

One typically uses 4 different probability distribution to model the inputs: uniform, triangular, normal and custom distributions. Examples of these distributions are shown in figure 8.7. Correlations between input parameters can also be introduced. For instance, one could expect the level of sales in a given year to be correlated to sales of the previous year. This can easily be achieved in software programs by assigning a specific correlation between two inputs, for example between sales in year 3 and sales in year 2. The modelling of distributions and correlations between them is the heart of the MC analysis. This process demands a lot of information and extensive modelling skills, but having done this, the software program does most of the remaining work.

All that remains is to run the model a given amount of times, typically in the order of 1000 iterations or more. For each iteration, the software conducts a calculation using the probability distributions to deduce the one specific number for each cell in the DCF model. Each iteration gives a final NPV result, and the total distribution of all the iterations can be illustrated in a frequency chart or in a cumulative chart,

[2]Developed and sold by Decisioneering, see http://www.decisioneering.com
[3]Developed and sold by Palisade, see http://www.palisade-europe.com

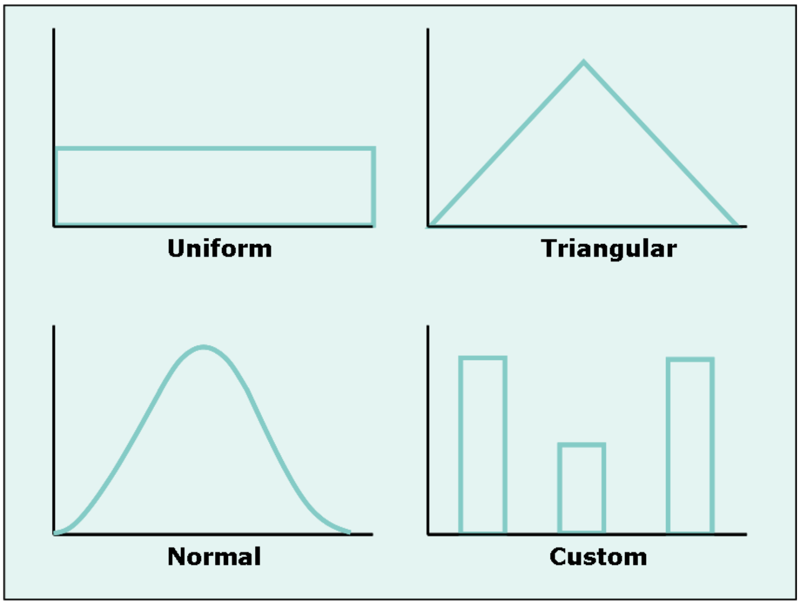


Figure 8.7: Examples of different probability distributions

as shown in Figure 8.8. We will use the cumulative chart for analyzing the licensee's payoff. In figure 8.8, a specific point is outlined to explain some taxonomy: The x-axis shows different percentage values, normally referred to as *percentiles* in a MC analysis. The specific percentile outlined, the 50th percentile, relates to a NPV value of X. This means that the MC analysis expects actual NPV to be lower in 50% of the cases, and higher in the remaining 50%.

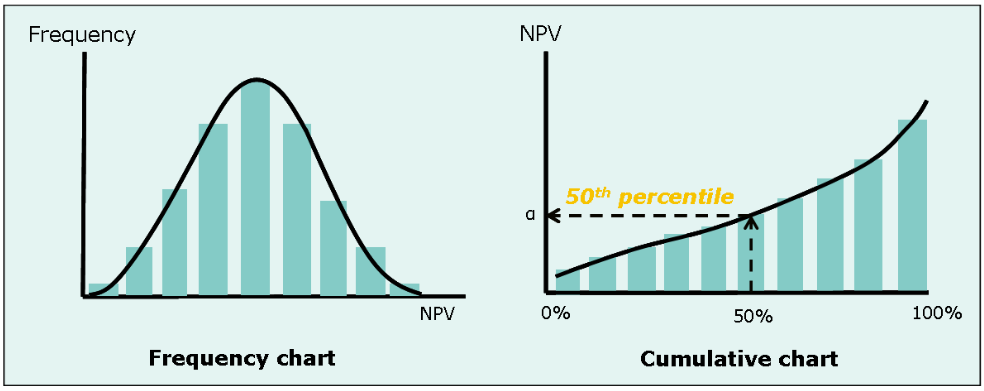


Figure 8.8: Examples of frequency and cumulative charts

Integration of TUR - risk in MC analysis An important and difficult aspect of the MC analysis is what discount rate to use in the calculation of NPV. This depends on how one intends to use the resulting distribution of NPV values, because investment analysis using MC sees risk from a different perspective than the traditional DCF method. Let us take a closer look at this: Under the simple DCF method, using a project specific risk-adjusted discount rate, a company should undertake any project yielding NPV larger then zero. Now, if one does a MC analysis with an underlying DCF model, for the moment using the same risk-adjusted discount rate, one no longer gets a single NPV value, but instead a NPV distribution. How then to do an investment decisions? Should the value relating to the 50th percentile be larger than zero for the company to accept this project? If using such a criterion, the company would double-count risk, or rather do two risk considerations: first one adjusts the discount rate to account for all risk in the projects; then one does another risk consideration of which percentile in the cumulative chart to use as investment criterion. There are hence clearly two risk-adjustments.

This problem has been pointed out in the literature [Pitkethly, 1997; Razgaitis, 2003*a*], stating that a double-counting happens but without explaining why, or giving any conceptual correct discount rate to use. In addition, what most literature seems to bypass, is that the question is inseparable to how one actually uses the resulting NPV distribution. One does not double-count simply because one uses a certain discount rate, one double-counts if one chooses a risk-adjusted hurdle rate and then another risk-adjustment when selecting a reasonable *hurdle percentile*. So what about using the risk-free rate? Let us take a look at the cumulative chart from figure 8.8 again, this time assuming that a risk-free rate has been used to deduce the NPV distribution. What investment criterion can one use then? If one chooses the 50th percentile, on average this would only give a return appropriate for risk-free investments[4] hence one can say that no risk-accounting takes place. One could however choose to aim for a certain lower percentile, stating that the company should only accept the project if the value given by this percentile is higher than zero. The problem is then that it is very difficult to know which percentile would on average give the minimum return needed to satisfy the company's stakeholders, i.eits owners and lenders.

A solution used by most practitioners, and suggested by Razgaitis [2003*a*] as appropriate, is to use the company WACC, the company's cost of capital and typically the general hurdle rate used for accepting projects. What is achieved by using this discount rate? If WACC reflects the risk of the company's average project, and if using the 50th percentile as the investment criterion, one can say that on average[5], the company will earn a return in the range of what is expected by the stakeholders. This is why WACC turns out to be the preferred choice when using MC analysis. However, in many circumstances the project in question is not an average project, and one should be more conservative than just using the 50th percentile. WACC does in theory only reflect the average business risk of the company. Any risk-adjustment above WACC should be reflected by where in the range between the 0th percentile and the 50th percentile one sets the investment criterion.

Razgaitis [2003*a*] discusses the correct percentile to use in deal-making situations, while in Razgaitis [2002*b*] he makes a similar discussion in the context of early-stage technologies. He asks what percentile reflects the appropriate price the licensee needs to pay for the opportunity in question. Figure 8.9 illustrates a typical deal-making situation, within which graph A shows the NPV valuation percentiles as given by a MC analysis[6]. If the parties agree that the reasonable price is reflected by the 20th percentile, graph B shows the new percentiles for the licensee, this time deducting

[4] This is not entirely correct as the 50th percentile actually gives the median, while the mean is normally a different value. However, it does not change much of our reasoning.

[5] The remarks of the previous footnote are still valid.

[6] This is identical to the normal cumulative chart, but adds a graph to the bars illustrating the percentiles

for the acquisition price of the opportunity. One can now see that the graph crosses the x-axis at the 20th percentile.

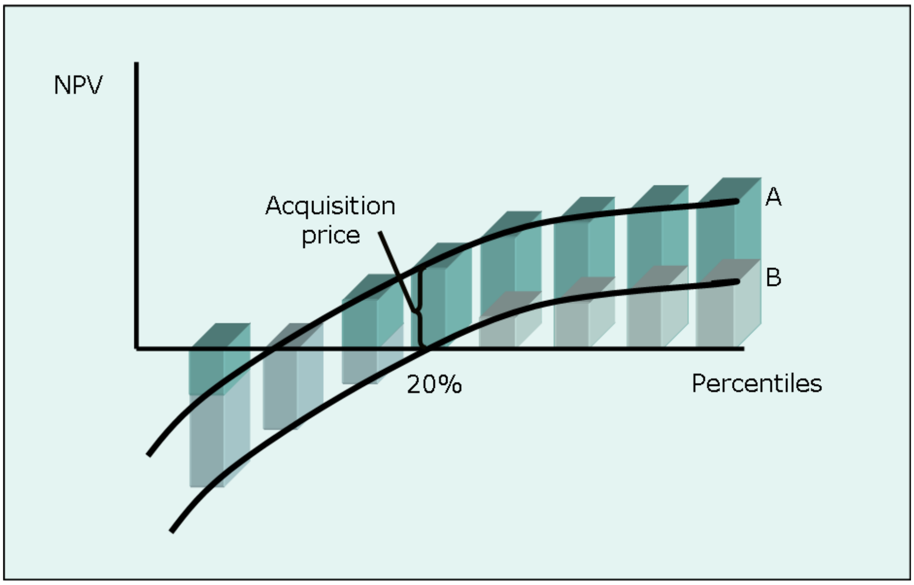


Figure 8.9: Example of MC analysis in deal-making situations

We now see that this discussion is identical to the one we did above. Razgaitis [2003*a*] is actually discussing the buyer's investment criterion, i.e; at which percentile should the licensees expect zero NPV. He mentions the possibility of using the 25% rule discussed in section 8.3, but recognizes that the context is not the same as the origin of the rule, which is normally applied as a reasonable split of the running operating profits. He therefore suggests that one should use the 20th percentile, referring to the widely known *Pareto principle.* [7]

We feel that such an approach is not very appropriate in the chosen TT context. The specific risk profile of a given technology may vary considerably from case-to-case, and this should be taken into account. The very nature of the MC approach indicates that risk is shown in the NPV percentile distribution, and to have a consistent investment criterion that distinguishes risky technologies from less-risky ones, we feel it is better to make a case-by-case consideration of the appropriate percentile. Although Razgaitis [2003*a*] chooses the 20th percentile, he indicates that an appropriate "split" would lie between 10% and 40%. We think it is more appropriate to use this range as a starting point and then make a judgement of where exactly in this range to aim. Again, it should not come as any surprise that we will argue for using the TUR method for this decision. The MC method conveys no decisive investment criterion besides that of determining an appropriate risk exposure, and since this will be a professional but qualitative judgment, the TUR method is the best approach we have available. It was simply built with the purpose of assessing a technology's risk and profitability. In this adjustment, we will only use the risk score for determining the appropriate target percentile. However, since it is a deal making situation, where bargaining power relies on leveraging all possible arguments, the total utility score could also be used to justify a different split. The integration of TUR is therefore

[7] Also known as the 80-20 rule, the rule states that for many phenomena, 80% of the consequences stem from 20% of the causes.

slightly different for the MC method: the four different stages of development will this time determine a quartile each; while the inverted risk score will determine in which eighth within that quartile, meaning which half of that quartile, to choose a target percentile. An example illustrating this process is shown in figure 8.10.

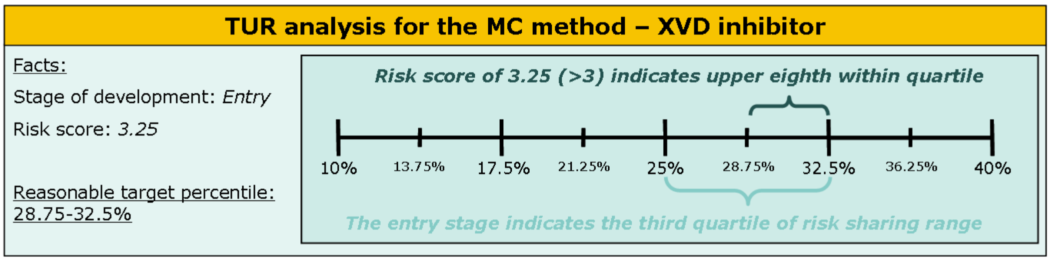


Figure 8.10: Integration of TUR for MC - target percentile

This also makes the pricing framework consistent, introducing the same philosophy as in the other methods, albeit a slightly different modelling. We also feel that by introducing a range in which the appraiser can use his qualitative judgment, we make the MC analysis more risk consistent than Razgaitis [2003*a*]. Riskier projects will translate into a lower *target percentile*, reflecting a fundamental concept of corporate finance; companies are risk-averse and *higher risk should be rewarded with a higher expected return*.

Royalty structure Finally, we need to discuss how we intend to use this target percentile and relate it to a specific royalty structure. If all value would be paid upfront, this would essentially be an upfront payment equal to the value indicated by the target percentile. However, in a licensing context, all the value is rarely paid upfront; some is also paid through a running royalty rate. To provide an easy approach of dealing with this, we will suggest first running the simple DCF method described in section 8.4. The resulting royalty structure can then be integrated in the MC analysis, though not varied, so that the simulation includes deductions for royalties when calculating NPV. The goal of the MC analysis thus becomes to analyze whether the royalty structure provided by the DCF method is appropriate or if some adjustments are needed. However, it may use any royalty structure as input.

The target percentile should in this case be compared to the percentile that corresponds to a NPV equal to zero. If the "zero" percentile is lower than the target percentile, there is room for increasing the royalty, and vice versa. This is illustrated in figure 8.11. With an updated royalty structure, the MC model could be run again to evaluate the changes.

Chapter summary This chapter have completed the development of the "target" part of the framework, allowing it to aim for market value. It has done so by integrating the TUR method across all the chosen valuation methods to account for a technology's utility in a coherent way, thereby increasing valuation accuracy. The exact integration is slightly different from method to method, reflecting their different valuation approaches, but the philosophy remains the same. Moreover, through the TUR method, many of the characteristics of the chosen TT context are duly accounted for. Thus, with the main part of the pricing framework completed,

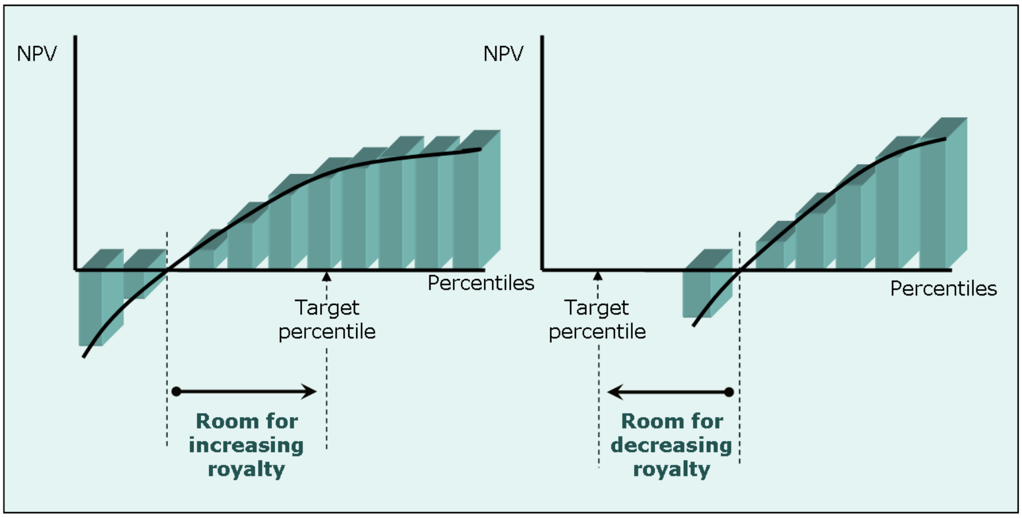


Figure 8.11: Consideration of target percentile vs. zero NPV

the next chapter will look into the two remaining aspects: the royalty structure and the walk-away point.

Chapter 9

Complementary analysis

Not everything that can be counted counts, and not everything that counts can be counted.

Albert Einstein, German physicist (1879-1955)

The previous chapters have developed the main part of the framework for pricing of technology licenses, trying to include and tackle the pricing considerations inherent to the chosen TT context. Building the estimation of a target price upon valuation methods from academic literature, the focus has clearly been on *that which can be counted*. We now proceed to a subject that clearly counts, but that cannot so easily be counted: incorporating the TT policy of favouring dissemination. This chapter will analyze the impact of this policy on the two remaining parts of our conceptual model: *the royalty structure* and *the walk-away point*.

9.1 Royalty structure

As has been pointed out several times, considering a specific royalty structure is essential when pricing licenses, and it has been treated in relation to each valuation method in chapter 8. Up to this point, however, a general royalty structure has been assumed: an upfront fee, normally based on transfer cost; and a running royalty percentage of net sales. This section will first relate the issue of royalty structure to an OTT's goal of dissemination. Afterward, it will briefly present other elements of a royalty structure and a license agreement that an OTT may consider for dissemination purposes.

9.1.1 The standard royalty structure

Much of the licensing literature deals with the question of how to determine the best royalty structure. Often, the underlying question of valuation is actually skipped, and the proposed methods work directly on the elements of a royalty structure[1]. In

[1] Much of the literature focuses on *determining a reasonable royalty rate and suitable upfront fees*, often in particular industries [see for example: Finnegan and Mintz, 1978; Muir, 1986]. Furthermore, Betten [2000] suggest interestingly to use some percentage of the MRC as a basis for an upfront fee.

this thesis we have discussed methods that work directly with a royalty structure, and more sophisticated methods that treat valuation and royalty structure as two separate issues. In both cases the technology is valued, and the OTT still has the possibility of making a trade off between upfront fee and running royalty. The simple solution would be to demand the whole value upfront, leaving the licensee to take all the risk. If the used valuation method sufficiently accounts for risk, a risk-neutral licensee would still be interested in taking the deal. However, few licensees are risk-neutral and the running royalty rate is therefore a means to share the risk between the two parties.

In the chosen TT context the commercialization risk is far bigger than in transfer of mature technologies between companies, but it is mainly, or fully, the company that is facing this risk. To the company, the riskiness of cash flows and payoffs are vital considerations, but to the OTT, riskiness of their royalty stream is of lesser importance. In line with its dissemination perspective, other aspects than net money return are important to an OTT: for example visibility of the transfer; a partner's expression of fast market dissemination; or maintaining a research relationship with a licensee. An OTT should therefore be in an excellent position to share that risk with the company and thus facilitate commercialization.

This analysis argues for a high degree of risk sharing with the company, meaning *a low upfront fee and a higher running royalty.* By doing this, an OTT will help mitigate the risk of commercialization and greatly increase the attractiveness of the license. For simplicity and for maximum risk sharing, we propose to base the calculation of an upfront fee solely on transfer costs, which are the costs incurred on the licensor because of the actual technology transfer. With an upfront fee any lower than that, the licensor would in effect be financing or subsidizing the transfer without any guaranteed return, something we discourage. This composition was used as the *"standard royalty structure"* throughout part II, and the justification for applying it with regards to the dissemination perspective should by now be clear. If another composition is wanted, the actual trade-off between the upfront fee and the royalty rate can be established by detailed calculation when an expected revenue stream is available, but otherwise qualitative judgment will have to suffice. The next section will present other elements of a royalty structure and license agreements that an OTT may employ to pursue its dissemination goal.

9.1.2 Other royalty structures and license elements

There are almost as many suggested royalty structures as there are practitioners, which is understandable given that the licensing situation, the stance of opposing parties, and the transfer object varies so much from case to case. This section will not try to treat many exotic royalty arrangements but will briefly present some elements an OTT may consider including in its royalty structures or license agreements. Where not otherwise stated, the description is based on the works of Razgaitis [2002*b*, 2003*a*] and Smith and Parr [2000].

Milestone payments Such payments are specified amounts that become due on the crossing of some milestone event, and are often used when the licensed technology require further development. By linking parts of the royalty structure to the success of intermediate development stages, milestone payments are clearly suitable for the chosen TT context. Sometimes a high upfront fee may be split into smaller payments linked to the development progress [Betten, 2003], and in the developed pricing framework, such payments could be linked to the stage-structure introduced in the TUR method. But often the calculation of the actual amounts is purely based on professional judgment of the licensee's willingness-to-pay. We propose that such payments should be looked at as a prepayment of royalties to come, and should thus be reflected in a lower royalty rate. However, since any large payments before market entry are likely to be viewed as risky by licensees, an OTT may want to avoid milestone payments completely.

Minimum annual payments It is not uncommon to stipulate some minimum annual payments in a license agreement, also called license maintenance fees, minimum royalties, or simply minimums. The rational behind demanding a minimum royalty payment are manifold; covering costs due to patents or patent application is often the main argument. Other arguments may be that the litigation effort done by the licensor should be rewarded, and that minimums may encourage the licensee to prioritize further development rather than putting the technology on hold indefinitely. This last comment is of special interest for an OTT that aims at speeding up the dissemination of its technologies. It is not uncommon that companies try to acquire exclusive licenses on technologies just to keep them away from the market and competitors [Smith and Parr, 2000]. Minimum annual payments are one way for an OTT to stimulate fast dissemination.

Royalty rate adjustments It is also possible to relate adjustments to the royalty rate to some defined event or specified date. For example, a structure where the royalty rate decreases in steps according total volumes sold are typically called a *wedding cake structure*. This is similar to the rebate given for large quantities in purchasing contracts but do not make much sense in the chosen TT context. Such step downs in the royalty rate would be appropriate when the production of a purchased good shows increasing returns to scale. However, in the TT chosen context, it is rather the licensee that is likely to experience increasing cost efficiency as sales volumes goes up, arguing for an increasing or *escalating royalty structure*. Malki [1997] develops a simple DCF model showing the rational for employing such a structure, for both OTTs and companies. Two similar royalty rate adjustments are those of *kicker and deflator royalties*. Both adjustments are related to some event, i.e. performance of the technology, proven IPR strength, ongoing litigation effort, regulatory or governmental approval, etc., and represent an increase or decrease in the royalty rate respectively. For the early-stage technologies of an OTT, such structures clearly make sense. Other common structures are: *multi market royalty rates*, when a technology may be used in several markets; royalties on *convoyed sales*, when the technology may also be incorporated into the licensee's products; and *sub licensing*, when the licensee is given the right to transfer and license the technology to other parties. A special form of this last concept is called *licensing-in: licensing-on*, which is when a company license the technology from a research institution, or a start-up is created, in order to develop the technology further and then license it further to a marketing partner. This latter business model requires special care when designing a suitable royalty rate, to ensure that both the originator and "interim" developer get sufficient return on their efforts [Finch, 2001].

Option arrangements There are several possible option arrangements in license agreements. One form of option is an initial payment made by an interested licensee to allow it to conduct additional R&D, or market assessments, or other feasibility activities, to enable it to make an informed licensing decision. The licensor would thus withhold the technology from further licensing during the option period, and the licensee is essentially buying itself time. For an OTT this may not be in line with its goal of fast dissemination. Other options are furthermore possible: an option to maintain exclusivity beyond a certain date; options to acquire additional fields of use or territorial rights; an option to buy out the licensor and end further royalty commitments; or options to buy down the royalty rate. An accurate calculation of such option arrangements would need detailed information and build on more advanced methods like risk-adjusted DCF, decision tree analysis, or contingent claim analysis [for examples of how, see Razgaitis, 2003*a*]. This is unlikely to be feasible for the early-stage technologies in the chosen TT context. Such options are therefore often based on guesswork and professional judgments.

Other license elements Another element that is essential for successful commercialization is the involvement of the inventor in helping a successful transfer and further development. The empirical study of Jensen and Thursby [2001] confirms this, and they furthermore develop a game-theoretical model analyzing incentive structures stimulating inventor involvement. They find that rewarding the inventor for his involvement greatly increases the chances of a commercial success. The best structure appears to be equity in the company or a share of the royalties due to the OTT. Few OTTs have the funds or legal possibility to provide equity, but many reward the inventor, and even his originating department, with a share in the royalty stream[2].

There are still other elements an OTT may consider as part of the license agreement and royalty structure: *Grant backs* are agreements where the licensor is granted a royalty-free, non-exclusive license on all further development and patents derived from the licensed technology; A *most-favoured status* given to the licensee ensures that his license terms will adapt if a more favourable one is given to a later licensee; *March-in-rights* gives the licensor the right to convert a license from exclusive to non-exclusive, reduce some exclusivity, or even terminate the license based on some standard of inadequate or non-performance of the licensee. In the chosen TT context, this could be unsatisfactory development or lack of market penetration.

9.1.3 Conclusion on royalty structure

This concludes our discussion of royalty structure. It would be impossible to define an ideal structure for OTTs to employ under their dissemination perspective, just as it was impossible to point out the correct valuation method to use. Rather, the royalty structure need to be adapted to each single case and are often a hot

[2] Such incentive schemes exist worldwide, including MIT, Harvard, Stanford, and John Hopkins University [Smith and Parr, 2000]. CERN TT also has a defined policy.

topic in license negotiations. This section has provided some analysis of what an OTT should consider: In the general structure, a low upfront fee together with a reasonable royalty rate reduces initial investments for the license, enables a sound risk sharing, and that encourages dissemination. Where appropriate, an OTT may also consider other licensing elements: milestone payments, minimum payments, royalty rate adjustments, option arrangements, inventor involvement schemes, grant backs, most-favoured-status, and march-in-rights (see also figure 9.1). The next section will analyze the last part of our conceptual model, the walk-away point.

Standard structure	More complex elements
A low upfront fee reduces initial investments for the licensee	Milestone payments
A reasonable royalty rate encourages risk sharing	Minimum payments
	Royalty rate adjustments
	Option arrangements
	Other elements, see discussion

Table 9.1: Standard royalty structure and more complex elements

9.2 Walk-away point

Knowing at which point to walk-away is probably the most important aspect of negotiations, ensuring that one at minimum do not loose unnecessary value on the transaction. The estimation of this point is crucial in the preparation phase, and for an OTT, with the goal of maximizing dissemination, it is essential to reflect upon how this goal affects the walk-away point. This section will start with a subsection on how to evaluate counter-proposals, followed by a related discussion of what would be a suitable discount rate in such calculations. Finally, the last section will discuss reasonable perspectives on the walk-away point for exclusive and non-exclusive licenses.

9.2.1 Evaluating counter-proposals

Being able to evaluate counter-proposals by the licensee is a prerequisite for knowing when one has reached the walk-away point, and as the previous section showed, royalty structures can be rather complex. Faced with two different proposals, it could be very hard indeed to decide which one is the better. Referring to our conceptual model, it would help to be able to translate a complex royalty structure to a single value on the whole deal line and vice versa. However, as pointed out in the last chapter and repeated under the discussion of the general royalty structure, some projection of expected revenues is necessary for this task. For the simpler methods in the framework, evaluating counter-proposals is bound to rely on professional judgment since sales estimates might not exist. When revenue projections are available, as in the DCF method, the calculations are quite straight-forward using the royalty structure module.

An important remark regards the discount rate used in these royalty structure calculations. During the valuation of a license agreement, one estimates the value to the licensee and use the royalty module to adjust this value or even drive it down to zero. In this process, it makes sense to use the licensee's risk-adjusted discount rate, since one is evaluating the value from his perspective. However, when estimating the walk-away point of the licensor, one should rather use the licensor's own risk-adjusted discount rate. The next section will briefly discuss the issue of public discount rates, before explaining what such a discussion implies for the walk-away point.

9.2.2 An OTT's discount rate

What would be the right discount rate for a public entity as an OTT, and why should it be different from the one used by a private company? Several highly regarded economists have engaged themselves on different sides of this debate. Arrow and Lind [1970] argue that the public diversify the project risk over many projects and thus should not risk-adjust the discount rate, a view supported by many others [see for example: Samuelson, 1964; William Vickrey, 1964]. The opposing camp argues that such an approach would lead to over-investment by the public sector [see for example: Hirshleifer, 1966; Diamond, 1967]. Sandmo [1972] argued that the disagreement is clearly a result of their different underlying assumptions about risk, but the debate has been further clouded by normative arguments. For instance, William Vickrey [1964] argued that by using the private discount rate one is neglecting benefits to future generations. Unfortunately, no consensus have been made during the years since then[3], but empirical evidence shows that most governments do something in between the solutions of these two camps [for examples of how, see Young, 2002; Strøm, 2003]. Interestingly, most OTTs are given the mandate to prioritize dissemination instead of income, meaning that an OTT should view projects differently from a commercial partner. A lower discount rate would thus be the only appropriate solution. It is up to the individual OTT to decide which rate to use, but we suggest considering the return of the longest living governmental bond available [like Tullock, 1964; Young, 2002][4].

What will in this case happen to the licensor's walk-away point? *Ceteris paribus*, a lower rate will reduce the discounting of future cash flows and increase NPV of a specific royalty structure[5]. This rationale enables an OTT to prioritize dissemination on pure financial grounds, by accepting lower expected royalties compared to a private company. However, the walk-away point further depends on whether the license in question is exclusive or not.

9.2.3 Perspective on the walk-away point

It is clear that the perception of a reasonable walk-away point depends largely on the licensing situation and the expectations for future licenses. An analysis of alternatives will therefore provide the best indication of when to walk away. In capital budgeting literature, the right economical term for such an analysis is opportunity cost analysis, which would estimate the best alternative use of the resources employed. For the chosen TT context, this concept is not easily applicable as an OTT

[3] [For further analysis, see the contributions of: Marglin, 1963; Tullock, 1964; Baumol, 1968; Mendelsohn. R., 1981; Caplin and Leahy, 2001]

[4] Although we are aware of the criticism by Pauly [1970] and others.

[5] The rate has no effect on the upfront fee, only on future royalties

seldom invest any resources in the licensing agreement, besides the actual technology *"sold off"*. An opportunity cost analysis would therefore focus solely on alternative license agreements.

For exclusive licenses, a forgone license agreement with a competitor should make up the opportunity cost. As exclusivity represents giving away a limited monopoly, and since this could limit the dissemination of the technology and prevent the OTT from licensing it to other companies, it makes sense to use a *market mindset* when deciding the walk-away point. One could imagine negotiating with several parties simultaneously to get the best deal possible and making estimations of alternative deals for other potential companies.

For non-exclusive licenses, the alternative deal is not as clear as the OTT may license the same technology to several competitors in the same industry/application domain. However, an OTT may have clearly defined licensing conditions that it will not cede on, including payment terms. These conditions may be based on a perception of fair licensing terms from an OTT or a previous license agreement on the same technology, if the OTT does not want to differentiate new and old licensees. Ultimately, the costs of the transfer should form the absolute lower bound on upfront fee, together with some low royalty rate, as one likely can get some small percentages on sales on most occasions. The costs of maintaining a patent may also be taken into consideration. However, in some cases, political considerations or other aspects may justify an even lower price. It is alas unavoidable, for non-exclusive licenses, that the walk-away point to some extent is based on professional judgment, and each OTT should thus decide on their own policy.

9.2.4 Conclusions of walk-away point

Type of license	Walk-away point
Exclusive	Employ a market mindset based on opportunity cost
Non-exclusive	Depends on policy and circumstances; ultimately as low as transfer costs

Table 9.2: Evaluating a suitable walk-away point

This section has analyzed the walk-away point for an OTT under its dissemination perspective. It was concluded that an OTT may use a lower discount rate than a private counterpart, leading it to accept a lower royalties on financial grounds. Furthermore, it became clear, again, that there is an important distinction between exclusive and non-exclusive licenses. An exclusive license will likely limit the spread of the technology, and an OTT should try to be compensated for lost profits and reduced dissemination by using *a market approach*, meaning employing a high walk-away point based on an evaluation of competitors' willingness-to-pay. For non-exclusive licenses, the analysis is not so clear; OTTs may, for some reason or another, have a defined policy on minimum conditions; moreover, depending the technology in question and its dissemination policy, an OTT may in some cases justify a very low walk-away point, even as low as transaction costs. Figure 9.2 summarizes these conclusions. The next chapter will recapitulate the whole framework, repeating the main arguments and conclusions.

Chapter 10

Summarizing the pricing framework

We all agree that your theory is crazy, but is it crazy enough?
Niels Bohr, Danish physicist (1885-1962)

Part II started with chapter 5 developing a conceptual model of the licensing situation and the pricing framework. Chapter 6 then analyzed the suitability of common valuation methods for the chosen TT context and chose six methods for inclusion in the framework. Identifying the need for a careful treatment of a technology's utility, meaning its potential profitability and risk, chapter 7 developed the Technology Utility Rating (TUR) method with this aim. Chapter 8 finalized the development of the target part of the pricing framework by integrating the TUR method across all the six chosen valuation methods, while chapter 9 provided complementary analysis of royalty structure and walk-away point. This chapter will summarize the development of the pricing framework through the presentation of *a pricing process* that suggests how the framework should be used and which considerations that are necessary for the appraiser.

10.1 The pricing process

The conceptual model presented in chapter 5 shows the three main aspects of our pricing framework: 1) the target point, 2) the walk-away point, and 3) the royalty structure. The first two aspects are part of every negotiation setting, but the latter is due to the licensing situation, in which the price is the royalty structure normally consisting of an upfront royalty fee and a running royalty rate. Consisted with the TT policy of the chosen TT context, the target price is based on estimation of market value, while the dissemination perspective is expressed by the two remaining aspects. Moreover, through the valuation exercise, the OTT will likely gain valuable insight into the market prospects of the technology in question and into the probability for a commercialization success. Figure 10.1 show how we envisage the pricing process and its different steps. The following sections 10.2 to 10.9 will discuss each part in further detail.

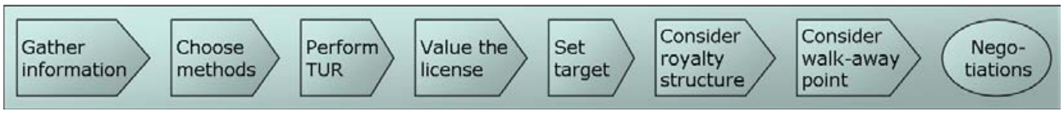


Figure 10.1: The pricing process

10.2 Gather technical and market information

The first task is gathering reliable information regarding the technology and how the licensee will employ it. This involves: analyzing the technology's development and characteristics; its possible domains of applications and where the licensee intends to apply it; the competition in these domains; the market prospects and possible sales generated by the technology; the further development needed for a successful application; and the strength of Intellectual Property Rights, to name a few points. Although much of this information may be hard to get hold of, it is vital both to a sound valuation and for the following pricing process.

Possible sources of information: the best would be if the licensee is interested in sharing his information; otherwise, the OTT or the R&D personnel may have some knowledge of market prospects in addition to knowing the technical details very well; if the OTT has industry connections from previous experience in a market, it should clearly leverage that network; but besides this, a market study is often the best approach, and it should look into industry statistics, income statements and business reports.

10.3 Choose suitable methods

The next step would be to choose which of the methods to use for valuing the license agreement: the modified replacement cost method, the paradigm licensing method, profit sharing analysis, the discounted cash flow method, scenario analysis, or the Monte Carlo method. The selection will clearly depend on the extent of information available as the two more advanced methods require substantial data to develop probability distribution and scenarios. If one thinks that the more advanced methods are necessary, one should of course return to the previous step and gather the necessary data. However, this may in some cases be infeasible due to the technology's early-stage nature or simply not worth the time and effort considering the limited market impact and high uncertainty of success. One should therefore choose which valuation methods to perform on a case to case basis.

We furthermore suggest using several methods to get a better indication of the deal value but also to understand the possible stance of the license in later negotiations. Since the chosen methods are complimentary in their approach to valuation, they may give insight that would otherwise have pass unnoticed. We suggest that an OTT, for most technologies, perform the valuation with: the paradigm licensing method, profit sharing analysis, and the DCF method. The paradigm licensing method give an indication of which royalty rates the license might be expecting, while the profit sharing analysis emphasize the revenue potential of the technology. The DCF represent a more academically valid approach, in a better way accounting for the duration, market size and uncertainty, but also for the exclusivity aspect. Furthermore, it estimates the highest possible price acceptable to the licensee, his walk-away point, which is valuable for later negotiations. Together, they should give a sound valuation of the license agreement.

10.4 Perform a Technology Utility Rating (TUR)

With enough information about the technology and its market application, an OTT should assess the technology's utility, meaning its potential profitability and associated risks. We developed a method, called Technology Utility Rating (TUR), for this in chapter 7 and the rating form was reported in figure 7.1. The associated procedure and necessary considerations was described in detail in that chapter, but briefly it involves: marking exclusivity; deciding the technology's stage of development; rating the profitability factors relative to other licenses of same type, that is, non-/exclusive; rating the risk factors relative to other licenses in the same stage of development; and calculating a score for each factor group as well as the overall utility score, remembering to invert the factors marked with y.

Since the TUR method necessitates a judgment of the current technology relative to comparable licenses, it may be hard to judge if it is properly done for the first couple of executions. However, *experience grows with time*, and it should thus become more and more valuable for adjusting the valuation methods according to a technology's perceived utility. Furthermore, we highly recommend OTTs to integrate the TUR factors with other rating schemes that are often used for work prioritizing. There is clearly an overlap of factors used in such schemes and in the TUR method, and by introducing the TUR earlier in the commercialization process, TT professionals may get experience and build trust in its application.

10.5 Value the license transaction

Having performed the TUR and gathered enough market information, the OTT may now proceed to the actual valuation exercise. Figure 10.2 shows the main steps of each valuation method, and, as we can see, the methods are sorted according to their dependency on market information. This section will now briefly explain the main steps of each method, leading to a proposed royalty structure (see chapter 8 for detailed information).

Modified Replacement Cost The first method consists of: asking the inventor how much time and resources he would require to recreate the technology; calculating the associated costs; evaluating the MRC estimate with regards to the TUR method's indication of utility - a high TUR score indicates that the MRC method is unsuitable, since it ignores potential profitability, and thus that other methods should be considered; and then designing a royalty structure. This last step will be hard, since the MRC only provides a cost estimate. Only when sales forecast exists, can one translate this single value to a royalty rate and then one has likely performed the DCF method as well. Thus, the MRC method should be used together with the DCF method, otherwise there will be no way of comparing it to the

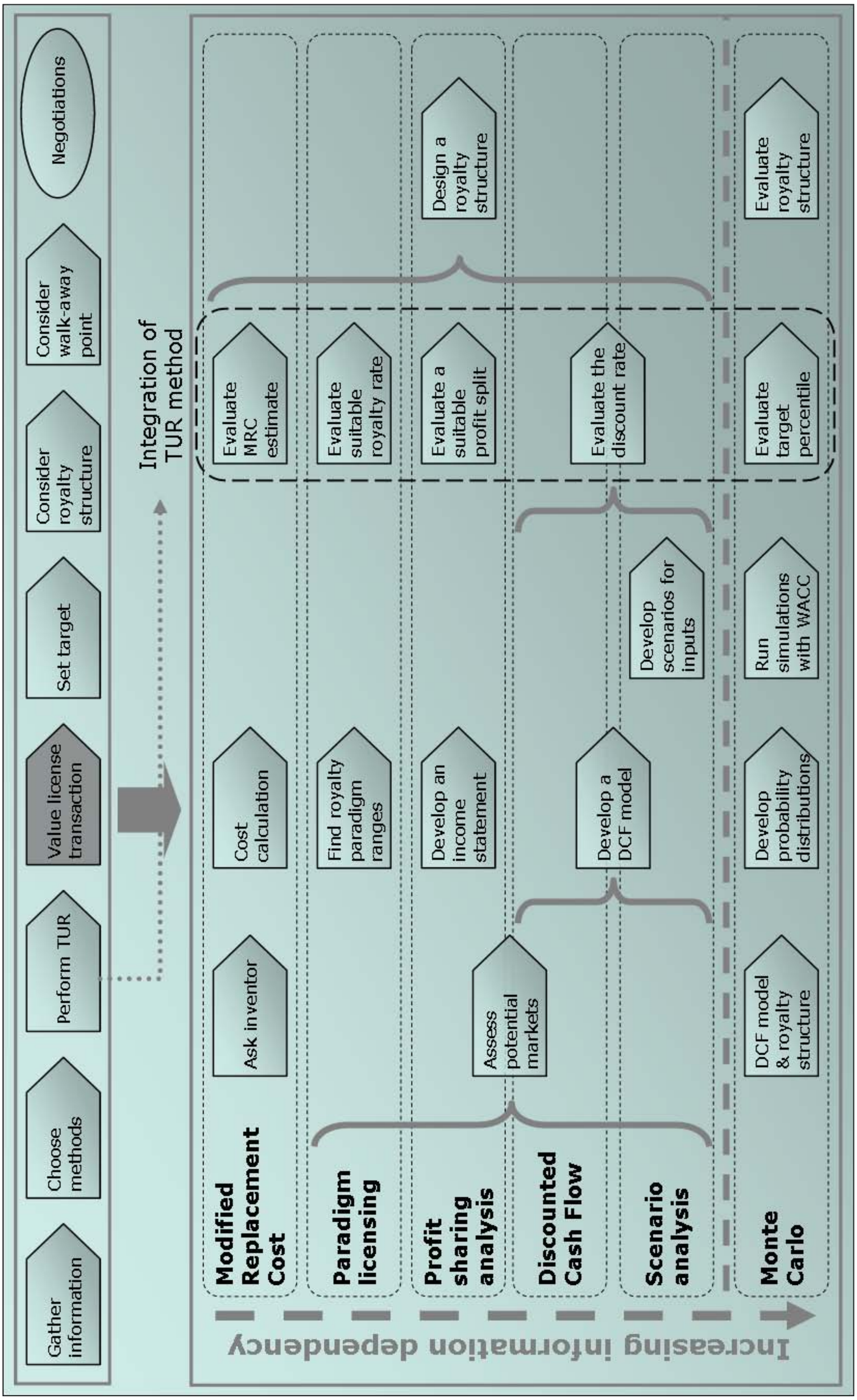


Figure 10.2: The pricing framework & process

remaining methods. When used, we furthermore suggest employing an upfront fee based on transfer cost, as for all methods, as this clearly encourages risk sharing and thus dissemination.

Paradigm licensing While the MRC manages without any market information, the paradigm licensing method needs to assess in which markets the licensee will use the technology. Thereafter, one should investigate the paradigm royalty rates in the specific industries and use the TUR method to pick a suitable royalty rate: first, one need to establish to ranges based on the mixture of exclusive and non-exclusive licenses, and pick the suitable one; then, the stage of development divides this range in two; thereafter, within this half, a utility score below 3 indicates the lower quartile, and a utility score above 3 indicates the upper quartile. The exact royalty rate within this quartile is up to the appraiser to decide. An upfront fee based on transfer cost is again suggested as standard.

Profit sharing analysis In this method, one develops an income statement representing a snapshot of the company's profits from employing the technology. The TUR method in then used to decide an appropriate profit split: again, the exclusivity aspect decides a certain range of suitable profit splits; the stage of development decides divides this range in two; the utility score decides which quartile within that half; and the appraiser should pick an exact rate within that quartile. The resulting profit split is applied to the operating profit and a royalty rate on sales is determined. An upfront fee based on transfer costs completes the royalty structure.

Discounted Cash Flow This more advanced method builds a model of free cash flows over the technology's lifetime. In this modelling, special care should be given to: the timing of different development stages and time to market; the estimation of cost structures and possible improvements over time; the (hopefully) increasing revenue stream as the product is adopted in the market. The resulting free cash flows are then discounted with an appropriate rate: suitable ranges are specified for each development stage of the project, and the risk score of the TUR method determines the exact rate within these ranges. The resulting net present value indicates the value to the licensee of the agreement after accounting for risk. A royalty structure module is then be used to develop a royalty structure that equates to this NPV and an upfront fee based on transfer costs is again standard. This module enables the appraiser to adjust and tweak the trade-off between royalty rate and upfront fee in a consistent way.

Scenario analysis Scenario analysis allows us to model uncertainty better by developing several scenarios in which the inputs of the DCF model change: development efforts, time to market, cost structures, and revenue streams are the most important ones. It is furthermore customary to develop three scenarios: a pessimistic case, a base case, and an optimistic case. Since vital parameters change between the scenarios, one should thus perform a TUR for each. There are several options for designing a royalty structure: one may use the expected NPV to calculate a royalty structure using the sale forecast of the base case; however, one may also develop a royalty structure for each scenario. This latter scheme may encourage risk sharing between the parties, and the activation of the more complex royalty structure should be clearly identified in the license agreement.

Monte Carlo The final, most advanced method employ the standard DCF model and take a suggested royalty structure as input. The Monte Carlo method is an interesting approach for modelling uncertainty, but contrary to scenario analysis, it assigns probability distribution to vital input parameters rather than developing distinct scenarios. Though, when later drawing random numbers from these distributions for each simulation, different scenarios are in a way created. One should carefully consider which parameters to model, and the most important ones were mentioned for scenario analysis. Furthermore, the method allows modelling contingencies, or correlations, between the parameters. A large number of simulations can then be calculated, normally 1000 or more, using the company's estimated weighted average cost of capital as discount rate. This ensures that the resulting NPV distribution incorporates the average return on capital of the company's projects. The stage of development and the risk score of the TUR method are then used to evaluate which percentile constitutes a suitable risk sharing between the OTT and the licensee.

10.6 Set your target

The outcome of each method, as described in last section and in figure 10.2, is a proposed royalty structure with an upfront fee based on transfer cost and an associated royalty rate. Furthermore, following the advice of using several valuation methods to complement each other, we should now have more than one proposed structure. Let us say we have three, one from the paradigm method, one from profit sharing analysis, and one from the DCF method as suggested before. Since the upfront fees are similar across the royalty structures, an OTT only need compare the three royalty rates to each other. Having performed several valuations, the appraiser should now be in a good position to evaluate what constitutes a reasonable royalty rate and this should become his target for later negotiations. However, the DCF method clearly accommodates the exclusivity aspect in a better way than the simple methods, and it furthermore estimate the licensee's walk-away point. It should therefore be treated specially in such a comparison.

In cases where one, for some reason, has royalty structures with different upfront fees, the comparison is more difficult. One then needs projections of sales for an exact comparison of the different royalty structures, which can be done by using the royalty structure module of the DCF method. When such expected sales are not available, the more advanced methods was likely infeasible, and the comparison must be base on professional judgment.

10.7 Consider the royalty structure

Having set a target, either in the form of a royalty structure or a deal value, one may now proceed to tweak it. By tweaking, we mean trading off a higher upfront fee with a lower royalty rate or vice versa. As before, such adjustments can only be precise in terms of equal NPV when sale forecasts are available. Otherwise, this trade off relies on the judgment of the appraiser. There may be several reasons for adjusting it: if the OTT is in desperate need of income due to financial stress or management's demand for result; if the OTT has some standard approach to upfront fees, justifying a higher fee than transfer costs; or if the OTT, for some other reason, perceive a higher upfront fee as acceptable. In general, however, we suggest using the standard royalty structure of our pricing framework, as it clearly encourages risk sharing and thus dissemination.

There are also other elements that an OTT may consider including either in the proposed royalty structure or as terms in the license agreement. Please see chapter 9 for the analysis of these elements with regards to the dissemination perspective; while table 9.1 listed them together with the proposed standard structure.

10.8 Evaluate the walk-away point

The last step of the preparation phase, before going to negotiations, regards evaluating the walk-away point, and this is where the dissemination perspective has the largest impact. Such consideration will naturally depend on the OTT's policy and vary from case to case, but there is an important distinction between exclusive and non-exclusive licenses, as analyzed in chapter 9. For exclusive licenses, one should employ a market mindset based on opportunity cost, while for non-exclusive licenses it clearly depends on policy and circumstances. Ultimately, transfer costs plus a reasonable low royalty rate should form the lower bound.

10.9 Negotiate the license agreement

Through the previous steps in our pricing process, an OTT should be well prepared for the negotiations. Having considered its target, walk-away point and possible royalty structure elements, it should be able to propose a reasonable deal to the licensee. The final deal value will obviously depend on the negotiation process where negotiation style, difference in stances, and asymmetric information will influence the outcome. This thesis will not go into further detail in this process[1], but it should be clear that the pricing framework may be of use during the negotiations as well: it may be used to evaluate counter-proposals by the licensee, estimating a deal value; one may use it to tweak counter-proposals to the better for the OTT; it *should* be used to evaluate how the current proposed deal relates to the walk-away point; if new information comes up, this should cause a revaluation of the license agreement; and lastly, the valuation methods may provide a sound pricing rational that can be used as arguments during negotiations, as it is harder to attack academically sound pricing rationales.

Chapter summary This chapter has presented a process for employing the developed pricing framework, thereby summarizing its development and different aspects.

[1] However, please see Thompson [2001] for a good treatment of negotiation theory.

As the analysis of background and context in part I emphasized, pricing of technology licenses is generally a hard task, but especially so for OTTs at public research institutions. The pricing framework developed in this part II aims at solving that challenging task by accounting for the pricing characteristics of the TT context identified in chapter 3.

The next part III will provide a case implementation of the pricing framework for a technology from CERN TT[2]. Through this case study, we will show the pricing process in practice and the different aspects of the pricing framework. After the case study, the following chapter will summarize the whole thesis. Our last chapter will finally conclude on the development of the pricing framework and suggest directions for further work.

[2]This part is confidential and not available in the public version of this thesis

Part III

Case implementation at CERN TT (Confidential)

Summary

Make everything as simple as possible, but not simpler.
Albert Einstein (1879-1955)

The origin of this thesis was that the Technology Transfer Group at CERN (CERN TT) wanted a standardized pricing approach to licensing, but they did not feel that any methodologies proposed by academia or business literature could fully accommodate their specific needs. Thus, the purpose became to establish a framework for pricing of licenses on CERN Technology, accommodating the specificity of CERN's policy for Technology Transfer: *"CERN will seek to obtain a price for the licensing of its technology reflecting, as much as possible, the market value of the technology. CERN will however favour pricing approaches that are deemed to maximize the dissemination as opposed to maximizing the income."* However, it quickly became clear to us that the specificity and policy of CERN TT is very similar to that of other Offices of Technology Transfer (OTT) at public research institutions, and we therefore decided to develop a general pricing framework for such OTTs.

Part I presented the Technology Transfer context and analyzed in detail which considerations a pricing framework should accommodate to be suitable for implementation in a TT context.

Chapter 1 departed benignly by introducing CERN, its history and purpose, and emphasizing how its mission of fundamental research in particle physics continuously drives the state-of-the-art of current technologies to new levels. Because the resulting innovations may benefit society in a wide number of fields, best illustrated by the proliferation of the World Wide Web, transferring such innovations to society has become an integral part of CERN's mission. Moreover, it led to the formulation of an active policy for Technology Transfer and the creation of CERN TT in 1999.

As **Chapter 2** presented, there is a global trend of surging interest in the field of Technology Transfer, leading to the foundation of OTTs at public research institutions around the world. The chapter therefore compared the TT context at CERN with that of other OTTs, with regard to policy, work process, and the vehicles used for the actual transfer of technology. Finding substantial similarities, it clearly defined a general TT context for which the framework should be applicable, thereby validating our problem formulation.

Chapter 3 proceeded to analyze the challenges of pricing licenses in the chosen context, and, through its analysis, it developed a set of characteristics that the pricing framework should accommodate. These characteristics, effectively forming requirements for the development in later chapters, are reported in table S.1. Finally,

three licensing cases from CERN were presented, illustrating the preceding discussion and the pricing characteristics. **Chapter 4** simply summarized part I.

Characteristics	Effect on pricing framework
TT policy	Aim for market value but favour dissemination
Technology licensing	Integrate royalty structure considerations
Negotiation setting	Accommodate that pricing is a process
Non-/Exclusivity	Distinguish and support both
Early-stage technologies	Assess stage of development
Limited market information	Include and employ several methods
Variations in technology utility	Coherent approach to risk & profitability

Table S.1: Characteristics of pricing in the chosen TT context

Whereas part I laid down the foundations for the pricing framework, **part II** developed it. Step by step, the framework was created based on a thorough analysis and understanding of the chosen TT context, combined with a sound discussion of academic theory.

Chapter 5 presented a conceptual model of the pricing framework based on the analysis of part I. It showed how pricing can be viewed as three complementary aspects: setting a reasonable target based on a market valuation; considering a walk-away point that accounts for the dissemination perspective; and, finally, providing a royalty structure that favour dissemination. Through this conceptual model, the framework does in fact seek to obtain, as much as possible, the market value of the technology, but at the same time it favours pricing approaches that are deemed to maximize dissemination. Moreover, it placed the framework in the negotiation setting inherent licensing.

Chapter 6 provided a primary study of valuation methodologies presented by academic or business literature, and based on the outlined characteristics it was able to choose the ones suitable to the chosen TT context: modified replacement cost, paradigm licensing, profit sharing analysis, discounted cash flow, scenario analysis, and Monte Carlo analysis. The chapter ended by pointing out the considerable room for qualitative judgment left by all methods. We emphasized that this judgment should be based on the utility provided by a specific technology, meaning its potential profitability and associated risk.

Chapter 7 picked up the last argument of chapter 6 and developed a methodology for quantifying the appraiser's qualitative judgment of a technology's utility. Literature on factors affecting licensing agreements was reviewed, and ten factors that were seen as essential for risk and profitability were extracted and put in a rating scheme. The resulting Technology Utility Rating (TUR) is shown in figure S.1, illustrating that the utility score consists of a number score reflecting the rating of eight factors, in addition to two letters identifying the exclusivity aspect and the stage of development, respectively.

Having chosen the valuation methods and introduced the TUR method, **chapter 8** finalized the target part of the framework. Each valuation method was discussed and illustrated, and it was described how the outcome of each method could be translated into an appropriate royalty structure. Most importantly, however, the chapter integrated the TUR method across all valuation methods and explained

Technology Utility Rating							
Technology:							
Licensee:							
Industry:							
Type of license:	**E**xclusive				**N**on-exclusive		
Stage of development:	**C**oncept	**P**rototype			**E**ntry	**M**ature	
Factor rating	**--**	**-**	**=**	**+**	**++**	Invert (y/n)	Final score
Profitability - relative to exclusivity							
Competitiveness						n	
Duration						n	
Profit margins						n	
Market size						n	
Risk - relative to technologies in the same stage of development							
Technical uncertainty						y	
Market uncertainty						y	
IPR strength						n	
Support training						n	
Total utility score							

Figure S.1: The Technology Utility Rating form

how: for the MRC method, no direct relation was modelled; for paradigm licensing the TUR method specifies in which part of the paradigm range to aim; in profit sharing analysis it specifies how much of the operating profits that should accrue to the licensor; in the DCF method and scenario analysis, the stage of development and risk score determines the appropriate risk-adjusted discount rate; finally, in MC analysis the same two factors determines the reasonable target percentile that would compensate the licensee for the risk he is facing.

After having developed the main part of the pricing framework, **chapter 9** provided a complementary discussion of the walk-away point and the royalty structure, with regard to an OTT's goal of dissemination. For the royalty structure we concluded that an OTT should extract as much as possible of the value through a running royalty rate, while the upfront fee should cover transfer costs. This encourages risk sharing and thus favours dissemination. With regard to the walk-away point, the chapter concluded that there is an important difference between exclusive and non-exclusive licenses. For exclusive licenses, one should employ a market mindset based on opportunity cost, while for non-exclusive licenses, ultimately both transfer costs and patent costs may be considered together with a *low* running royalty rate.

Chapter 10 summarized the entire framework through a pricing process that illustrates the different steps of using the framework. Figure S.2 shows this process and focuses particularly on the valuation exercise.

Part III consisted solely of **chapter 11**, which implemented the pricing framework for a real licensing situation. The analysis of an historical case, in which CERN granted an exclusive license to a Swedish start-up in the medical radiotherapy field, provided a first test of the framework. Based on that exercise, we could draw some initial conclusions and perform a thorough sensitivity analysis of our modelling approach. Through the analysis, we commented on some weaknesses and suggested possible solution; however, the next chapter will go into further detail on this, providing conclusions on the development and indicating where further work is justified.

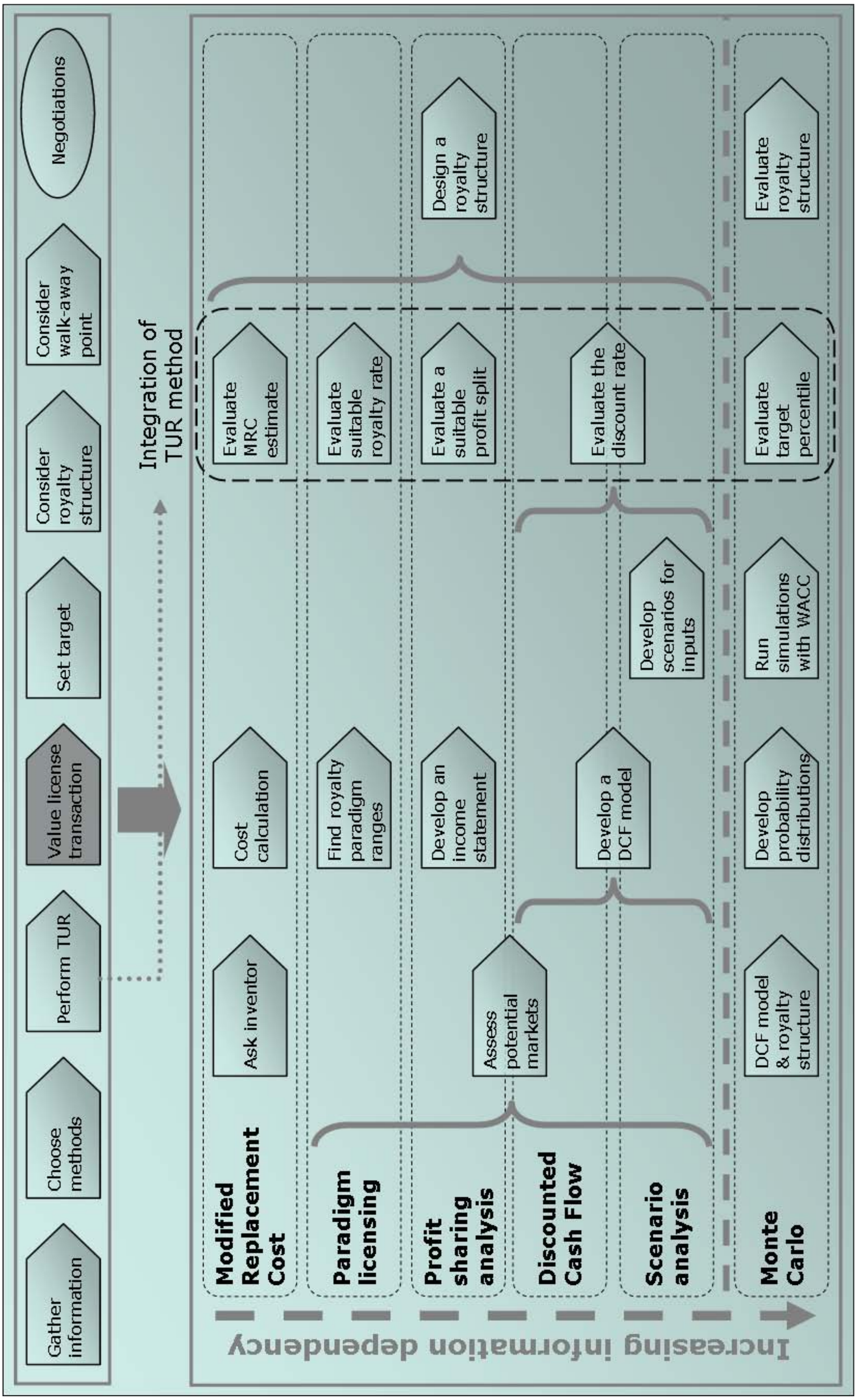


Figure S.2: The pricing framework & process

Conclusions and Further work

This is not the end. It is not even the beginning of the end. But it is, perhaps, the end of the beginning.
Winston Churchill, British politician (1874-1965)

This last chapter will *end the thesis* by examining how well the problem formulation has been answered. It will do so by reviewing how the pricing framework accommodates the pricing characteristics, which have been so central to this thesis.

First and foremost, the pricing framework was developed to facilitate the specific **TT pricing policy** that so clearly distinguishes OTTs from private companies. Essentially, this policy is comprised of two parts: Firstly, an OTT should aim for market value in its technology transfer activities; secondly, it should favour dissemination in this process. The conceptual model was promoted to achieve this balance; however, it requires further discussion to judge its success.

The pricing framework clearly aims at market value by basing it target price on an underlying valuation, and different valuation methodologies therefore form the core of the pricing framework. These methods were selected based on a thorough literature review and an analysis of what characterizes pricing in the chosen TT context. The exact modelling will be discussed later, but we would say *the framework undoubtedly aims at market value.*

For the latter part of the policy, we claimed that the goal of dissemination should purely impact the selection of an appropriate royalty structure and walk-away point, and we have tried to provide a sound discussion of these aspects throughout the thesis; however, the realisation of this second part of the TT policy might not be so clear as for the target price. Nevertheless, for the royalty structure we have shown that an upfront fee based on transfer costs and the remaining value extracted through the running royalty definitely encourages dissemination. However, *further effort is clearly needed on evaluating the impact of more complex license elements and providing practical guidelines for their application.*

The analysis of the appropriate walk-away point under the dissemination perspective was even less decisive. For non-exclusive licenses, we have made a clear recommendation for the *ultimate* walk-away point, but it was not defined under what circumstances this should be applied. For exclusive licenses, the application of a market mindset and opportunity cost approach are conceptually sound arguments; however, what will they mean in practice? These two parts of the conceptual model was marked as complementary analysis and we strongly *advocate further work on them with regard to the dissemination perspective.*

Furthermore, the conceptual model also accounted for two other pricing characteristics: **the negotiation setting** and the **technology licensing situation**. However, we have not looked at pure negotiation topics as strategy, style, trust building, price acceptance, etc., but we encourage *further work in these directions as there are few studies related to the TT context*. Furthermore, it would be interesting to analyze the effect of employing the pricing framework and its rationale *in negotiations*. Lastly, the benefits generated in industry through the in-licensing of technologies vary greatly depending on whether they result in a new product, an enhancement to a product, or cost savings. We have not considered the resulting consequences for our pricing framework in detail, but it could clearly be handled by calculating and isolating the benefit in a "value added" mentality. This would not change the overall framework, but *further work is required to evaluate the adaptations needed*.

Limited market information is another important characteristic of pricing in the chosen TT context. The framework tries to solve this issue by including several methods that vary in information dependency, thus allowing OTTs to choose which methods are feasible from case to case. We strongly encourage the use of several methods, our preferred set being the paradigm licensing method, profit sharing analysis, and the DCF method, even when additional resources must be spent to acquire the information necessary. The required resources are furthermore likely to decrease over time as the OTT acquires experience and knowledge both in gathering information and performing the valuation. Likewise, qualitative judgment of the technology's utility, meaning its potential profitability and associated risk, becomes more important when limited market information exist. The Technology Utility Rating was proposed as a means for quantifying this professional judgment, outlining a pragmatic method for assessing ten factors deemed important by licensing literature. Although we performed a sound literature review to establish the chosen factors, *further work on whether the factors included actually are good proxies for risk and profitability is justifiable.*

This leads to the chosen integration of the TUR method across the valuation methods, a feature that took into account the three remaining pricing characteristics: **the exclusivity aspect**, modelled by selecting different ranges; **the early-stage nature of technologies**, modelled through the stage structure; and **the variations in technology utility**, modelled through the utility score. The sensitivity analysis of chapter 11 discussed the robustness of our modelling approach and indicated its weaknesses.

Concerning exclusivity, the simpler methods accounts for this factor by establishing two separate ranges: one for exclusive licenses, and one for non-exclusive. Assuming that one has enough information for determining such ranges, this is approach is conceptually sound. However, as we clearly pointed out, such information will rarely be available, and one needs to assume a certain concentration and mixture of the two types of licenses. In this thesis, we suggested employing a 37.5/25/37.5 mixture in these cases, but we strongly *recommend further effort be put in determining suitable mixtures for the relevant industries.* This modelling of mixture effectively puts a price on exclusivity, and *one therefore needs to assess whether it gives sound and consistent answers over time.* For the more advanced methods, the issue of exclusivity poses less of a problem as it should be directly reflected by the input parameters (sales, volumes, etc.) of the methods.

The stage structure has a considerable impact on the valuation outcome, reflecting our arguments that it is the prime indicator of risk. We do have clear academic backing for such of risk classification; however, it is not equally clear that all technologies fit into this categorization. Some technologies in the concept stage might be less risky than technologies in the entry stage, and vice versa. Therefore, it *remains as further work to test the consistency of the chosen risk classification and its integration across the valuation methods*.

The exclusivity aspect and the stage of development have been given the greatest influence in our modelling approach, leaving *the utility score* with little impact. It would have been possible to model the relation between the utility score and the stage structure differently, but this was a deliberate choice as indicated above, stage being the most important risk factor. However, *further work is clearly warranted to judge whether this balance is appropriate or whether some alternative modelling should be introduced*.

Lastly, the pricing framework was developed with CERN TT as the primary recipient and validated on a licensing case from their practice. It remains to see whether the final implementation will be successful, but we are eager to start. Clearly, Winston Churchill was right: *this is not the end*.

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Appendices

Appendix A

Intangibles and Intellectual Property

The concept of a *new economy* or *knowledge economy* has received increasing attention the last decade or two. The evidence for such a change in the economy's structure is evident in both hard numbers and analyses from well-regarded economists. Measured by the gross domestic product (GDP), the output of the US is five times greater today than 50 years ago, however, as Alan Greenspan, the recent chairman of the US Federal Reserves, worded it, *"the physical weight of our gross domestic product is evidently only modestly higher today than it was 50 or 100 years ago"*[1]. By physical weight, he means the part of GDP generated from the exploitation of physical assets. Following this line of thought, the remaining GDP value has to be created from some non-physical assets. On the microeconomic level, the same trend can be seen in companies' price-to-book ratios that have surged since the 1980s [Razgaitis, 2002*a*]. These non-physical assets are representations of the increasing importance of knowledge in our economy, and economists and accountants call them by the term *intangible assets*[2]. This appendix A will in its first section briefly introduce a model for understanding the concepts of intangibles and Intellectual Property (IP). Different classes of IP is then considered in further detail, with examples from CERN, to illustrate how IP is an expression of the underlying technology and partly forms the legal basis in a license agreement.

A.1 Intangible Assets

So what is intangible assets? Similar to the introduction above, Webster's dictionary defines it as *"an asset that is not corporeal"*, physical, but how can such non-physical assets drive the value of today's companies? Let us turn to the descriptive model of Sullivan and O'Shaughnessy [1999] for better understanding how tangibles and intangibles relate to each other.

[1] In his speech before the Dallas Ambassadors Forum, Texas, April 16, 1999, see: http://www.federalreserve.gov/boarddocs/speeches/1999/19990416.htm

[2] CERN TT has devoted studies to knowledge transfer that has extensively analyzed both scientific projects and TT projects, and that furthermore has made proof of the importance of multidisciplinarity in the knowledge transfer process [Bressan, 2004; Huuse and Nordahl, 2004; Cruz et al.,

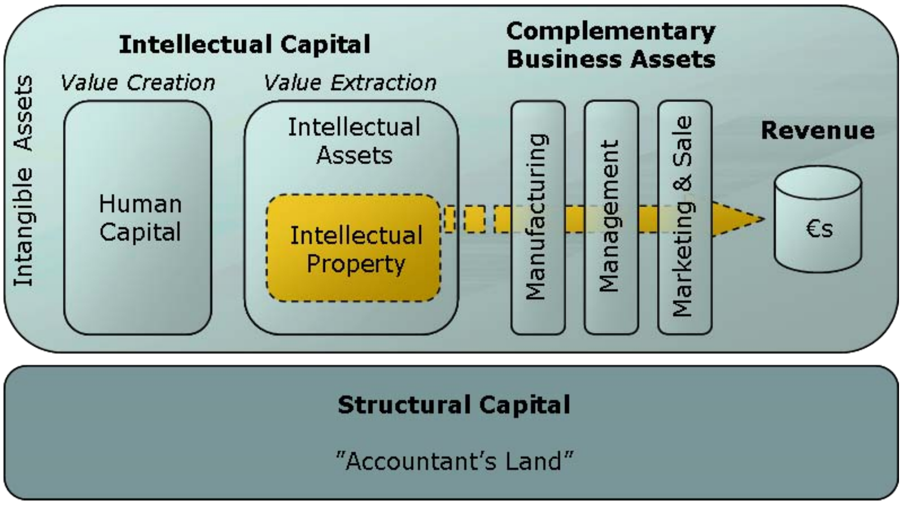

Figure A.1: Model of the Knowledge firm

Our main focus in this figure should be on the outlined left side. To briefly explain the other elements: *structural capital* is the physical, tangible assets, introduced before, that can be easily accounted for, and is by some referred to as accountants' land; the upper part of the figure is the *intangible assets* of a company; where the three aligned boxes on the top right are illustrations of *complementary business assets* that are not the core business of the company, like management, sale force and distribution; however, some companies might have their competitive edge here, in which case it should be moved into the first outlined box on the left. This box represents the *intellectual capital* of the firm, of which there are three subsets: the *organizational capital* consisting of organizational structure, procedures and external relations, that allow the *human capital*, the employees, to create value. Intellectual capital has even been defined by business managers as simple as what walks out the door at the end of the business day. However, the remaining subset, the intellectual assets, *"are created when the human capital commits to media any bit of knowledge, know-how or learning"* [Sullivan and O'Shaughnessy, 1999]. Examples include plans, procedures, memos, sketches, and computer programs among others. Now, no matter how much a person feel owned by a company, as employee, and human capital, he may actually leave the company at any time, while the company owns the intellectual assets he leaves behind.

The basic idea is now easier understandable; in the knowledge firm, human capital depends on the company's structural and organizational capital to create value in the form of intellectual assets; that value is extracted through complementary business assets to generate profits for the company. Intellectual Property (IP) is in this definition *"the subset of the company's intellectual assets of the firm that is protected by law."* The model further stresses the importance of IP in the value extraction of a company and why it is important for an Office for Technology Transfer (OTT) to have a clear IP strategy. Parr [1996] expresses the emotion in industry by saying that *"IP..., is the most important asset that any company owns."* Another argument is that the increasing number of patent disputes shows the importance that companies put on their IP today [Barron et al., 2005]. The next section will look into different

2004].

IP classes illustrated by examples from CERN.

A.2 Intellectual Property (IP)

Intellectual Property (IP) is a broad concept and there are many different taxonomies, differing on how they classify and treat each subclass. The seminal work of Smith and Parr [2000] provide the following classification: proprietary technology (including trade secrets), patents (of different kinds), copyrights, trademarks, computer software, mask works, and right of publicity. In addition, there are more rare classes of IP as plant breeders' rights, traditional/indigenous knowledge, domain name, and moral rights. This wide variety is understandable considering the different nature of many intellectual assets, and it is furthermore clear that different intellectual assets require different laws for protection. The next subsection will briefly introduce the main classes: *patents, trade secrets, copyrights, trademarks, mask works, and computer software.*

A.2.1 Patents

A patent is essentially, according to Burge [1984], *a negative right*, normally lasting 20 years, giving the patent holder the right to exclude others from making, using, or selling the patented innovation. In this sense, and in economical terms, a patent creates a limited monopoly, both in scope and time, for the holder. The rationale for society, as a whole, in giving away such monopolies, are twofold; first, it may stimulate and encourage innovation that otherwise would not have been profitable; secondly, it necessitates the inventor to disclose his innovation to the public, allowing further innovation to build upon it. There are *different kinds of patents:* utility patents on processes, machines and products; plant patents, similar to plant breeders' rights mentioned above; and industrial design patents on the design of a products. CERN has a number of utility patents, ranging from a concept, called the Diaprahm System, for positioning components precisely using off-center lamels and pressure to a gas detector design using of specially coated and etched polyamide sheets, called GEM foils[3].

A.2.2 Trade secrets

In some circumstances, secrecy may be the best way of protecting your IP. Information as working procedures and customer lists, are business sensitive information that companies keep secret. U.S. Supreme Court [1969] defined trade secrets in a ruling as broadly as *"any information not generally known in the trade."* Inventions related to processes and machines can be trade secrets, when they are not protected by patents. There are several imaginable situations where it makes sense for a company to wait for filing a patent or even abstain from it. They may be afraid of competitors designing around it or just preferring to avoid the associated costs of a patent procedure. Regarding CERN's aforementioned patent of using GEM foils in

[3]For a more detailed account of the different technologies developed at CERN, see: http://www.cern.ch/technologytransfer

gas detectors, the process of producing the high quality GEM foils needed is actually not part of the patent but remains a secret for the moment.

A.2.3 Copyrights

A copyright concerns *the expression of an idea*, though not the idea itself, and gives the exclusive right to regulate its use [Smith and Parr, 2000]. It is important to note that, unlike patents, it is not necessary to register the work to enjoy this right. Furthermore, its application is quite wide, i.e. incorporating artistic works (films, music, photographs, literature etc.), architectural designs (buildings, parcs, other constructions). Under this definition, it is clear that *this thesis is copyrighted.* Other examples from CERN are its logo, illustrative pictures, educational movies, and its scientific and educational publications.

A.2.4 Trademarks

Trademarks are not so relevant to CERN or other OTTs, however it is extremely important in normal business, especially for consumer goods. Considerable amounts of money are spent each year in creating, developing, and defending a trademark. Its definition is very wide however. Historically, it has been *"a distinctive visual representation of the company"* in the form of a logo, name or phrase. Recently, however, a few *smell marks* and even tastes have been registered as trademarks [Anson and Suchy, 2005]. CERN has actually patented the phrase *"... where the Web was born"* but is unlikely to sell it.

A.2.5 Mask works

Mask works are the design representation of a semiconductor chip, and it derives from its photolithographic production process. In short, the semiconductor is produced by chemically etching a layer of the wafer, according to the design print left by illuminating the wafer through a mask. These mask are not protected under either copyright or patent law, so a separate protection is usually provided in most countries. CERN have an extensive experience in customized electronics design for its physics detectors and possess the rights to many mask works.

A.2.6 Computer software

The reason for naming computer software as a separate IP class is disputable. Software is, from standard law, subject to patent, copyright, or trade secret protection [Smith and Parr, 2000]. Trademark protection, as in any industry, is also becoming more important. However, the importance of computer software in business activities is increasing, hence most taxonomies treat it separately. In the context of CERN, its engineers has developed many well-written computer programs for its physics applications and internal management, but maintains an *open source policy.*

Appendix B

CERN's Technology Transfer Process

The Technology Transfer process employed by CERN TT builds on the concept of goal-directed project management and the experiences reported by other OTTs. Each work package has a set of documents associated, including detailed work descriptions, templates, and reports. Figure B.1 on the next page reports the main steps of the process, but more information may be available on request.

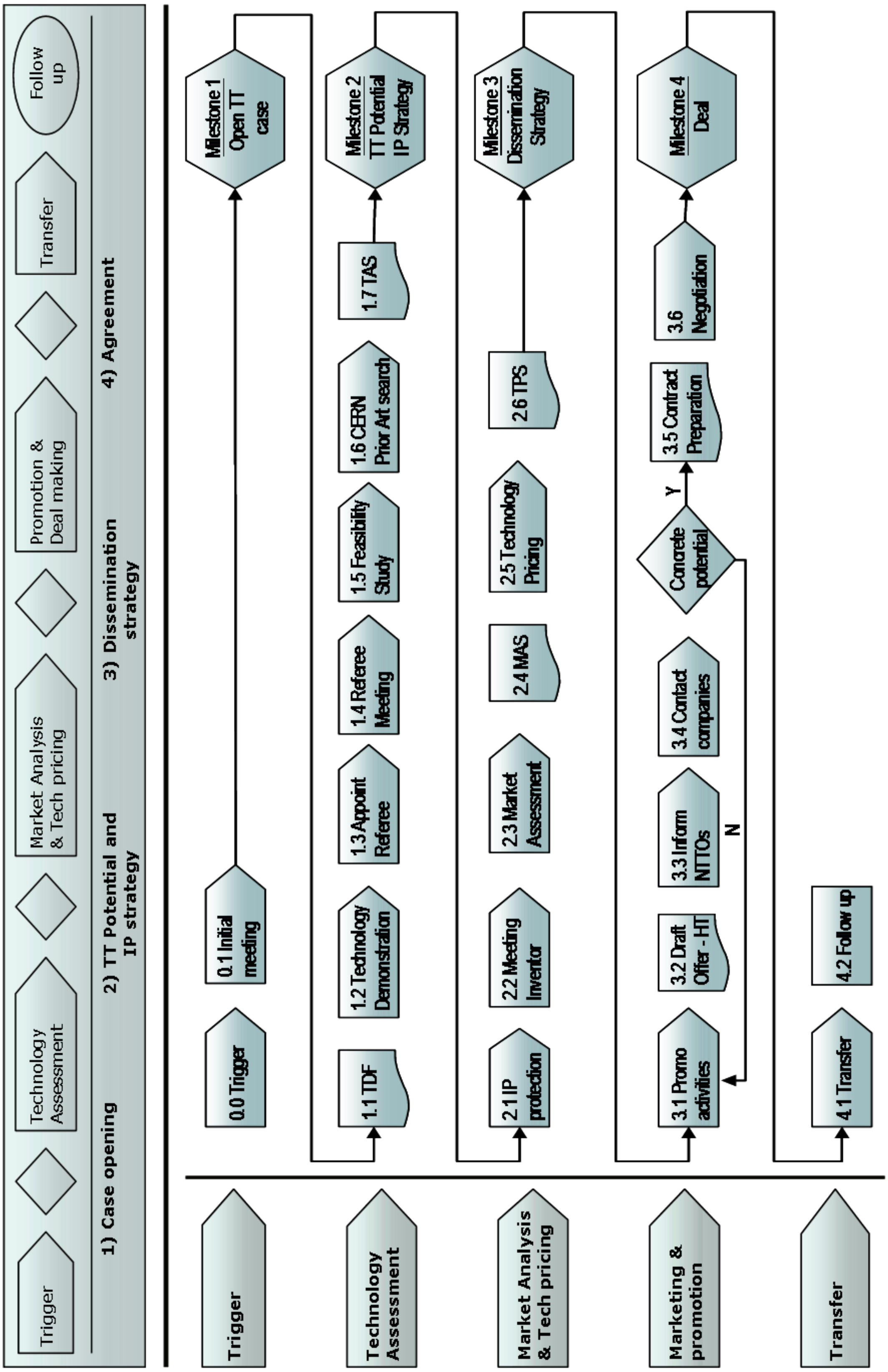

Figure B.1: CERN's Goal Directed Technology Transfer Process

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