VALUATION OF LICENSING AGREEMENTS IN AGRICULTURE BIOTECHNOLOGY

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ABSTRACT

As demand for agricultural commodities expands throughout the world, competitors are finding it advantageous to form strategic partnerships. Firms seek to collaborate in an organized effort to advance technology as quickly as possible. This thesis develops a discounted cash flow model embedded with real options and Monte Carlo simulation to value the most common rights, restrictions, and options found in agriculture biotechnology license agreements. Due to the complexity and uncertainty involved in the incubation of new technology, the incorporation of flexibility provided through real options is paramount to the analysis. Implications from changes in critical variables are analyzed as to how they may affect decision making. This thesis establishes an extensive background and analysis of licensing intellectual property in agriculture biotechnology, valuation techniques for intellectual property licenses, as well as tactics for quantifying specific terms. Thus creating a framework for the valuation of agriculture biotechnology licensing agreements.

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CHAPTER 1. INTRODUCTION

Problem Statement

Strategic partnerships through licensing agreements have become increasingly common in Agriculture Biotechnology. Over the past several years numerous public-private partnerships have been formed by land grant universities and large agribusiness companies. For example, Monsanto has partnered with Kansas State (2010), South Dakota State (2011), and NDSU (2012) to improve wheat breeding programs. The ultimate goal of these partnerships is to provide the best genetic material to wheat growers. In addition, Dow AgroSciences partnered with the State of Victoria (Australia) in 2013 to improve agriculture productivity by enabling the creation of new canola and oil seed varieties. Since most germplasm is under the control of the public sector, biotechnology companies seeking to purse “seeds and traits” strategies will need to develop partnerships (Wilson, 2012). These public-private partnerships combine a high level of experience and knowledge from the land-grand university’s research program with proven breeding technology of the large private companies.

With the world population estimated to exceed 9 billion by 2020, there is an eminent increase in demand for food especially in the developing world. More farmland cannot be created, in fact there has been a decline in productive farm land as it is developed into non-farm uses (Dodds, 2007). This coupled with limited water access continues to decrease the overall acreage available to produce the commodities necessary to meet demand. With increased pressure to produce more yield per acre, plant breeders have emerged to significantly contribute to meeting these challenges.

Genetically modified crops not only produce a higher yield they are more resilient to drought, pest, and disease. This potentially decreases the need for fertilizer, herbicides and other chemicals which in turn would decrease pollution and overspray from their application. In addition, these crops would cut down on the need for irrigation. Both of these attributes contribute to environmental conservation efforts.

Historically, plant breeders have had trouble recovering their initial financial investment. For this reason some sort of intellectual property (IP) protection is obtained. For example, in late 2015 Arcadia Biosciences received a patent on “Wheat with Increased Resistant Starch Levels”. The first phase of IP protection is very crucial as the development of most new varieties takes between ten and twenty years (Dodds, 2007). With this type of time commitment involved, breeders need to ensure ownership of new variants as protection from infringements. By obtaining rights of ownership the breeder is able to determine the optimal strategy for commercialization either through licensing or sale of the IP itself.

Transfer of intellectual property has become increasingly important as each party to the deal seeks to maximize their utility while mitigating the risk associated with early stage biotechnology. Intellectual property protection most relevant in Agriculture Biotechnology (Ag Biotech) are patents, plant variety rights, trade secrets, copyrights, and trademarks. The owner of a patent for example has two basic options to consider when they are seeking to transfer their intellectual property for financial gain; either sell the IP outright or offer it to be licensed.

There are two distinctive advantages that licensing has over selling intellectual property. First, the inventor or owner of the intellectual property is able to retain ownership. Each type of intellectual property whether it be patents, trademarks, trade secrets, etc. have specific rules relating to its owner. By retaining ownership the inventor is able to exercise their rights as well as seek damages for any infringement on their IP (Cahoon, 2007).

The second advantage allows the owner to decide which rights to contract out through licensing and which rights to maintain. For example, the owner could license an invention to a licensee but restrict that licensee from subleasing the invention without approval by the owner. In addition, the licensor (owner) can choose if they would like to license exclusively or non-exclusively with the latter enabling them to license to numerous licensees if they see fit.

The technology option can be considered in two parts, each part requiring investment by the optionee/buyer. There is first an upfront cost to obtain the option, followed by some buyer investment (in most cases) to advance the technology further toward commercialization by removing or reducing an important uncertainty, such as the one(s) causing the largest contribution to NPV variance. If such results are sufficiently favorable, the optionee/buyer then must spend additional sums to exercise the option and complete commercial development of the technology (Razgaitis, 2007).

When an inventor has acquired some sort of protection for their work such as a patent or other form or Intellectual Property (IP), commercialization of the invention is the next step. However, commercialization efforts are often costly and require some time in order to develop. With this in mind inventors usually seek to transfer their IP to a party in a better position to bring the invention to commercialization. One method is free distribution. This rarely occurs in biotechnology because of the large cost associated with the invention as well as the incentive for the inventor to benefit financially. Alternatively, the inventor can seek to sell, commonly called assignment, or license the invention (Erbisch, 2003).

Assignment of an invention may happen in a few different ways. The entire patent may be assigned which includes the exclusive right to make, use, and sell. Another option is only a share of the exclusive right and lastly the exclusive right within a defined geographical region.

An inventor may face certain issues when assigning or selling their IP. For example, after the sale is complete the inventor would have no future claim to revenues from commercialization of their invention. Since the sale happens only once the price to be paid is often a difficult conclusion. The difficulty in valuing the invention at the time of assignment is because most biotechnology inventions are underdeveloped. In order to avoid such pitfalls there is an alternative, licensing. A license is a binding, revocable privilege to use the IP, for a fixed number of years, in a fixed territory in exchange for money or other form of compensation. Since a license is a contractual agreement its enforcement in the United States is governed by contract law (Erbisch, 2003).

IP owners (licensor) have numerous incentives to collaborate or license their invention to an outside party (licensee). Licensing is a tradeoff between the potential for long term income and the certainty of a more modest short term payoff. If the licensor doesn't have the ability to exploit or develop certain areas of the IP in-house they would benefit from licensing with a partner who has this ability. If the IP owner is relatively small and unknown, collaborating with a well-known company may help to enhance their reputation.

Developing technology in-house is not only sometimes infeasible but also consumes valuable time and resources. Therefore, firms look to take advantage of synergies created by entering into strategic partnerships through licensing agreements. For example, the 2014 creation of Arden Mills, a premier flour-milling company, which is a joint venture between ConAngra, Cargill, and CHS Thus, collaborations have become necessary to reduce a firm's cost of entry as well as expediting the commercialization process.

Agriculture Biotechnology (Ag Biotech) licensing has similarities to traditional Intellectual Property (IP) licensing. However, there are considerable differences due to the nature technology included in the license. The emergence of seeds and traits as an industry segment has given rise to the importance of project valuation at various stages in the R&D process. Patents can be considered options on the stream of future revenues. Results of option valuation techniques to determine license prices are important for both patent licensees and for licensors seeking to maximize license revenue (Richards, 2014). In addition, irreversibility associated with new genetic seed technology has a high level of uncertainty resulting from information that is not yet accessible.

Introduction of genetically modified organisms (GMO) would be considered an irreversible technology. The optimal time to license such a technology is affected by uncertainty as well as the externalities caused by its adoption (Furtan, 2003). Terms for royalty payments, the right of first refusal, as well as geographical restrictions are often part of an Ag Biotech license.

Specific terms can be valued using real options, which account for probability and flexibility. Each option has a buyer and a seller and adds potential value to the license. Knowledge and practical application of this approach adds value compared to the traditional discounted cash flow (DCF) model, and is beneficial to both parties in the negotiating process. A real options analysis helps to overcome valuation challenges from a DCF by accounting for the optionality of licensing terms within the agreement. The unique aspect of real options is that they can bundle finance, risk, and strategy into one model.

Objectives

There has been limited published research on the incorporation of real options into the valuation of licensing agreements in Ag Biotech. Previous studies haven't went as far as to value the specific rights restrictions, and options embedded in these contracts. This study aims to identify and value those terms which are typically included in an Ag Biotech license. Although there has been previous research into real options in practice (Hardy, 2012; Turvey, 2001), they have predominantly dealt with an ex-post analysis to evaluate managerial decisions. This thesis focuses on providing the framework to do this type of analysis ex-ante, or during the negotiation phase. Doing so will allow decision makers to quantify specific terms included in the license.

The valuation is designed to make sure each option that adds value is taken into consideration before the deal is completed by incorporating the real options framework through a binomial options pricing model. Incorporation of the flexibility and uncertainty that arises in a long duration licensing agreement enables a more robust valuation.

The Ag Biotech industry has a high level of uncertainty and decision makers have the ability to be flexible over time in their decisions. It is also of importance due to the irreversible nature of the technologies developed in Ag Biotech and their ability to aide in global food supply sustainability. This thesis creates a framework which can be built upon to assist decision makers and negotiators of license agreements specifically in the Ag Biotech industry. Enhancements to existing methods can undoubtedly add value. That's precisely what this thesis intends to do by enhancing the traditional DCF method with real options. Making this type of real options valuation more visible allows decision makers to look past the complexity to see the hidden value it unlocks through optionality. Thus creating a more robust analysis.

The main objective of this thesis is to evaluate how different terms within the license affect its value. Options are very important elements within licensing agreements. The values of these options can be determined using "real options" methodology. An overall decision tree analysis can be incorporated as well. Since there is limited published research on this problem research using prototypical values would be constructive. This process will be beneficial to include a value for each of the options within the overall value of the licensing agreement. Decision makers are routinely faced with making decisions under a high degree of uncertainty.

<u>Specific Objective</u>

i. Review previous studies relating to (1) intellectual property licensing agreements, (2) common rights, restrictions, and options in specific to Ag Biotech, (3) pricing intellectual property agreements, (4) option pricing model including various types of real option pricing analysis methods.

ii. Develop real option models to evaluate the value and flexibility added by the inclusion of the most common rights, restrictions, and options in an Ag Biotech license agreement.

iii. Use results to identify those terms which add the most value to the license and establishing a framework to assist decision makers and negotiators in the deal making process.

Procedures

To reach the objectives listed above, a discounted cash flow (DCF) and real option model was developed to value of the most common options in an Ag Biotech license agreement. The DCF model was developed from the view of the germplasm developer evaluating alternative technologies and licensing options. It estimates adoption rates of the new technology, the yield increase from the new technology, and royalty payments to estimate annual cash flows. These cash flows are then discounted to arrive at the net present value (NPV) of the license. Next, the NPV is used to value the rights, restrictions, and options using a real options methodology.

The methodology for pricing real options used in this research is the binomial options pricing model. The binomial specification allows for a large number of potential scenarios and asset values to be considered. The incorporation of flexibility provided by this analysis is not present in the DCF model. Thus providing management with a more comprehensive assessment of options included in the license. Results indicate what value or flexibility each option provides to the overall license above and beyond the NPV result.

A review of literature will focus on licensing agreements focusing on Ag Biotechnology. Doing so will help identify the most common rights, restrictions, and options included with a licensing agreement. A review of how license agreements are currently valued in the Ag Biotech sector is followed by a review of literature on real options and their application identifying the best techniques for valuing the most common rights, restrictions, and options.

Interviews were conducted with biotech companies and universities to determine relatively common options that are included in agreements. Individuals who deal with negotiations for licensing of new technologies in Ag Biotech give insight into the industry and what practices are common. They can be helpful in identifying the most common types of rights, restrictions, and options that are presently used. These interviews are helpful for a number of purposes, but most specifically to understand what is currently being done and most common in Ag Biotech licensing.

Due to the subjective nature of license agreements and the importance on an ex-ante analysis a hypothetical deal structure was considered. Input parameters were kept constant across option types (simple and compound) in order to provide a comparative analysis on the value added from options within the agreement. The models in this thesis were developed in Microsoft Excel using @Risk simulation software. Simulation of the model defines a NPV, cash flow volatility, real option values, as well as the value(flexibility) provided by the real options analysis (ROA).

Organization

Chapter 2 of this thesis provides an extensive review of literature pertaining to licensing agreements in agriculture biotechnology and common options within these agreements. Royalty and other compensations are reviewed along with common methods for pricing intellectual property license agreements. The chapter concludes with a focus on real options. Chapter 3 reviews the empirical methods of options theory including the Black-Scholes model and binomial pricing method. Subsequently, the specific theory for each option involved in this thesis are documented. Chapter 4 provides a description of the methodology used to value a licensing agreement as well as the most common rights, restrictions, and options in Ag Biotech. Chapter 5 presents the results of the model and a sensitivity analysis of critical variables. Finally, chapter 6 provides a summary of the study and implications for parties involved in Ag Biotech licensing agreements (universities, private firms, venture capital firms, etc.) as well as suggestions for future studies.

CHAPTER 2. BACKGROUND AND REVIEW OF STUDIES

Licensing Agreements in Agriculture Biotechnology

The purpose of this chapter is to go into detail on licensing agreements in agriculture biotechnology. Its similarities to other forms of licensing as well as those aspects that are unique and most important to agriculture biotechnology licensing in particular. It then goes into detail the most common types of options within a license agreement with detailed descriptions of each. The last half of the chapter gives some background on valuation techniques and real options which sets up the methodology and empirical analysis in the following chapters.

Licensing intellectual property (IP) in agricultural biotechnology has numerous similarities to other types of IP licensing. Things such as boilerplate language are similar to any other technology license agreement since these are provisions that are not usually negotiated and included due to contractual considerations in regard to contract law. However, there are certain aspects that make licensing Ag Biotech inventions unique. There are often multiple property types incorporated into one product. Ag Biotech may have two or more traits present in the same organism which leads to the issue of royalty stacking if the traits belong to different owners. This in turn leads to a freedom-to-operate issue that drives anti-royalty stacking provisions as licensees do not want a large percentage of their net sales to be handed out as royalties. The section on royalties below goes into further detail on this and other considerations for determining how royalty payments may be broken down.

There can be pressure in the Ag Biotech industry to include philanthropic and humanitarian clauses into licensing agreements. This is especially true if the crops involved are an important food staple in developing countries. A philanthropic and humanitarian provision as part of a licensing agreement must set clear boundaries between the commercialization aspect and other uses that directly impact a poor country's population. Often they are based on the scale of production and scope of the intended commercial activity (Cahoon, 2007). In addition, both types of provisions (philanthropic and commercialization) are intended to enhance the overall purpose of the agreement and not as a hindrance (i.e. using a philanthropic and humanitarian provision to hide commercialization scale intentions.)

Technology stewardship is also a common feature of Ag Biotech license agreements. This is to ensure oversight and ongoing development of the commercialization process. For the licensor, the stewardship aspect helps to sustain its overall interest and the long-term use of their transgenic crops. Traditionally the main use for stewardship clauses in Ag Biotech has been to ensure regulatory approvals and effective management of public relations. These obligations will obligate the licensee to act in a manner that will not deter regulatory approvals or deteriorate relations between government officials the licensee and/or the licensee (Cahoon, 2007). In some situations the licensor may wish retain the rights to maintain control over public relations within the stewardship clause.

A successful Ag Biotech invention is extremely prone to a significant amount of patent infringement. There is a long history of companies in this industry suing each other as well as individual farmers for unauthorized usage of their patented material. When drafting a licensing agreement enforcement and litigation proceedings need to be present with the assumption that if and when the invention is commercialized there is a high probability that there will be some type of infringement.

An owner of intellectual property rights, in deciding the optimal time to license their Ag Biotech patent, needs to consider a number of factors. The total overall costs associated with creating, developing, and potentially commercializing the technology is important as these costs determine a break-even point as well as a basis for the actual pricing of a proposed license. This will be covered in more detail in chapter three as the option to wait. Governments around the world have enacted regulations specific to the Ag Biotech industry that can play a critical role in testing procedures as well as the commercialization process itself. Since Ag Biotech products have such mixed perceptions it will be important to consider the public's reaction and acceptance of the technology (Cahoon, 2007).

Licensing is different from a sale in that the ownership of the intellectual property does not transfer between the parties but remains with its owner. In licensing the owner of the intellectual property, known as the licensor, transfers rights of both possession and use to the licensee. However, ownership does not change. In Ag Biotech licensing there is a complex issue that deals with the necessity of combining different, and often times proprietary, technologies into creating new products. This can lead to numerous licensing complexities. Patent protection and licensing are often done long before commercialization. This feature contributes to increasing the uncertainty of if and when the product will reach commercial use. Below are some common issues when it comes to agriculture biotechnology that must be considered in every negotiation for a licensing deal.

- Tragedy of the anticommons creating different technology owners with respect to a single product.
- Obtaining Freedom to operate for Ag Biotech technologies and related products.
- Royalty-Stacking problem, where each owner of the proprietary technologies involved expect royalties on sales.

- Multiple forms of intellectual property may exist in a technology or product specifically; utility patents, plant patent, plant breeder's rights (for example, Plant Variety Protection (PVP) based on the UPOV Convention) (Doods, 2007).
- Trade Secrets, Trademarks, and other forms of IP.
- Tangible biological property

Other unique aspects of the agriculture industry should also be addressed. These are low profit margins, economics of commodities, national food security issues as well as the humanitarian concerns over hunger and malnutrition. Complex aspects of multiple intellectual property instruments present in Ag Biotech licensing cause the type and scope of the rights within the license to be carefully defined. Therefore, the following key elements must be considered during the negotiation of the license.

Key Elements of an Agriculture Biotechnology License

- Exclusivity
- Territory
- Evaluation of the Licensed Material
- Protection of Germplasm
- National Registration Protection
- Royalties
- Effect of Termination
- Reporting to Licensor
- Field of Use Restrictions

(Cahoon, 2007)

Common Options within Ag-Biotech Licensing

<u>Option to License</u>

The first and foremost option that needs to be considered by the inventor or owner of the IP is weather to offer the technology to be licensed. Most of the time the answer to this question would be yes because the owner is seeking to extend the reach of the invention by accessing additional capital or technological capabilities through licensing. This consideration should be done in a timely manner due to the finite nature of IP protection. The owner needs to consider the length of time required to reach an agreement with a potential licensee. Depending on complexity of the license and/or disagreements on rights, restrictions or other terms the actual negotiation time may erode the value of the underlying technology and in turn the agreement itself. Therefore both parties within the process must keep in mind the leakage value for waiting and or the considerable time it may take to close the deal. Although each license is a case by case basis the average time to complete the dealmaking process is around one year (Zetocha).

Technology is preferred to be licensed at early stage of development, mainly due to funding issues. The sooner the technology can be commercialized the better. This allows for maximization of potential cash flows as well as decreases the amount of potential profits lost due to the finite life of the patent. This is known as leakage, and will be discussed in greater detail as the paper moves forward. A plan for contingencies should be established. This can include a development plan for maintenance as well as a diligence provision to ensure that things are progressing as they should. There should also be steps for resolving issues when/if they arise. Language for a maintenance or diligence option should be included within the language of the initial agreement. In addition, a payment scheme is essential to have in the agreement. There are many different ways to approach this which are discussed later. The payment scheme, especially in exclusive licensing, is decided on a case-by-case basis during the negotiation process.

Deciding on whether to license an Ag Biotech patent such as a new genome of seed is typically based on numerous factors. The cost to create, develop, as well as commercialize are important factors when faced with the option to license. However, it is not the main driver of the price or value of that license. As will be discussed later in the chapter the value of the license is impacted by the market or commercialization value of the new technology. The critical role of government regulations in testing and commercialization is also an important consideration. Due to the ambiguity of genetically modified technology there is a real threat that a certain trait may not be accepted. In addition, governments around the world may restrict certain traits or reject shipment of grain which have those traits present. For example, in 2014, the Chinese government refused a shipment of GMO corn. Also, the European Union is very strict and has many restrictions when it comes to GMOs.

Numerous considerations must be addressed when the owner of intellectual property is making the decision to license the technology. Licensing allows the owner to access additional capital and technology. Once the decision has been made to offer the technology for licensing the licensor moves forward and begins negotiations with potential licensees. Next, other types of important options within licensing agreements are discussed.

Exclusivity Options

Usually options are granted on an exclusive basis (Anderson, 2007). Granting of rights defines the nature of exclusivity and whether there are any time limits to this exclusivity. (Cahoon, 2007). One consideration in determining a license's exclusivity is whether the licensee is willing to defend the patent. This is an important juncture for both parties. When a potential licensee doesn't prove its loyalty, the licensor may become dissatisfied that the licensee isn't as committed as they require. As with most non-exclusive licenses the burden will fall back on the licensor as the licensee has limited incentive for advancement due to a lack of flexibility. Both parties should take exclusivity option implications into consideration as they advance licensing deals.

Exclusivity must be specifically defined in the agreement. There could be exclusivity to one aspect but not another. For example, the licensee may have an exclusive license for a certain geographic region but not for field of use as other licensees may be using the same technology in another region. The restriction can be for different crops and/or different companies. According to Dale Zetocha, director of North Dakota State University's Technology Transfer Office, terms are usually whatever is negotiable between the parties. Ag Biotech licenses are relatively unique with regard to the scope of rights concept field-of-use. In Ag Biotech licensing field of use typically refers to a crop type that may be broadly or narrowly defined (Cahoon, 2007). Limited field of use licenses are then usually tailored to the strength of the licensee.

Licensors may wish to include a diligence provision which allows them to ensure the licensee is complying with the terms of the license. For example, within an exclusive license there language can be inserted that calling for a reversion to a non-exclusive license after a certain time period and/or if a minimum royalty payment is not received. This safety net protects the licensor from a non-performing licensee or one which shelves the product. In the event of reversion the licensor will have the ability to seek other potential licensees. However, assuming the original licensee keeps its rights under the license the licensor would no longer be able to seek out an exclusive license. For this reason a diligence provision along with complete reversion would be desirable to ensure that the technology moves as quickly as possible through the development stage (Freeman, 2007).

A geographic exclusivity restriction is another form of exclusivity that can be used in a license agreement. The restriction limits where the licensee can operate by defining a geographic location. The licensor may have other licensee in other geographical regions as well. In the Ag Biotech sense geographic exclusivity would restrict where the new technology could be grown. This would be in an effort to learn more about the technology before releasing it on a larger scale. The geographic exclusivity option can be valued using a learner option. An instance where irreversibility is present restricting to a certain geographic region will give the ability to learn without a full scale launch. After a time period it could expand to other geographic regions as well depending on prior outcomes. Thus the learning option is used when there is high uncertainty about a full scale launch and learning how the market reacts enables decision makers the ability to make much more informed decisions.

Typically a licensee can expect to pay five times more for an exclusive license. This is because the licensor is putting all its confidence in one licensee. At the same time that licensee is getting the exclusive opportunity to take the new technology to commercialization.

Non-Exclusive Licensing

Nonexclusive licenses are rare and experience indicates that breeders grant exclusive rights more willingly than nonexclusive ones. Breeders believe that exclusivity brings about a mutual commitment that will be much stronger when the parties are working exclusively. (Nilsson, 2007). Non-exclusive licenses can be problematic if numerous business models are practiced by various licensees. It may be necessary to keep terms of the licenses similar and lay out the business model in the non-exclusive license. Ensuring license homogeneity amongst licensees will also decreases the risk of unstable royalties.

For universities making royalty agreements nonexclusive licensing is more common. Exclusive licenses, when granted, tend to contain more strict requirements for the diligent development of all applications. They may also contain a flexibility option. This can include the option for the licensee to convert to a non-exclusive license. Under certain conditions of risk, it may be necessary for the licensee to move or allocate resources from one market to another thus having the ability to convert from an exclusive territory license to a non-exclusive license to access other markets. The licensor may also wish to reserve the right to deny the licensee the ability to switch if they feel that doing so may be detrimental. For a non-exclusive plant variety license similar agreements are used between all licensing partners (Zetocha).

Right of First Refusal (ROFR)

Development of new traits have emerged in Ag Biotech at a rapid pace. When an IP is under license the licensor may continue with research and development (R&D) to create new variants of the product line in an effort to increase yield, become drought resistant, or some other type of additional trait as well as improvements to the current IP. In the event that the licensor does make an improvement, the options that are available should be laid out and clear in the initial license agreement. In order to guarantee that it has the ability to be the first to adopt any improvements it may be advantageous for the licensee to have a Right of First Refusal (ROFR) in place within the agreement.

A key distinction between an option and a right of first refusal, involves who initiates the granting of rights. The grantee of the option is the party that benefits from the option and has a period of time in which to exercise it by notifying the grantor of the license that it would like to exercise the option. However, with the right of first refusal the grantee cannot initiate, the grantor is in control of when it would like to grant the right (Anderson, 2007). If the grantor has determined that it would like to grant the rights it must then notify the grantee who has the option to accept or refuse. This opportunity must be presented to the grantee whenever the grantor has determined they are ready to offer the rights or when the grantor is about to sign an agreement with a third party. In the latter, the terms must be equal to the terms offered to the third party. If accepted the grantor must grant the right to the grantee and not the third party. This is where a practical issue of the ROFR may arise. One party must decide when is the optimal time to tell the other party in a negotiation that some third party has a ROFR over the same rights that are being negotiated. If told at the onset of the negotiation process the second party may not be willing to continue forward using time and resources to attempt to negotiate when another party will have the option to accept the identical terms agreed upon.

Is a right of first refusal necessary in every licensing agreement? Probably not. However, there are cases where it is advantageous to have one. In a situation where one party to another underlying agreement (research) is either sponsoring the research or providing materials a ROFR would be a good to include (Krattiger, 2007). This is common practice for Universities.

The right of first refusal can be present in a variety of ways. In each it deals with the improvement of licensed material by one of the parties in the licensing agreement. For example, if the licensee improves the invention there may be a variety of options available depending on the language in the license. An exclusive license in all fields of use, a royalty free non-exclusive license, and a right of first refusal to an exclusive license (Anderson, 2007). The right of first refusal can also be present as the right to purchase shares or acquire a royalty stream.

Other provisions may be embedded within a right of first refusal and must be considered on a case by case basis. As with most other types of options these are agreed upon by both parties before the initial agreement is signed. When a right of first refusal is part of a licensing agreement the alternate provisions can become complex and should be carefully thought out by dealmakers in advance. The following are questions that should be answered and agreed upon when a right of first refusal is in play.

- How long do the parties have to negotiate once the right of first refusal has become available?
- When may a third party be informed about the right of first refusal?
- Will the optionee have the ability to match any offer by a third party, if they have first refused the option?

These questions can lead to other issues that may need to be addressed prior to reaching an agreement. The right of first refusal could also be used in conjunction with expanding the field of use restrictions, geographic restrictions or both.

Example of ROFR Language

Below is an example of right of first refusal language. There could be variations depending on the circumstances of the deal. However, most have the same basic structure.

> Company A agrees with Company B that it will not sell or otherwise transfer all or any material of its X biotechnology, trait, or business to any third party without first giving Company B the opportunity to purchase on terms identical to those offered to the third party. (Anderson 2007).

As with all other types of options, the exact meaning and extent of any right of first opportunity or refusal, and the proper procedure to be followed when exercising, should be clearly defined in the license agreement. This eliminates any ambiguity caused by vagueness of terms. The procedure would be used as a guide when the ROFR is in play.

As an example, if the licensor (grantor) makes improvements to the licensed patent rights, under the ROFR the licensor may not license with any other third party without first offering the patent improvements to the licensee (grantee). In terms of real options, the right of first refusal can be classified as a chooser option (discussed at length in Chapter 3). If the licensee refuses the option to license then the licensee has the option to license the technology to alternative licensees. At this juncture the licensor could also consider the option to wait.

A variation on options and rights of first refusal is called the right of first opportunity. This gives the grantee the right to make a proposal to the grantor at a defined point in time. The grantor, however, has no obligation to accept the proposal from the grantee or negotiate exclusively with the grantee. Universities usually don't like to use a right of first refusal and will instead opt for the right of first opportunity (Zetocha).

This is because a right of first refusal can be expensive to include in a license. It can also negate efforts in research and/or the negotiation process. In addition the right of first refusal is more restrictive in nature. The right of first opportunity can provide more flexibility for the licensor. If a licensee is adamant about a right of first refusal they would be required to pay a premium for it. Instead Universities typically use the right of first option to negotiate (Zetocha.) This is another term for the right of first opportunity (Anderson, 2007). "Universities should be cautious about giving any ROFR." This is also consistent with the information obtained in the interview with Dale Zetocha.

<u>Option to Sublicense</u>

Ag Biotech licensors frequently provide incentives for licensees to sublicense, especially if the sublicense covers markets where the licensee isn't as strong or has no presence. Granting of the sublicensing right and its scope, therefore, is often an important issue (Cahoon, 2007). The option to sublicense may be included in the terms of an exclusive license, providing flexibility to the licensee. If a licensee doesn't have access to certain markets or technology, the option to sublicense will greatly enhance the value of the license for both parties. Not having this license may hinder progress.

Withholding the sublicensing or assignment option does not guarantee that the nature and character of the license will remain constant (Freeman, 2007). With this in mind the licensor may want to have the final say on who their licensee is sublicensing to. Best practice here is to have the option to sublicense contingent on approval from the licensor. Withholding the sublicensing or assignment option does not guarantee that the nature and character of the license will remain constant (Freeman, 2007).

A typical compensation structure with sublicensing is usually 50/50 (Licensor/Licensee). Upfront fees can be negotiated and licensors would prefer them to show commitment from the licensee. A milestone & royalty scheme with a sublicense will be similar to original license structure (Zetocha).

Term Length Options

Basic contract language usually gives either party the right to opt out of the agreement. Depending on what the parties agree to there may be certain restrictions as to the process of negating a contract. It would not be advantageous to have a licensee or licensor decide to move forward without honoring their obligations with little or no warning at a time they choose. Therefore, the stipulations for negating a contract should be clearly defined in the initial agreement.

Limited term contracts give both parties the option to exit the contract. Exit options in terms of real options would be classified as an abandonment option. This type of option is present in almost every real options decision. The agreement would state that if obligations not being met by one party as specified could allow the other party to terminate license agreement. Usually a 60 day notice of cancellation by either party required (Zetocha). However, this could be modified to something both parties agree upon.

There could be an option to extend the life of the patent and newly patented improvements added to license, which could be tied into the Right of First Refusal as well. Term length exclusivity is another option to be considered. It gives the licensee exclusivity, but only for a limited time (Razgaitis, 2007). This gives the licensor the option to make the license non-exclusive at the end of the specified term. It also puts pressure on the licensee to perform to their contractual obligations because there is the threat that they may lose out on potential revenue if the licensor decides to strip the licensee of the exclusivity right.

Royalty Structures

When the parties involved in an agreement have a term structure in place i.e. exclusivity, right of first refusal, and/or any of the other terms mentioned above, the royalty structure is then be addressed. It is important for both parties to keep in mind the uncertain future when drafting royalty clauses. Although this may be difficult to do, there are some guidelines that can be followed to ensure that royalty clauses become the source of business windfall, and not lay the pillars for business pitfall (Verbraken, 2011).

A percentage of revenue is often used in calculating royalty payments. It is important to clarify that percentage as gross or net revenue. If net revenue (net sales) is used it is also important to clarify which items can be used as deductibles. Net profits can be used to determine royalties. However, caution should be used because ending royalties can vary widely due to different accounting practices.

Compensation Options

Due to low profit margins in agriculture, royalty payments linked to sales volume as a percentage of net sales are typically less than 10%. Royalties between 1% and 5% are common *(Cahoon, 2007).* In addition, most new agreements use comparable royalty and licensing terms used in previous deals. This includes performance and financial milestone payments (Zetocha).

Consideration on the size of the potential market and the stage of development are typically used to set royalties. For example, high value with low volume would constitute higher royalty payments. These payments are pre-established and reviewed at agreed upon time intervals. Royalty stacking can also be an issue which can get increasingly complex as more traits are stacked into the royalty payment flows. Traits can be stacked together and royalties owed to numerous parties. Prior to any agreement an analysis should be done to determine optimal royalty rates when there numerous traits and parties involved.

There are numerous forms of royalty payment structures. Some are straight forward while others may be more complex. The structure that is agreed upon depends on the parties involved as well the subject technology. Typical payment structures include a running royalty as well as upfront and minimum payments.

When specific sales milestones are reached the royalty payment changes. This is known as a running royalty structure. The licensee prefers a declining royalty rate with increasing sales. However, the licensor can argue that profitability to the licensee increases with increasing sales so, the royalty rate should actually go up with increasing sales. The declining rate structure is more commonly used.

A licensor doesn’t have much ability to increase the rate ex post. The licensee, however, can threaten to drop the license because of less than anticipated margins unless it gets a reduction in the royalty rate. This is a drastic move for the licensee but not one that should be taken lightly by the licensor. Abandonment would likely set back commercialization progress as well as loss of precious patent life.

Upfront Payments are an excellent way for the licensee to prove their commitment to the success of the project. They can be a series of payments made by calendar or progress in conjunction with or in lieu of royalties. Upfront payments are most common with nonexclusive licenses. Minimum payments are sometimes used in conjunction with a royalty scheme. When total royalties are less than the minimum the licensee must pay up to that minimum. Exclusive licenses usually have minimum payments. This gives the licensee significant leverage, due to threat of abandonment. Rule of thumb for minimum payments is typically 25% to 50% the annual projected reasonable royalty based on sales estimates. Higher risk and uncertainty of the estimates will lower the minimum royalty and vice versa.

There are some potential analytical issues when valuing optimal royalty structures for a new licensing agreements. The first is how to incorporate royalty stacking when applicable or how to best plan for it if it becomes necessary. Another important aspect is the probability that there will be commercialization, especially exclusive licensing deals that aren't "cookie- cutter" as nonexclusive deals. Those exclusive licenses are valued on a case-by-case basis best done in real time as opposed to ex-post analysis.

Royalty negotiations can sometimes be lengthy and time intensive, especially when the parties involved have different perceptions. A licensee is unlikely to agree to an NPV associated with the most optimistic outcome in determination of royalties. At the same time the licensor isn't interested in setting a low rate which has the potential to hinder its profitability. While both parties typically do their own valuations when it comes to the deal making table it is important that everyone involved is on the same page.

Hybrid Licensing

Hybridization has been practiced for centuries. Crossing two pure lines produces a hybrid. Different genes from both the parents form the hybrid which has a higher agronomic value than the parents. The term used to define this is heterosis which becomes expressed from these genes as the plant develops. This can come in many forms most commonly higher grain productivity. In the case of wheat, hybrids are taller than their parental lines and produce more straw. The root system is better developed and the plant has a better tolerance to stress (cold, excess water, drought compared to self-pollinating varieties. The phenomenon of heterosis (hybrid vigor) was discovered in the early 20th century. Ever since plant breeds have continuously created new hybrid crop varieties (Hybrid Wheat, 2015).

The hybrid seed industry is highly competitive. It can be profitable but also quite risky. Combination of parent lines is important for elite hybrid development. Licenses which are non-exclusive in nature enable the germplasm to be distributed to the greatest extent possible. Since all lines are publicly available a breeder could use two parent lines, one parent line mixed with in-house germplasm to produce a commercial hybrid. Cross breeding publicly available germplasm with in-house material (derived lines) which is then crossed with other parents producing commercial hybrids is a third alternative. Royalty rates depend on contribution of publicly available lines to the hybrid upon commercialization (Cruickshank, 2011).

Companies invest a large amount of resources into identifying a particular hybrid combination. For this reason, information on parental lines used commercially is highly sensitive especially when agreements are non-exclusive in nature due to increased risk of copying. This is the case in the Australian sorghum hybrid germplasm program (Cruickshank, 2011).However, not all hybrid germplasm commercialization agreements are non-exclusive. Adding exclusivity eliminates the risk of copying but increases the overall royalty rate.

The general rule-of-thumb for hybrid royalty rates is that the parent is about one third of the potential royalty for the variety. This is substantially lower when the agreement is non-exclusive, generally half the exclusive royalty rate (WIPO). Licensors must be careful to distinguish royalty payments attributable to any licensed patents from payments for the rights to the non-patent IP. Failing to do so can lead to an unexpected cut-off of the royalty revenue stream. In addition, the margin on each bag of seed sold when all cost are taken into account is important in the determination of royalties. Margins are difficult to predict when commercialization is a number of years down the road. This may lead the parties to decide to delay the determination of the royalty structure until commercialization is closer.

Grain harvested from the female parent is first-generation hybrid seed "F1" which is used by farmers. Replanting seeds from a hybrid won't yield exactly the same kind of plant. For this reason most seed companies don't bother getting patents on their hybrids. Typically the licensee will be required to provide annual reporting to the licensor on usage of the licensed material. This is to ensure that development is progressing at an acceptable rate and to identify any issues hindering commercialization efforts.

The following are details of a sample hybrid licensing agreement. In this example the licensee would be using hybrid germplasm technology from the licensor and combining them with its own germplasm to create hybrid varieties. Ownership of the any continued advancements in the technology is determined in accordance with U.S. Patent Law.

The licensing agreement is exclusive to licensee with option to sublicense. Exclusivity allows licensor to collect higher royalties and also ensures that licensee needs to obtain separate licensing agreement if it wishes to move forward with commercialization of a Hybrid. The licensee has the option to obtain an exclusive commercial license to use and exploit the licensors seed materials. This option will remain in force for 10 years from effective date. The licensor is seller and the licensee is buyer of this option.

The licensee has the option to assign the agreement without prior consent. Therefore, the licensee is the buyer and the licensor the licensor is the seller of this option. This assignability option no doubt adds value. What is it worth? Should the licensee be required to pay for this? If so, how much? Non-exclusive licenses tend to be more open for assignment while exclusive licenses are more restrictive. Assignments may or may not have fees attached to the transfer (Bobrowicz, 2007).

The framework to value the options just described is with a real options analysis. In the example above there are three real options: exclusivity, option for exclusivity in commercialization and an assignability option. Valuation framework for these types of options are discussed at length in Chapter 3.

Royalty Rates and Alternatives

Payment structures are typically separated into value blocks. A higher perceived probability of commercialization gives more bargaining power to the licensor. All parties in the negotiation must be clear of the royalty payment structure while considering potential pitfalls in doing so. The example below illustrates a potential royalty payment scheme for commercialization of hybrid germplasm. It is followed by a royalty scheme used for sorghum hybrid germplasm in Australia.

The licensee is required to pay the licensor an upfront of $80,000 in year 1, $100,000 in year 2, and if mutually agreed to continue collaboration by Feb. 1, 2017 $120,000 by April 1, 2017. These payments are used for accomplishment of the work plan. Upon Commercialization the royalty fees would be due based per unit sold (1 Unit = 50 pound bag of hybrid seed) as well as the genetic makeup of the hybrid. As an example:

- Male Parent from licensor = .5 * Varietal Rate * Units Sold
- Female Parent from licensor = .4 * Varietal Rate * Units Sold
- Royalty Rate if both parents are from Licensor = Royalty Rate male + Royalty Rate Female

The difference in multiples on the male and female above is indicative of the nature of hybridization. The male parent has the role of pollinator while the female parent does not produce viable pollen and is used as a seed plant. Therefore, the male parent would demand a premium compared to the female. The female line may also be referred to as male-sterile.

Percentage royalties may present a disadvantage for the licensor as income may vary with price variations the licensee practices under their sales policy. If the licensee pursues a strategy of market share increase or optimization of turnover their aggressive sales tactics may place downward pressure on the sales price (Verbraeken, 2011). This is relevant if the licensee pursues a market share increase or optimization of turnover strategy instead of profit maximization. Alternatively, a fixed rate per pound of certified seed sold can be used to determine royalties.

Compartmentalizing the license agreement into separate value blocks is a modular approach under which the disappearance of any particular (substantial) IP right will give rise to the right to a revision of the royalty rate (Verbraeken, 2007). Minimum royalty payments can be used to prevent the licensee from shelving the product (Erbisch, 2004). This may begin in the initial year or deferred to a later date. If licensee is not making at least the minimum royalty it is an indication that it will not want to retain the license. This is a way to deal with future uncertainty. A 25-50% minimum royalty is equivalent to saying that the most likely forecast of royalties is 2-4 times greater than the most conservative scenario (Razgaitis, 2007).

Contribution of genetic material to a commercial hybrid is most often reflected in the calculation of royalties. The sorghum commercialization study uses only non-exclusive licensing in order to provide access to material. Their royalty rate for a hybrid using both of their lines is 8% of net sales. Royalties on hybrids containing less than 100% is calculated on the basis of the genetic contribution of their lines. (Cruickshank).

All licensing agreements should have language in case of potential disagreements that cannot be resolved between the parties. The following is an example taken from the IP

Handbook. DuPont pays royalties on net sales as determined by agreement at the time of commercialization, or in the event UH and DuPont cannot agree, a third party arbitrator experienced in royalty arrangements (Razgaitis, 2007).

> Royalty rates in WIPO "Line Ten" License which are a 3.5 center per pound of certified seed resulting from the use of Line Ten in the breeding program, sold by the licensee for domestic sales and sold for export sales (Non-Exclusive License). If the line was exclusive, 7 to 10 cents per pound would be expected in a parent line with hybrid breeding. An alternative way of looking at this royalty is 2.5% of retail price of the certified seed sold by the company for an exclusive license to the line (parent).

Alternatives in this case could be waiting to determine royalty rates at the time of commercialization (varietal rate at the time of commercialization in term sheet may accomplish this) as well as the inclusion in addition a minimum royalty payment. An upfront fee as a royalty down payment can be an effective way to show the commitment of licensee. This gives the licensee "skin in the game" prior to commercialization. For the licensor it also helps recover projected NPV particularly when the licensee terminates agreement for reasons unrelated to the commercial merit of the opportunity (Razgaitis, 2003). One has to be careful in stating rates for germplasm unless all the circumstances are factored into the royalty rate. (WIPO)

Pricing Intellectual Property License Agreements

The main objective in dealmaking valuation is to assess and value the aspects that are important and unique to both the buyer and the seller. The value to a potential buyer (licensee) is the overall prospect of commercialization including all relevant costs and the time commitment necessary to generate returns. This also includes all risks involved in the process. The main idea in valuing a technology is determining what is being transferred between the parties of the agreement to arrive upon a certain price. This price can be a combination of the types of rights, terms, and restrictions described earlier in this chapter.

An important consideration is that the market pays for value received not the cost to create. So there is a fine line decision makers and those involved in pricing agreements must be aware of. Inclusion of costs is not relevant as they are to be considered sunk costs. In the end we are only interested in the future value of the technology when it is brought to market or commercialized. There are six methods for pricing that all have some basis on the market's expectation of value (Razgaitis, 2011).

In his 2003 book, Dealmaking using Real Options and Monte Carlo Analysis, Richard Razgaitis defines the 4 Cs of deal making: Conceiving, Communicating, Compromising, and Consummating. These four steps follow in order and each must be completed before moving full steam into the next. Conceiving can be the creating of a new technology and/or when a new patent is approved. The inventor has conceived the new idea, decided to explore licensing options, and is now ready to communicate with potential licensees. After initial communication, the parties must compromise on a set of terms and overall structure to the license. This is where valuation techniques that are the subject of this thesis are put at center stage. As discussed there are different methods of valuation. Depending on the situation, dealmakers will use one or a combination of methods to determine the value of the license.

Common Methods of Valuation

There are numerous ways to place a value on a potential licensing agreement. Some are fairly simple and straightforward while others are more complex and require advanced analytics. It should be made evident from the beginning of the negotiation and following valuations that cost is not basis for price. Price is the value placed on the agreement by the market. Incurred costs up to this point are not a consideration in the product's future value stemming from the licensed technology at commercialization. As an example, R&D costs may or may not reduce risks associated with commercialization of the invention. All motion is not necessarily progress.

Price is a very tricky idea as it is affected by things that affect an individual's judgement. From the viewpoint of the buyer his perception always affects what he is willing to pay. The same goes for the seller as it affects what he is willing to accept as payment. Price is often used as leverage in negotiations to obtain other things. Those involved with deal valuation must remember that pricing is a process not a one-time event. The following six methods are commonly used valuation techniques. Each has advantages and disadvantages and a combination of methods is usually most effective in producing a robust valuation.

Industry Standards Method

The industry standards method can be a good method when there is comparable agreements or technology. However, with early stage technology licensing the problem is that there isn't a track record for comparable products. There is also ambiguity as to the products that can or will be introduced (Razgaitis, 2007). This method works best when there are numerous deals with multiple buyers and competitive sellers with one technology or within an industry segment. An advantages of this method is that values are based on the market meaning no calculations necessary. Also, when there are comparable deals both parties can have confidence in comparable reference points.

This method has numerous pitfalls that many time make the deal very difficult to price based on this method alone. Surveys used for the determination of standard royalty rates can be very broad. Some of this information may have an adverse effect on the present value of a similar deal. In addition, royalties aren't always explicitly defined. A wide range of royalties reported without value explanations add to the ambiguity of the industry standard. These published values often lack the specific rights granted or their significance and strength. Other information in the license often affects the total value and are reflected in the royalty rate, but are not known. Usually there is no information on payments (upfront or minimum) or on due-diligence provisions.

The bottom line is that there is no way to uncover a comparable agreement between comparable parties at a comparable stage in the development. So an interpretation of available data is used to apply to the present situation. Based on perceptions, the viewpoints of the licensee and licensor may be in conflict. The following methods can help to take out the ambiguity of the industry standards method.

Rating/Ranking Method

This method uses some type of rating or scoring system to differentiate the deal based on the known price of comparable deals. The smaller the list of factors the simpler the analysis. A technology transfer manager must keep this in mind so as to not bog down the ranking with less relevant factors. It may also be wise to include a weighting scale so each factor is not treated equally (Razgaitis, 2007).

The approach in keeping factors to a minimum is an important one. It helps focus only on those factors that provide the most value. Keeping in mind that the most important issues will vary from deal to deal, a technology transfer manager may opt to use the following factors in the rating/ranking method.

1. Comprehensiveness of the IP protection
2. Stage of development or the willingness of the licensee in bringing the technology to market (based on the magnitude of investment).
3. Expected size and value of the market.
4. Present and anticipated competitive alternatives
5. Sustainability of the innovation

There are often tradeoffs in every agreement. One cannot simply compare one aspect without consideration to other terms within the agreement. What are the differentiating factors? Does the technology transfer manager really know what the important factors are? There are no simple answers to these questions and perceptions may play a role in their determination. However, performing the rating/ranking method against numerous standards will help to better understand the helpfulness of this method.

This method has a couple of benefits. First, it helps in preparation for negotiating, marketing, as well as beginning to think about the important economic factors. Second, it is a conversation starter for stakeholders and may help incorporate any additional insights they have. In addition, it can be helpful in determining a commercialization path. A commercialization strategy has endless possibilities such as an exclusive or non-exclusive license as well as the inclusion or modification the numerous types of options that may be part of an agreement. The rating/ranking method is helpful in sorting out these opportunities. It may also be used to rank potential licensees by comparing the advantages and disadvantages of each, identifying which candidates likely have the most to gain from the license. These candidates would be the most likely to enter into an agreement. This information can then be used to determine who is likely to pay the most (Razgaitis, 2007). With these insights the rating/ranking method may be most beneficial in determining an optimal commercialization path.

It is important to remember that each agreement is a snapshot in time as no two technologies are completely identical. The market is rarely the same, and negotiators and organizations involved will most likely be different. Therefore, as is a common theme with license negotiations, each should be considered and evaluated on a case-by case basis.

Rule of Thumb Method

One of the most widely used valuation tools is the 25% rule. While there can be many applications depending on the situation there are two main manifestations of the rule.

1. The royalty should be one-fourth of the savings in dollars to the licensee from using the subject matter of the license.
2. The royalty should be one-fourth of profit before taxes, earned by the licensee from using the subject matter of the license.

On the surface it sounds simple. However, there are many questions that arise from both sides of the bargaining table when deciding to go with the 25% rule as a form of valuation. To what degree was the savings or profit affected by the subject matter of the licensee. For example, the licensed material may have been one of several technologies used in the development of an invention. Should the licensor then be entitled to one-fourth of the savings or should it be discounted before the rule is used? If so by how much and why? This type of valuation hinges on if the licensed materials is the key to unlocking the door to savings or if it is only a one cog in a wheel that combines to save.

The second manifestation is much more intricate and is where things can become increasingly complicated. Since there is no widely accepted definition of profit before tax it leaves interpretation to the parties involved. Both sides must take extreme care to avoid some common pitfalls here. The most common being the decision on what the appropriate income statement should look like. Most issues arise after the gross margin calculation. Should all overhead costs incurred by the licensee be include or just those in relation to the licensed technology? Is the cost of sales being allocated amongst all items sold or just the product using the licensed technology? What is the “other” category and what is its relevance in drawing down profitability? Lastly, what makes up the Research and Development (R&D) component?

An underlying issue with these questions is coming up with reasonable estimates. Annual reports of companies selling similar products is a starting point but should be looked at subjectively. Typically in the United States it is common that the COGS, SD&A, and R&D deductions above the EBIT line are acceptable for determining true profitability of the commercialization of the product being licensed (Razgaitis, 2007). This can be helpful in determining where to apply the 25% rule. However, the make-up and determination of what constitutes each line and if it will be included in the calculation needs to be well thought out and agreed upon during negotiations.

A licensee may argue that R&D is a necessary business expense. Without it there would be no high value, competitive products needed to sustain the licensee's operations. Conversely, the R&D expense is actually an investment for future payoffs. Depending on how far into the future the investment comes to fruition the licensor may not be able to enjoy these benefits. The overall R&D expense may include other items in addition to the specific licensed material. Why then should the licensors potential profits be reduced by the licensee's investment in research on other projects? To remedy some of these issues costs below the sales line should be analyzed in context of the subject technology. This will help to determine if the EBIT percentage reasonably predicts the licensee's profitability in the present case (Razgaitis, 2007).

Despite these drawbacks the 25% rule is widely used. To remedy some of the difficulties with this method the licensor may request that the licensee provide a predictive (pro forma) income statement. Razgaitis provides a key piece of advice for using the 25% rule "use it to *only* develop the calculation of the *royalty rate to be based on sales* – never allow the royalty to be calculated on an as-you-go basis as a percentage of earnings before tax."

Discounted Cash Flow Analysis with Risk Adjusted Hurdle Rates

The rule of thumb method introduced the concept of proportioning profits based on the contribution from each party and risked incurred in the creation of those profits. The DCF method performs these considerations in a more sophisticated manner. This is done with a determination of future cash flows by accounting for the time over which the profits are expected to be received and incorporating the risks involved in receiving the cash flows.

There are numerous types of risks that a technology transfer manager must be aware of such as market risks, technical risks, as well as other risks. Technical risks may not be as obvious as market risks but an important technical risk deals with if the technology actually works. A potential market risk is a competitor developing a superior product with a more cutting edge technology that becomes a direct threat to the erosion of profits. In addition there are numerous other risks, some not as evident as others. One such possibility is the changing taste of consumers. In agricultural biotechnology, there is geopolitical risk as well. One country may be accepting of a certain trait but another may not allow it within their borders. Public opinion on genetically modified crops is somewhat skewed to the negative side due to (unproven) health concerns. Until GMO products are more widely accepted these are important risks to consider.

A risk-reward model is used by investors to help guide their investment decisions. The higher the risk of a proposed investment or project the higher return is necessary to rectify the investment. The increased rate of return is known as the hurdle rate. The perception of the project being good or bad at the time of the investment is dependent upon the anticipated return of that project and if those returns are adequate in relation to the risk of undertaking the project.

The "k" value or hurdle rate is very important here. If projected cash flow cannot be attractive using k (hurdle rate), then the investment does not jump the hurdle and should not be made. The mathematics assume a compounding of risk with each succeeding year. More things can go wrong as more time progresses. From the licensee's point of view the amount of risk that has been eliminated by the licensor's R&D and other activities. The licensee will perceive a higher value the higher the level of risk reduction. The licensor may then see increased R&D as a way of reducing risk to the licensor and the ability to demand a premium for the license. However, they must be careful as to the investment in R&D that goes into risk reducing activities as not all will. This goes back to the case that cost is irrelevant in assessing value. Figure 2.1 is a representation of return and risk.

The expenditures of the licensee are fairly certain however their returns are not. Initial investments are typically much easier to predict than profits whose arrival is delayed. Each opportunity for licensing has several case specific factors affecting both value as well as risk. What is to be done when the NPV analysis indicates a negative number? Is this the end of negotiations? Not necessarily. Firms perceive risk differently depending on their current technology and customer base, so there still may be some opportunities. Business startup risk may be present. The firm should also consider what R&D and market development activities it can do to reduce their risk exposure. In addition to overall risk reduction, the firm can elect to work directly on enhancing value. The key idea here is to spend small amounts of cash on the most critical commercially relevant experiments.

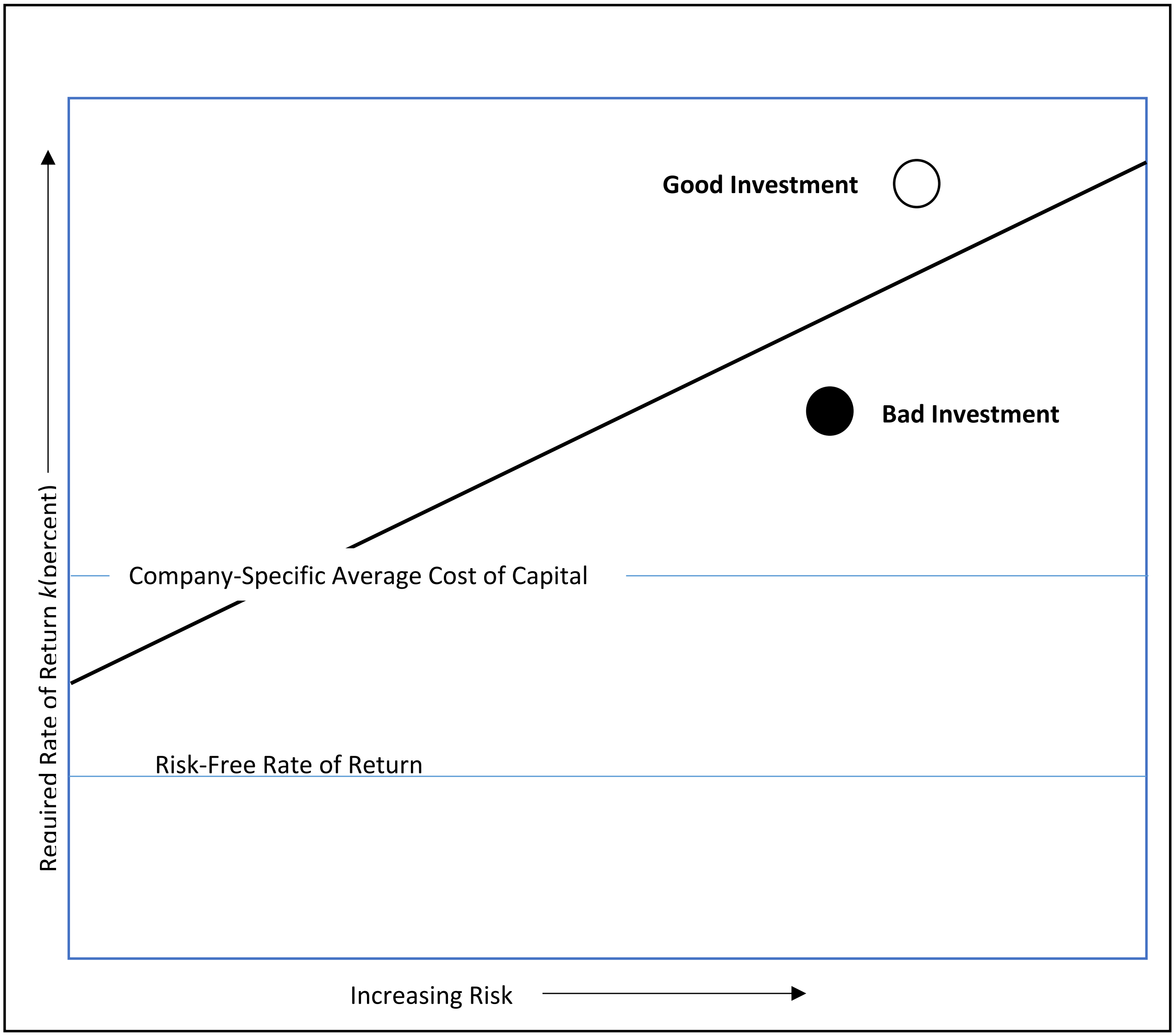


Figure 2.1. Return and Risk

To properly calculate a Net Present Value (NPV) the first step is to determine the appropriate calculation for earnings before interest and taxes (EBIT) similarly to the methods described in the rule of thumb method. Next expenses for royalties, depreciation and other expenses are subtracted to obtain earnings before taxes (EBT). Taxes are then deducted to obtain earnings after taxes (EAT). Depreciation, investment, and any changes in net working capital and then accounted for and we have a net cash flow figure. The next step is to discount the cash flow to obtain the NPV using the hurdle rate (k). A net present value is equivalent to the future benefits of ownership compressed into a single payment. Figure 2.2 is a depiction of the process.

DCF Valuation Principles

Calculations of value stemming from a DCF analysis have a wide range of estimates. This is due to numerous factors relating to future cash flows such as their magnitude, the timing of, and the risk associated with. Inputs are thus important to the outcome as fair royalties may only be negotiated when reasonable estimates are able to be made of the future cash flows from the endeavor. As with many aspects in the licensing process royalties also have some rules of thumb when it comes to the DCF model.

Royalties should be uncapped. Capping royalties is a hindrance to the licensor because it will not have much bargaining power after the initial agreement to increase royalties if they have been capped. The licensee on the other end has significant bargaining power in decreasing royalties for poor performance as they may threaten to drop the license. Royalty scales which are based on total sales must be based on value, not a model which discounts for quantity sold. This again puts the licensor at a disadvantage.

Value within the model is incorporated as a down payment (option or license fee) as well as a future royalty, which in turn may be used in determining a one time, upfront payment for a fully paid-up license. Any down payment for a continuous (running) royalty license should be a minor proportion of the estimated value and should be based on one of two options. Either by approximation of the higher risk bound but not zero or alternatively, 5%-10% of the total NPV based on a best estimate.

Royalties based below the top line (sales) effectively put the licensor at risk due to any inefficiency or ineffectiveness of the license. This has the effect of doubling the accounting of risk.

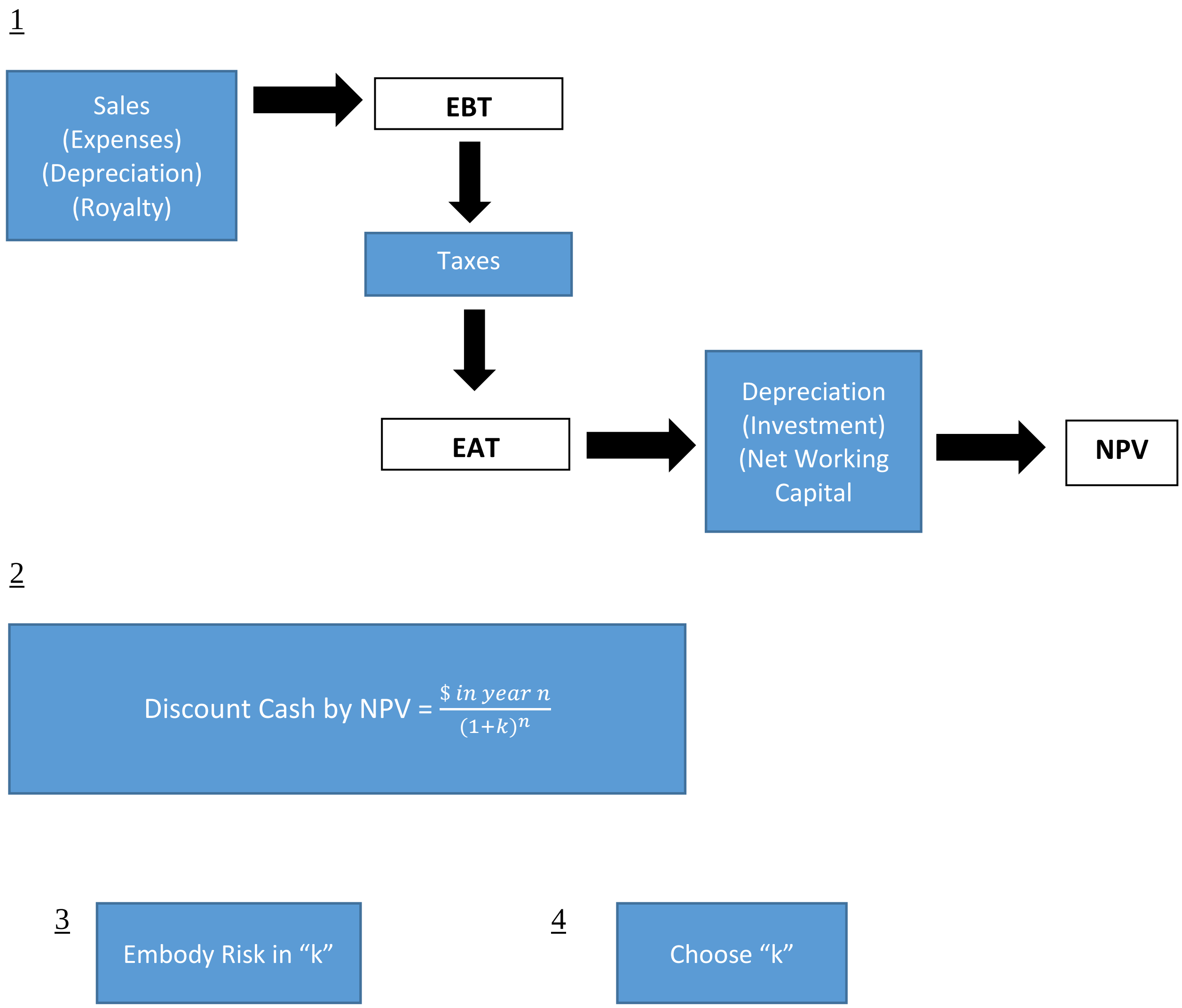


Figure 2.2. Value - Risk Plus Magnitude and Timing of Future Cash Flows

There isn't one risk model that is above all others. So there isn't a right and wrong model to be using. In the same sense there is no one right price. It is determined by what the buyer will give for rights to potential future cash flows. This again is perception driven. The further out in time the cash flows are expected to go exposes the endeavor to a much wider range of risks. It also increases the uncertainty of the price. Since the value is dependent upon risk, the risk adjusted hurdle rate is an important concept to incorporate into the analysis. It is also a solid basis for the determining if the investment is good or bad.

Net cash flow models are more labor intensive and have significant assumption criteria about future operations. The licensee is most definitely using them to value their opportunities and the licensor should be doing the same. For a licensor their pricing aspirations depend on their risk adjusted hurdle rate and how optimistic they are. More optimistic values translate into a reduced probability of finding a buyer which means more time and resources are required to find that buyer (licensee). Cash flow streams for standard categories such as home mortgages have well established markets that significantly reduce risks to the price. There is however no such market for early stage technologies (Razgaitis, 2007). The techniques described in this section are used to take out some of the ambiguity of pricing licensing agreements.

Auction Method

The auction method is the oldest method discussed. However, when it comes to early stage technology licensing it is the least used. Any prospective buyer (bidder) must do exhaustive due diligence. It's not as straight forward as buying grain on the Chicago Mercantile Exchange. In addition the complexity of a licensing deal is much more complex than a single cash payment, such as purchasing bushels of corn.

Although rare, auctions do occasionally take place. Most of the time they occur when a bankruptcy has caused a shutdown of a firm and the courts have ordered liquidation. In this context the highest bidder will be able to make an acquisition at a discount. Another potential auction situation may arise if a technology has a very high-perceived potential value which garnishes a considerable amount of attention from numerous potential buyers. However, in the vast majority of situations there will only be a few potential buyers. The cost of due diligence along with the seemingly small probability that a company will be successful with their bid will cause them to seek alternative acquisitions with their time and money.

Advanced Tools Method

After the DCF model has been established the analysis can be taken to the next level through complex mathematical modeling tools. This enables a better understanding of the economic impact of the variables. The most common tool for this type of analysis is the Monte Carlo method, sometimes referred to as probabilistic modeling.

This method has the effect of using probabilistic variables instead of static variables as in the DCF method. By running the model thousands of times a distribution of outcomes can then be compared. It is much like running the company 10,000 times and then having the advantage of seeing potential outcomes before they actually happen. Comparatively, the DCF will have the same outcome every time. The beauty of the Monte Carlo methodology is that the model can be ran over and over again with different assumptions. This is an advantage to understanding the key assumptions that should be scrutinized in more detail. In doing so overall uncertainty can be reduced.

Another advanced model is a real options analysis. An advantage of this methodology for early stage technologies is that they do not punish substantial but distant outcomes with high and compounded risk-adjusted hurdle rates (Razgaitis, 2007). Another advantage is that real options can be used to breakdown different risks. This is done by valuing an opportunity stage by stage and risk by risk, as investments are made. Next is a more detailed discussion on real options.

Real Options

In the biotechnology sector licensing agreements between firms and organizations have become commonplace. Developing all the necessary technology in-house is not only sometimes infeasible but also consumes valuable time and resources, so firms look to take advantage of synergies created by entering into licensing agreements. Negotiating these agreements pose challenges as to the valuation of the rights, restrictions, and options (terms) within the agreement itself.

Licensing in Agriculture Biotechnology has similarities to traditional Intellectual Property (IP) licensing. However, there are considerable differences due to the nature of the technologies included in the license. Some technologies may be irreversible and have a high level of uncertainty, resulting from information that is not yet accessible. The emergence of seed and traits as an industry segment has given rise to the importance of project valuation at various stages in the R&D process. Thus, collaborations have become necessary to reduce a firm's cost of entry as well as expediting the entry into the market. Patents can be considered options on the stream of future revenues. Results of option-valuation techniques to determine license prices are important for both patent licensees and for licensors seeking to maximize license revenue (Richards, 2014). Some important decisions to consider take the form of real options and thus a real options pricing analysis can be very beneficial.

Genetically modified (GM) crops are considered irreversible technologies. The optimal time to license such a technology is affected by uncertainty as well as the externalities caused by its adoption (Furtan, 2003). With this in mind a real options analysis provides an excellent insight into these uncertain outcomes. In addition, terms for royalty payments, the right of first refusal, as well as geographical restrictions are often times part of a licensing agreement. Each of these represents a real option with differing probability and flexibility. The unique aspect of real options is that they can bundle finance, risk, and strategy into one model.

Real Options Background

A conventional net present value (NPV) analysis doesn't take into consideration the value of growth options and cannot capture the multitude of contingencies arising from investment. In recent years the real options approach to valuation has gained traction for being a more reliable way to value investment decisions. The notion behind real options is based on three factors; flexibility, irreversibility, and uncertainty. The reason uncertainty creates value is because it creates options and flexibility. In real options the strategy with the most flexibility is likely the one with the largest value (Turvey, 2001).

Luehrman (1997 Harvard Business Review) outlines the limitations of traditional valuation methods and the new methods which are emerging, in particular options analysis. An active approach in developing new capabilities has the ability to yield more focused, powerful results. He argues that for companies to get from where they are to where they want to be with new valuation techniques, organizational development will be required (Luehrman 1997).

Turvey uses the Real Options Analysis to do an ex-post analysis on the Mycogen case study by Kalaitzandonakes. One example is the ability for management to incorporate an option to wait or postpone the proposed investment to see if any further information becomes available in the future. The option to wait, however, should only be exercised if the expected value of waiting is greater than the expected value of not waiting. If this is not true the option does not have a value and therefore will not be exercised. Real options valuation is synonymous with the value of the flexibly it provides. For example, the option to wait can be used to avoid loses due to unforeseen circumstances into the future (Turvey 2001).

Taking into consideration that no real empirical work had been done on irreversibility and uncertainty, Purvis, et al. presented a work that took both the uncertainty about costs and requirements about environmental compliance into account in their 1995 paper.   The authors argument is that approaching decision analysis of adoption from an ex ante approach generates research results with simultaneous implications for policy design and implication (Purvis 1995). In determining the optimal decision timing for an investment that is irreversible an option to wait is introduced. The optimal timing of the investment is the point of tangency between two curves, one describing the value of investing and the other the value of waiting to invest. In other words when the point where the value of investing and waiting are tangent equals the expected returns from the investment is the optimal timing to undertake the project. Gains from postponing investment are due to apparent opportunities to avoid downside risk (Purvis, 1995). In Purvis's work the authors were able to identify and describe obstacles to adoption. Also, the relative magnitude of the effects of uncertainty and reversibility were quantified.

There has been much debate on the adaptation of different valuations on decision analysis. Smith and Nau were able to successfully demonstrate the short comings of NPV and decision tree analysis due to the "naïve" incorporation of a single-risk adjusted discount rate, which overlooks market opportunities to borrow and trade. This paper explains that options pricing methods which incorporate these market opportunities provide a unique project value and optimal strategy. The resulting decision tree analysis gives the same value and optimal strategy. They argue that if time and risk preference are captured using a utility function and the market opportunities are explicitly modeled, decision analysis and options pricing will yield consistent results (Smith 1995).

Introduction of a binomial option tree incorporating the flexibility and risks inherent in the New Product Development (NPD) process shows how the approach leads to a much more defensible valuations. It also leads to more powerful insights for value-based management of technology-intensive companies (Jagle, 1999). A unique aspect of Jagle's paper is how it ties options based valuation of growth opportunities to the "gut feel" of individuals with a considerable amount of industry experience. He also demonstrates that this approach has the ability to produce different valuations and decisions than the simple discounted cash flow analysis. Essentially, it helped offer a fresh perspective on the management of a technology-intensive company as the management of a portfolio of options.

The value of biotechnology products can be determined not only by minds, but also by hearts, and frequently actions, in particular savvy negotiating skills (Arnold 2002). This work provides an insight into the top manager's views at biotech firm's views on the optimal time to license as well as a ranking of the value drivers in a licensing deal. By analyzing 105 biotechnology drug deals over the prior 10 years and using 31 independent variables, Arnold was able to rationalize that a savvy manager has the ability to influence as well as integrate both quantitative and qualitative factors. This knowledge is used to communicate as well as enhance value in the deal making process.

As real options analysis has emerged as a recommended technique for valuation of high-risk investment projects, it is important to understand how firms are incorporating real options analysis into their valuation techniques. Written questionnaires to some of the top pharmaceutical R&D companies painted a picture that real options analysis is not the preferred approach but rather an auxiliary tool. (Hartmann 2006). One such reason is the assumed complexity of the tool and lack of acceptance by decision makers and/or customers. However, from the survey it can be noted that the application of real options analysis is gaining favor. Mainly because real options analysis provides a more holistic project analysis without the necessity to change the fundamentals of current valuations methods (Hartmann, 2006).

Conclusion

Licensing in Agricultural Biotechnology has become increasingly common over the past decade especially with the emergence of seeds and traits as an industry segment. The license agreement itself can be incredibly complex and varies case by case. The purpose of this paper is to expand upon traditional valuation models by incorporating a real options analysis. It seeks to answer the question: With defined financial agreements in place, what do the various options in the license contribute to its value and what are they worth to both the buyer and the seller?

In terms of dealmaking and in regards to a licensing agreement, a good deal can be characterized as one that is completely understandable to both parties, can be articulated by parties who aren't present, and has the ability to respond to future events as originally intended (Razgaitis, 2003). This describes a well thought out and planned licensing agreement. Both parties seek to get the best deal possible while reducing ambiguity and maintaining integrity with the opposite party. Incorporation of a real options analysis into valuations of licensing agreement terms will help decrease ambiguity, which in turn will make for better deals.

Agriculture biotechnology licensing shares common themes with other types of licensing. The complex nature of agriculture biotechnology makes each license agreement unique often having special built in mechanisms mutually agreed upon by the licensor and licensee. The complexity and specificity that make up Agricultural Biotechnology licensing is a prime stage for real options analysis. It is clear that adding a right of first refusal for example adds value to the license. What is this value? Who is the seller and buyer of this option? In fact, almost every right, restriction, or option can be analyzed in the form of real options. This powerful tool has become more widely used in recent years however, has failed to gain mainstream traction due to its perceived complexity.

CHAPTER 3. THEORETICAL MODELS

Introduction

An Agriculture Biotechnology (Ag Biotech) license has numerous rights, restrictions, and options built in during negotiation. Evaluating these terms and how they affect the value of a licensing agreement is a critical step in the negotiating process. Traditionally a discounted cash flow (DCF) and its resulting net present value (NPV) has been used for valuing licensing deals between Ag Biotech firms. A DCF which doesn't allow for the evaluation of optionality tends to undervalue the asset.

Real Options Analysis (ROA) has emerged as an extension to the DCF valuation method due to the incorporation of uncertainty and managerial flexibility. Licensing agreements, depending on the structure, may have a high uncertainty of potential outcomes and a high level of managerial flexibility in decision. Presence of these features increase the value of a real options analysis. However, even with obvious benefits, some firms have been reluctant to use the real options approach due to its complexity and lack of understanding (Arnold, 2002 & Kodukula, 2009).

This study addresses current types of rights, restrictions, and options most common in Ag Biotech licensing deals. The purpose of this chapter is to develop a theoretical real options framework for valuing these terms. It begins with a brief discussion on licensing terms and associated types of options commonly included in Ag Biotech licensing agreements. Option theory is then described to give a basis for option valuation. The binomial specification for valuing options is defined and then applied to each type of option. Lastly, a strategic interpretation is presented focusing on how ROA enhances license valuation.

Licensing Terms

Ag Biotech licensing agreements have many similarities to that of traditional biotechnology licenses. However, there are some aspects that are important to the agricultural sector. The rise of genes and genetics as a sub industry has made licensing agreements between Ag Biotech firms and smaller firms much more common. The challenge is to efficiently organize the intra-firm relationship. The role of real options valuation is to help structure the licensing agreement, not guide strategic decisions. The following explains in detail the options analyzed in this study.

There are numerous licensing terms that are used in Ag Biotech agreements. These are listed below in Table 3.1 and discussed as appropriate in other sections of this and other chapters. Accompanying each term is the associated real option used in its valuation.

Table 3.1. List of Real Option References

Licensing Term	Real Option	Reference(s)
Option to License	Option to Wait	Anderson, Guthrie, Zetocha
Sublicensing	Option to Expand	Cahoon, Freeman, Kodukula, Zetocha
Assignability	Option to Expand	Anderson, Freeman, Kodukula
Create New Variants	Option to Expand	Anderson, Cahoon, Kodukula
License Conversion	Option to Expand	Erbisch, Kodukula
License Extension	Option to Expand	Erbisch, Ertl, Kodukula
Geographic Exclusivity	Learner Option	Anderson, Cahoon, Ertl, Guthrie
Right of First Refusal	Chooser Option	Anderson, Kodukula, Krattiger, Zetocha
Term Length	Abandonment Option	Kodukula, Razgaitis, Zetocha
Term Length	Barrier Put Option	Kodukula, Razgaitis

A common real option that has relevance is the option to wait or postpone in an attempt to gather more information to aide in the decision making process (Guthrie, 2009). An example is an Ag Biotech firm who has spent numerous years and a substantial amount of capital to obtain a patent on a type of Genetically Modified (GM) crop. The next step would be to determine if the optimal time to license is now or if waiting would be the more viable option. The optimal time to exercise the option to wait is when the value of waiting exceeds costs associated with continued operations as before. There may be situations where a licensor would be forced to exercise the option to wait such as the inability to find a licensing partner or government restrictions deterring licensing.

Once the decision has been made to move forward with licensing an important first step in exclusivity. There are different forms of exclusivity such as geographic, field of use, as well as in the number of licensees having access to the technology. Normally an exclusive license refers to the exclusivity of the subject technology to a single licensee. Whereas a non-exclusive license keeps the option open for numerous licensees. In addition, a non-exclusive license can include an option to convert to an exclusive license within a predetermined timeframe.

Geographic exclusivity refers to the licensee's right to sell or produce in a certain geographic region. This option is especially useful when there are a firms that have strengths in one region while another may be better suited to capitalize on another region. The licensor may also opt to use geographic exclusivity as a test-market approach to learn more about the market and demand on a small scale before initiating a full scale launch which demands a large irreversible investment at its onset.

This study examines two potential exclusivity options. First, the option to convert a non-exclusive license to an exclusive license. A licensee who has exclusivity can expect to pay a higher premium. Therefore, the inclusion of such an option into a non-exclusive license will also yield a higher premium and is the option for the licensee to expand operations with limited to no competition. Geographic exclusivity is the other type of option considered in the form of a test market approach. This learner option allows for small scale investments in lieu of a larger scale investment in an attempt gain information and decrease volatility.

The option to sublicense, the ability for the licensee to create new variants of the subject technology, and the option to extend the length of the license are options that may be included in a licensing agreement that can be valued as an expansion option. In all cases the licensee has the ability to expand its operations organically (new variants) and inorganically (sublicensing) while extending the license may incorporate a combination of the two. An example of creating new variants in Ag Biotech would be the licensee retaining the right to make crosses of the licensors plant line with its own proprietary germplasm. Further detail on these options is in the following sections.

The right of first refusal is a right that is included in many Ag Biotech licensing agreements. The licensor has the right to continue non-commercial R&D and any subsequent improvements to the patent must be offered to the licensee first. The right of first refusal gives the licensee the first option to adopt ownership of improvements to the patent or refuse them. The refusal to adopt may open up the door for licensing to an alternative licensee. This right of first refusal can be considered a chooser option due to the fact that the licensee faces a choice when a license improvement has been made.

Sometimes progress doesn't go as planned and alternative decisions may need to be made. This includes an underperformance by one of the parties in the agreement. For this reason during negotiations each party should be interested in potential exit strategies. While the abandonment option is ever present it is often difficult to exercise due to political and psychological reasons. The abandonment option traditionally would be exercised when the assets value falls below the strike price. However, such price movements may be temporary. To avoid poor timing in abandonment of a project a critical value lower than the strike price before the abandonment or exit option can be exercised. The inclusion of this critical value introduces a barrier put option. In addition, this type of option takes out psychological forces that may hinder management from making an optimal decision.

The preceding licensing terms all are important to an Ag Biotech licensing agreement. However, there has been little effort done to quantify the value each brings to the overall agreement. It is important for decision makers on both sides of a negotiation to understand how the inclusion of these terms affects the overall value of the license. The following provides details how real options can be used to value the rights, restrictions, and options of an Ag Biotech licensing agreement.

Real Options

Real options allow for an investment decision involving real assets while allowing for managerial flexibility in the valuation. While similar to financial options there are differences. A financial option's value is derived from the underlying financial asset whereas a real option's value is derived from a real asset such as a piece of machinery, a licensing agreement, or ownership rights to an oil field for example. Real options are based on multistage investments that require a decision at each stage.

Different pricing methods can be used in a real options analysis (ROA). The Black Scholes option pricing model is the basis for real options pricing however, its closed form characteristic isn't as flexible and it is continuous. Therefore, the discrete binomial decision lattice is a more preferred valuation technique for real options as it allows for more flexibility in the valuation. The binomial component enables, in each time period, the option value to go up or down to a particular value (Copeland, 2004). Each type of option examined in this study is unique and use differing approaches to the lattice. This is illustrated in-depth at the end of this chapter. In addition, the incorporation of a Monte Carlo simulation allows for numerous simultaneous simulations in performing sensitivity and probabilistic analyses.

As explained in the previous chapter, NPV analysis cannot capture the multitude of contingencies arising from investment. When the NPV of a project has large positive or negative values the decision path is obvious. Real options have the most value when a NPV analysis yields a result at or near zero. In dealmaking, the seller is motivated to not leave money on the table from an ambitious buyer thus pricing the deal to maximize their NPV. At the same time, the buyer is working to pay as little as possible while still closing the deal therefore maximizing their NPV. This give and take naturally incurs compromise driving the overall NPV to a marginal amount. As this happens it provides a prime stage for a (ROA) and the flexibility it provides. This study focuses on how much value each option adds to the overall licensing agreement so the NPV doesn’t necessarily need to be at or near zero.

Real options create alternatives that are likely to reveal highly valued and specific interests that may not be expressed by all or nothing approaches such as discounted cash flow. A project with a high potential value and a significant amount of uncertainty affecting that value requires a more complex and complete analysis (Razgaitis, 2009). Licensing agreements in Ag Biotech fit this mold. There is a high level of uncertainty behind these technologies along with a high potential for value. Therefore, an ROA enables a more robust analysis.

There are drawbacks to a real options analysis. Additional flexibility does not come without cost. Proper assessment of various potential options takes time in the form of creation as well as communication of results. Also, the elusive quest for certainty may result in avoidable pitfalls. Real options are not able to see into the future and its practitioners are not mediums conveying unknown secrets. It is important to keep in mind that real options are a compliment to the DCF model, enhancing it through the incorporation of uncertainty and flexibility.

Real option analysis is a systematic way to grasp opportunities by approaching it in steps in an effort to gain an understanding of risk and value with minimal necessary investment. The purpose is making well informed decisions. This study uses a real options analysis to value licensing terms through a net present value assessment, followed by a binomial lattice. Both methods also incorporate a Monte Carlo simulation. The following section describes the rights, restrictions, and options common in an Ag Biotech license agreement, which are the subject of the real options analysis in this study.

Types of Options

Real options can be classified into two broad categories, simple and compound. Simple options are traditionally sequential while compound options may be sequential or parallel, meaning they happen simultaneously. The type of option determines the valuation technique used. This study includes common simple options such as the option to wait, abandon, expand, and a barrier option. Exotic compound options are included in the form of chooser and learner options. Sequential and compound options are also included to combine the options into one valuation.

Option to Wait

The option to wait is common in many projects. After a patent has been obtained it may be beneficial to exercise the option to wait because the project currently has a negative or marginal net present value but has high uncertainty. Waiting allows the uncertainty to potentially be cleared which may result in the project having a positive NPV. At this time it may be optimal to license the patent.

A patent owner may not want to develop and market the product because the payoff is not currently attractive. However, there are potential losses of revenue every year there is a delay because the patent has a finite lifetime. In the option to wait, the leakage rate represents the finite value of a patent and its declining value for every time period it isn't in use or shelved. Leakage is equivalent to dividends on financial assets. The strike price for the option to wait is the continued cost of research and development. When the value of the option to wait is greater than the strike the option will be exercised.

Option to Expand

The option to expand is relatively common in high growth industries. Ag Biotech is no exception as expansion is at its forefront. By retaining the right to produce new variants of the current technology the licensor and/or licensee in essence has the option to expand. Only those variants which have a high probability of continued commercialization will be pursued. When there is the ability to create new variants stated in the license the option to expand is present. There may be circumstances where the licensor would want to restrict the licensee from intentionally trying to find new variants to solely focus on the objective of the license.

The strike price for the option to expand is the cost of the expansion. This type of option is a call option because it would be exercised when the expected payoff is greater than the strike price. For projects where the NPV is marginal or even negative the option to expand can add significant value. A decision maker can accept a negative or low NPV in the short run due to a high potential for growth in the long run. Without consideration of an expansion option great long term opportunities may be missed due to a short-term outlook.

Learner Option

A learner option decreases the immediate financial commitment in exchange for larger future payments when they can be better rationalized due to new information. It is often described as a test market approach. Since expenditures related to a full-scale launch are often irreversible, a small scale test launch allows the firm to potentially learn valuable information. Cost of the test launch is incremental compared to the riskier full-scale launch. This type of real option embedded into a project may introduce asymmetry into the effect of any new information gathered (Guthrie, 2009). Each successive decision is based on information collected during the previous time period making the learner option a type of compound option. The value of these options are based on the value of another option and not an underlying asset's value.

The learner option is attractive when the product is extremely innovative. It's not as valuable when the product displays heterogeneity because there isn't a high probability of any new information to be learned. An important aspect of a learner option is the ability to postpone a full scale launch in lieu of a series of smaller launches in an effort to learn about potential market conditions. It also introduces risk in the form of volatility in both information obtain and resulting change(s). This risk differs from market risk in that a decision maker contributes to volatility with its information seeking behavior. As with market risk the decision maker waits until upside risk dominates downside risk and the accompanying delay in the receipt of payoffs.

Typically firms do not make a single one time investment especially with large R&D projects. In practice a sequence of investment decisions are made which incur a series of cash flows (Guthrie, 2009). At various points during this process the firm has the ability to change its course of action. If a decision maker has the ability to halt investment program after it has begun then a compound option framework is best suited to analyze the situation. This in known as a sequential compound option and its attributes are used in the valuation of the learner option as well.

Chooser Option

In Ag Biotech a right of first refusal is a prime example of a chooser option. This right enables the licensee to have the first opportunity to adopt any improvements to the intellectual property made by the licensor before it is offered to a third party. The licensee is the buyer in this case and has the option to choose to adopt or not adopt. When a right of first refusal is present in a license agreement it can be valued using a type of real option know as a chooser option.

A chooser option is classified as a type of exotic option. It consists of multiple options combined into one. The options main attribute is the ability to choose. At expiration it can be converted into either a call or put. This is similar to the options strategy known as a straddle which consists of purchasing a call and a put at the same strike price. However, the holder of a chooser option does not have to entirely pay for both options. There is the flexibility to decide which option to buy later. At expiration the option with the highest value is in-the-money (ITM) and is exercised.

Option to Abandon

The option to abandon is present in nearly all projects (Guthrie, 2009). In Ag Biotech the licensing agreement can be for the length of the patent and any subsequent improvements to that patent. This is known as a term length agreement (Erbisch, 2004). If one of the parties involved would like the option to cancel the license it should be included into the language of the initial agreement. This may occur after a certain period of time or a milestone payment and is agreed upon by all parties.

The option to abandon the relationship or cancel the licensing agreement is a viable option for either party when term length language is absent. There can be potential stipulations for the firm exercising its option to abandon such as fees paid or waiting until a certain period of time has passed before the option is even available. This option to cancel or abandon is similar to a put option which increases in value as the underlying asset decreases in value.

There are some common issues that arise in relation to the strike price for an option to abandon. Costs recovered or a salvage value is difficult to determine with complete certainty. A strike price can change from year to year throughout the life of the option. Also, the abandonment may cost the firm instead of providing a positive value.

Barrier Option

An abandonment option is difficult to exercise due to psychological and/or other issues. To take the psychological effect out of the decision making process decision makers may opt to use a form of exit option known as a barrier option. The barrier price selected is below the strike price of the traditional abandonment option. When the barrier price is reached the exit option is exercised.

For example, assume the net present value of commercialization efforts falls below the strike price of a traditional abandonment option sometime during development. It is easy to say the project should be abandoned, however a considerable amount of time and resources have been expended thus far. Decision makers may believe that the project will turn around in the future and opt not to exercise the abandonment option only to have the project completely fail in the future. In the same sense if the abandonment option could be exercised and later it is realized it was only a short run problem that could have been corrected.

In an effort to eliminate psychological and other issues a barrier price is introduced which is below the strike price of the abandonment option. Determination of the barrier price varies depending on the project and should be closely related to the decision maker’s tolerance for risk. Because a barrier option is exercised when the NPV is less than zero a loss would be realized.

Therefore, the decision maker must consider the maximum amount of loss that can be tolerated. A barrier option helps avoid risk of premature abandonment by protecting against short term volatility.

Compound Options

Projects often come in the form of multistage investments where management has incredible flexibility in decision making. In order to value the various stages in the investment process a compound option can be used. A compound option can either be sequential or parallel (simultaneous). When exercising one option leads to another option it is sequential. For example, a licensing agreement must be entered into before the other options are available. With a parallel option the options are available at the same time, such as the option to sublicense and the right to create new variants. Both types of options have basically the same valuation calculations, with minor variations. The main difference between the option types is the framing of the application.

Option Theory

Black –Scholes

The Nobel Prize winning Black-Scholes options pricing model developed by Fischer Black and Merton Scholes is widely used in financial options. It is also important for real options as it provides the basis for the binomial specification which will be discussed next. First, the basics of the model and how it’s used to value options.

Two powerful assumptions are at the core of the model, the law of one price and no opportunities for arbitrage. The law of one price states that two assets with identical payoffs must have identical current values, which leads to the assumption that there will be no arbitrage opportunities. An option is the right but not the obligation to purchase the underlying asset for the strike price at the time of expiration. Determinants of the value of an option are: time to expiration, risk-free interest rate, the strike price, the underlying asset's price, and the market's implied volatility.

The holder of a call option benefits when the underlying asset's value increases. Whereas the holder of a put option benefits when the underlying asset's value decreases. The formulae for calculating the values of call and put options below is for European options without dividends. A European option cannot be exercised until expiration. It should also be noted that the distribution of prices is assumed normal. However, lognormal distribution works as well to ensure a non-negative outcome.

$$\text{Call Option} = N(d_1)P_0 - N(d_2)Xe^{-r*T} \quad [3.1]$$

$$\text{Put Option} = N(-d_2)Xe^{-r*T} - N(-d_1)P_0 \quad [3.2]$$

$$d_1 = \frac{\ln\left(\frac{P_0}{X}\right) + (r + \frac{\sigma^2}{2})t}{\sigma\sqrt{t}} \quad [3.3]$$

$$d_2 = d_1 - \sigma\sqrt{t} \quad [3.4]$$

N is the distribution function
P_0 is the current price of the underlying asset
X is the strike price
r is the risk free rate of return
t is time to maturity
σ is the implied volatility

With the exception of implied volatility all of the variables in the equation are observable. Therefore, all else being equal the theoretical value of the option is a monotonic increasing function of implied volatility. Increasing volatility translates into higher option values. Next, we turn to the more preferred method of valuation for real options, the binomial lattice.

Binomial Specification

The binomial options pricing model (BOPM) was first proposed in 1979 by Cox, Ross, and Rubinstein. This model uses a lattice based discrete-time series and is the preferred valuation technique for real options. Binomial models are the method of choice for a real options analysis because of their ability to reflect changing volatility, early decision points, as well as multiple decisions. In addition binomial models do not have closed-form solutions as in the Black-Scholes model.

The binomial method allows for easy corrections due to a sharp increase or decrease in asset value. Real options may potentially have negative and/or positive cash flows affecting the underlying value. The binomial lattice allows for flexibility in valuing these positive or negative "leaks". Leakage is similar to dividend payments in financial options and is further explained within the option to wait.

The basic premise of the lattice method is that during a time period the value will either go up or down. Starting with the NPV of the project up and down values, represented as U and D are calculated for each time period using the following formulas:

$$u = e^{\sigma * \sqrt{(\delta t)}} \qquad [3.5]$$

$$d = \frac{1}{u} \qquad [3.6]$$

These calculations are continued for the life of the option and the resulting lattice is similar to a decision tree with different price paths. End nodes represent the range of possible asset values at the end of the option's life.

The next step is to calculate the value of the option. Starting with the terminal nodes just calculated a decision rule (dependent on option type) is applied and the optimal decision is selected. Option values at each node are calculated backwards from option values of successor nodes by discounting them using the risk neutral probability formula in equation 3.7. This process, referred to as backward induction, is continued until reaching the far left which reveals the value of the option. A generic recombing binomial lattice is depicted graphically in Figure 3.1.

$$\text{Risk-Neutral Probability} = \frac{[e^{(r*\delta t)} - d]}{(u-d)} \qquad [3.7]$$

r is risk free rate of return
δt is change in time period

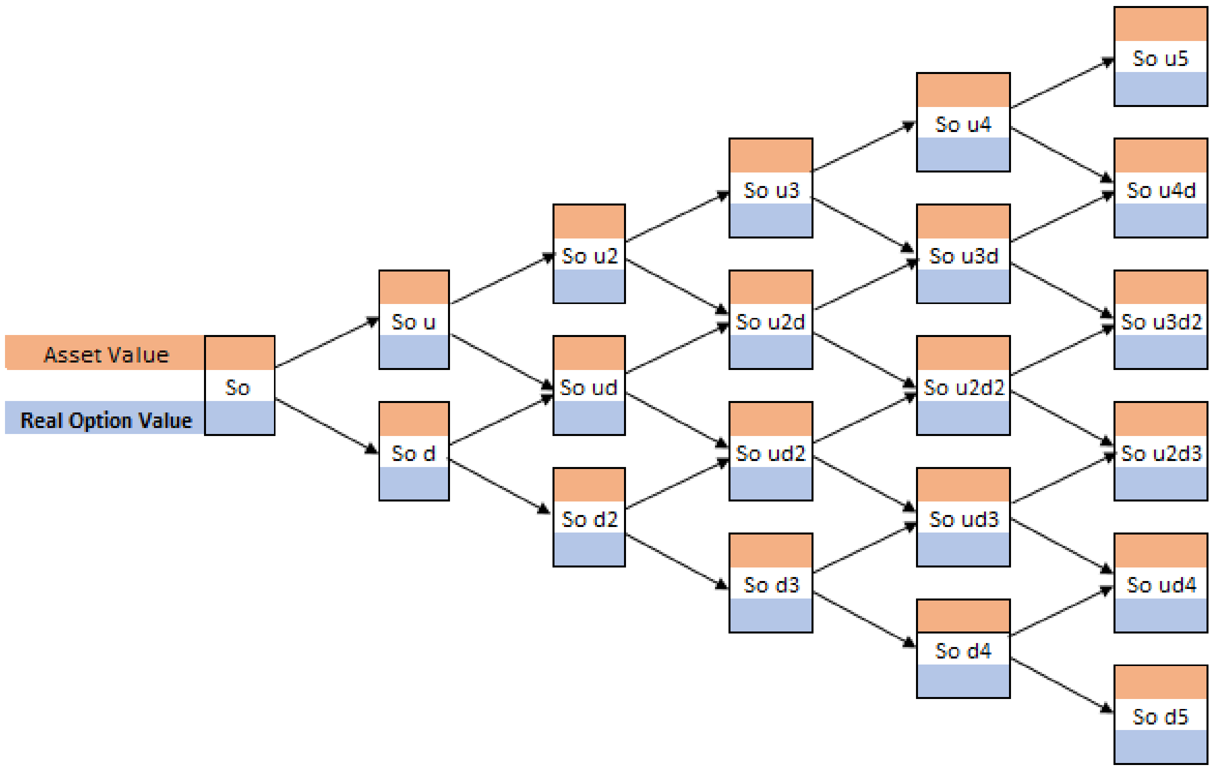


Figure 3.1. Generic Recombing Binomial Lattice for Real Options

Option Pricing

For all of the following options a discounted cash flow's NPV is done first to value the overall license. Then each option is priced using that NPV as a base. This will enable an understanding of what the options inclusion into the license is worth and the license's overall value with the embedded option. Following are six common options within an Ag Biotech license. The analysis focuses on each option by itself and then an incorporation into the license followed by a sensitivity analysis of various options into the license. In addition to real options analysis the model proposed by Villiger as well as stochastic probability model for germplasm licensing where royalties paid depend upon the overall contribution of the licensor's IP material. This is especially relevant in hybridization of germplasm licensing.

Option to License – Option to Wait

A patent owner may not want to develop and market the product because the payoff is not currently attractive. There are potential losses of revenue every year there is a delay because the patent has a finite lifetime. In the following example, the leakage rate represents the finite value of a patent and its declining value for every time period it isn't in use or shelved. Leakage is equivalent to dividends on financial assets.

The strike price on the option to wait is the investment required to continue or dealmaking the cost to license the patent. The net present value of cash flows from the DCF analysis (asset value) is multiplied using the appropriate movement to calculate the next nodes asset value (orange boxes in Figure 3.1). This is done successively until reaching the terminal nodes. Up and down movements are calculated using equations 5 and 6.

At the terminal nodes the strike price is subtracted from the asset value to determine the option value. The real option value is derived by using backward induction to flow from the terminal nodes back to the initial node. The risk-neutral probability used in backward induction on the option to wait incorporates the leakage rate.

$$\text{P} = \frac{e^{(r-L)*\delta t} - d}{u-d} \qquad [3.8]$$

L is the leakage rate

The Option value is then calculated using backward induction starting from the terminal nodes.

For example at Node So u4 in Figure 3.1 the option value is equal to the following formula.

$$S_0\, u4 = (\text{P}*(S_0\, u5 \text{ Option Value})) + (1-\text{P})*(S_0\, u4d \text{ Option Value}))* e^{-r*T} \qquad [3.9]$$

Each successive node is calculated to the present node revealing the value of the option to wait. The option is exercised if the real option value is greater than the strike price. In this sense the option to wait is similar to a call option on a financial asset with the incorporation of dividends.

<u>Sublicensing, Right to Create New Variants, and Term Length Extension as Options to Expand</u>

An option to expand is very common in high growth industries. There are several ways an Ag Biotech license agreement can allow for expansion. Commonly the licensee is given the option to sublicense upon approval by the licensor. This enables the expansion into new markets where the licensee and/or licensor may not be as strong. Second, the ability to create new variants out of the licensed material. Some licensors may not want the licensee to have this ability merely to stay focused on the task at hand, however when present the right to create new variants is synonymous to expansion. Lastly is an option to extend the license after a pre-defined time period. This allows for the opportunity to continue or expand operations provided both parties are in agreement.

The strike price for an option to expand is the cost of expansion. If the expected payoff is greater than the strike the option would be exercised making it a call option. Calculation to the terminal nodes of the lattice is exactly the same as for the option to wait using the up and down factors in equations 5 and 6. At each node there is the option to continue operations or expand. An expansion factor and the cost of expansion are used to calculate the option's value at the terminal node. The expansion factor, based on the underlying asset value, represents cash flow from current operations as well as the expansion.

$$Option\,Value = (LV * E) - C \qquad [3.10]$$

When the resulting option value is greater than the license value at that node the optimal decision is to expand. However, when the license value is greater than the option value the optimal decision is to continue with current operations.

Backward induction for the option to expand is the same as well with one exception. The leakage rate is excluded from the risk neutral probability calculation. The option to expand uses the risk neutral probability in equation 11 along with the backward induction formula described in equation 9.

$$P = \frac{e^{r*\delta t} - d}{u - d} \qquad [3.11]$$

The resulting options value at the present node is the project's value with the expansion option. To calculate the NPV of the option to expand simply take the options value less the original NPV.

Framing of the option to expand has some ambiguity that is left up to the practitioner. First is the appropriate time to expiration. If there is significant patent protection then a longer time frame may be appropriate as compared to an industry with low barriers to entry. With a long time frame one risks overvaluation of the option due to decreasing product life spans in today's market. However, using a short time frame for expiration may not allow for enough time for uncertainty to clear making the option valuation less meaningful. High growth opportunities are prime candidates for expansion options. Due to high market uncertainty they usually start on a smaller scale but as this uncertainty clears expansion is a viable option if conditions are favorable.

Right of First Refusal as a Chooser Option

When the right of first refusal (ROFR) is present in a licensing agreement it gives the licensee the choice to adopt or not to adopt any improvements to the subject technology. Since the licensor cannot offer to any third party before offering it to the licensee first this option adds significant value to the license. The buyer of this option (licensee) should expect to pay a premium to secure it. When the ROFR is in play the option holder has what is known as a chooser option.

A chooser option incorporates expansion and contraction factors into the calculation. At each terminal node there is the choice to either adopt the improvement or decline. The expansion factor indicates the perceived expansion of profits by adopting the improvement. There is also a cost incurred when adopting the new technology. The contraction factor represents the potential reduction in operations due to competitors having the ability to license the improved technology. Also, a savings is associated with the refusal factor.

Valuation to the terminal nodes is the same as described in the previous options. However, at expiration the value of the chooser option is the highest value between the alternatives. In the case of the right of first refusal it is the maximum between adoption of the improvement or refusal to adopt. When adoption is the highest value it is said to be in-the-money and would be exercised. The same is true when refusal has the highest value. This similar to an option strategy known as the straddle. It involves buying a call and a put at the same strike. For the right of first refusal adoption is the call option and refusal is the put option. Calculation of each is below.

$$Adoption = LV * E - C \qquad [3.12]$$

$$Refusal = LV * R + S \qquad [3.13]$$

LV is the License Value at the respective terminal node
E is the Expansion Factor
C is the Cost of Expansion
R is the Refusal Factor
S is Savings

Backward induction for the chooser option uses the same risk neutral probability as the option to expand (equation 11) and the same process as described above using equation 9. At the present node the value of the right of first refusal is the difference between the license value and the option value.

<u>Geographic Exclusivity as a Learner Option</u>

A learning option is a type of compound option that helps to clear uncertainty with active learning. Compound option values are not derived from an underlying asset value but rather the value of another option value. There are typically two types of compound options, sequential and parallel. A sequential option is when a predecessor option depends on the value of the successor option whereas a parallel option both are active at the same time. For this study the learning option is framed as a geographic exclusivity option with successive decisions based on information learned during a specific time frame. This is consistent with a sequential compound option.

The main characteristic of the learning option is that probabilities change as time evolves and information is gathered. All values that are relevant to the project need to be identified and assigned a probability. It is important to note how the probability distributions capturing decision maker's beliefs change over time. The ability to gather information introduces an additional source of volatility, in addition to market risk, into the payoff from waiting to invest. Risk associated with information gathering is treated like technical risk in as much as the decision maker injects risk by actively learning. It is also important to know how good news affect the probability distributions.

The initial value is based on a single distribution of possible values. However, as new information is learned the distribution changes ultimately affecting market value (Guthrie, 2009). Therefore, several probabilities are needed in order to properly analyze the learning option. For example, the probability that the project is large and the project is small, the probability of good news and the probability of bad news. The four outcomes are used to completely determine all probabilities necessary to analyze the learning option. Then, if the learning option is exercised what are the revised probabilities? Bayes' Theorem works well for this.

Suppose a project has one of two values, referred to as "large" and "small". Prior to an investment the owner has the option to acquire some knowledge about the characteristics of the project. This information is perceived as either "good" or "bad" news. Good news indicates a high probability and bad news indicates a low probability that the project will be large. It is safe to assume that all of the uncertainty won't be cleared by a single investigation. Since there are two possible characteristics and two possible outcomes there are four distinct outcomes. By knowing these probabilities the learning option can be properly analyzed. The project is either be good or bad. Therefore, the probability that the project is good equals

$$\Pr[G] = \Pr[G \; and \; L] + \Pr[G \; and \; S] \qquad [3.14]$$

The probability that the project is bad is

$$\Pr[B] = 1 - PR[G] \qquad [3.15]$$

Conditional on receiving good news the project is large with a probability

$$\Pr[L|G] \frac{\Pr[L \; and \; G]}{\Pr[L \; and \; G] + \Pr[S \; and \; G]} \qquad [3.16]$$

Conditional on receiving bad new the project is large with a probability

$$\Pr[L|B] \frac{\Pr[L \; and \; B]}{\Pr[L \; and \; B] + \Pr[S \; and \; B]} \qquad [3.17]$$

Normally, all the necessary probability information is not readily available. Often the most reliable estimate is the current (unconditional) probability distribution of project characteristics. If the probability the project is large, Pr[L], and the (unconditional) probability of a large project will result in good news, Pr[G|L], the probability of a small project will result in good news, Pr[G|S], are all know then the project is small with a probability

$$\Pr[S] = 1 - PR[L] \qquad [3.18]$$

Then, good news occurs with a probability

$$\Pr[G] = \Pr[G|L] * \Pr[L] + \Pr[G|S] * \Pr[S] \qquad [3.19]$$

Bayes theorem can then be used to determine if there is good news then the probability the project is large is revised to

$$\Pr[L|G] \frac{\Pr[G|L] * \Pr[L]}{\Pr[G]} \qquad [3.20]$$

Similarly, bad news occurring a revision of the probability that the project is large

$$\Pr[L|B] \frac{\Pr[B|L] * \Pr[L]}{\Pr[B]} \qquad [3.21]$$

Before information gathering relevant project characteristic probabilities are Pr[L] and Pr[S]. By gathering information, good news occurs with probability Pr[G] (equation 19) and bad news with probability Pr[B] = 1 – Pr[G]. Immediately after good news is received the relevant probabilities of the project characteristics become Pr[L|G] (equation 20) and Pr[S|G] = 1 – Pr[L|G]. If bad news is received then the relevant probabilities of the characteristics become Pr[L|B] (equation 21) and Pr[S|B] = 1 – Pr[L|B]. It is also important to note that large project may generate bad news and small projects may generate good news. From this stand point it is clear that information gathering only reduces uncertainty it does not eliminate it.

Suppose there is the option to launch a new type of germplasm. The manager initially has the decision to go national, stay local, or wait. In addition the patent only has a limited life therefore, the option expires when the patent does. There are five possible project states: pre-investment, successful local, unsuccessful local, successful national, and unsuccessful national. The market value in the each of the last two states is an explicit function of the state variable. Therefore, a binomial tree for the project's market value is necessary for the first three states with a binomial tree for the state variable (Guthrie, 2009). The three market values can be denoted as V_{pi} (i,n) for the pre-investment state, V_{sl} (i,n) for successful local, and V_{ul} (i,n) for unsuccessful local. The launch takes one period to complete and the expansion rights are lost if not completed by the patent's expiration. If the firm expands locally prior to expiration then a perpetual cash flow is generated after the expiration of the IP rights. The following equations are used to fill in the final column of each market value binomial tree.

$$V_{sl}\left(i, n_p\right) = \frac{YrX(i,n_p)}{r-K} \quad \text{And} \quad V_{ul}\left(i, n_p\right) = \frac{rX(i,n_p)}{r-K} \qquad [3.22]$$

Np is the time period in which patent protection expires.
YX(i,np) is perpetual net revenue when successful local
r is the one period risk-free rate of return
K is the risk adjusted growth factor

Now, if going local is successful the manager has to make the decision to wait or go national. The decision that maximizes value will be chosen so that

$$V_{sl}(i,n) = \max\{YX(i,n) + \frac{\pi_u(i,n)V_{sl}(i,n+1) + \pi_d(i,n)V_{sl}(i+1,n+1)}{r},$$

$$Y_{sl}X(i,n) - I + \frac{Y_{sl}KX(i,n)}{r-K}\} \qquad [3.23]$$

π_u is the up factor
π_d is the down factor
I is additional investment required

A similar problem arises if going local has been unsuccessful. As before the manager must either wait or go national and will choose the course with the higher payoff as indicated by the following recursive equation which is very similar to equation 23.

$$V_{ul}(i,n) = \max\{YX(i,n) + \frac{\pi_u(i,n)V_{ul}(i,n+1) + \pi_d(i,n)V_{ul}(i+1,n+1)}{r},$$

$$Y_{ul}X(i,n) - I + \frac{Y_{ul}KX(i,n)}{r-K}\} \qquad [3.24]$$

If an up move occurs then the project will be worth either Vsl(i,n+1) or Vul (I,n+1) which depends if it is successful or not. The risk associated with the success or failure is diversifiable.

Therefore, only the market value of the up state is necessary since success occurs with probability, q the expected value is

$$qV_{sl}(i,n+1) = (1-q)V_{ul}(i,n+1)$$

If a down movement occurs the expected market value at n+1 is equal to

$$qV_{sl}(i+1,n+1) = (1-q)V_{ul}(i+1,n+1)$$

Then, the manager will choose whichever action has the higher payoff, which is captured in the following recursive equation:

$$V_{pi}(i,n) = \max\{\frac{\pi_u(i,n)V_{pi}(i,n+1) + \pi_d(i,n)V_{pi}(i+1,n+1)}{r}, -I_{ul} + Y_{sl}(1+q)$$
$$* \frac{KX(i,n)}{r-K}, -I + \frac{1}{r}(\pi_u(i,n)\big(qV_{sl}(i,n+1) + (1-q)V_{ul}(i,n+1)\big)$$
$$+ \pi_d(i,n)(qV_{sl}(i+1,n+1) + (1-q)V_{ul}(i+1,n+1)))\}$$

[3.25]

All the equations necessary to value the firms learning option have been explained above. First by building the binomial tree for the project if going local has been successful using the terminal condition (patent expiration) and the equation 23. If going local has been unsuccessful the tree is constructed the same way except using equation 24. Lastly, the binomial tree for the initial state is calculated using equation 22 and the recursive equation 25.

Depending on the results the firm has two reasons not to go national right away. First, by going local the firm can avoid a large loss associated with an unsuccessful national launch. Second, delaying the investment and going local allows the firm to acquire more information and decide to go national under more favorable conditions. This is a direct reflection on the extremely valuable information the firm can gain about the ventures profitability at a lower cost. The value of the learning option is included in the payoff from going local (Guthrie, 2009).

Term Length Limits as an Option to Abandon

The option to abandon is present in virtually every project and licensing agreements are no exception. This option has the most value with a marginal NPV and a high possibility of loss. Most contracts have provisions that allow for each party to terminate the agreement. Depending what is agreed upon this usually deals with underperformance by one of the parties. The terminating party essentially does not see a point in moving forward with the agreement and envisions more lucrative opportunities elsewhere thus minimizing losses.

To value the abandonment option using the lattice can be done using the same techniques for other options. The binomial tree is developed over project's timeline using the up and down factors in equations 5 and 6. License valuation at the terminal nodes is straight forward. The strike price is the investment recovered by exercising the option. If the asset's value is greater than the strike the real option value is the same as the assets. The option is only be exercised when the asset value is less than the strike price. This is consistent with a put option. At this point the firm would be able to gain more from cancelling the agreement then to continue. Equation 11 is then used for backward induction all the way to the initial node where the overall real option value is determined. The difference between the license value and option value is from the flexibility of the abandonment option.

Term Length Limits as a Barrier Option

In practice, many stakeholders are reluctant to abandon a project when the NPV falls below its salvage value. There may be psychological factors or other outside influences which contribute to this "project stickiness" (Kodukula, 2006). The abandonment option has the assumption that the decision to exercise it will be a rational one. A barrier option is a way to take out the psychological effect, cut losses, and walk away. In the case of a barrier put option the strike (barrier) price is one that is below the salvage value but still an acceptable loss should things go awry. The barrier price is the point where the price will definitely be abandoned and is decided upon by stakeholders at the onset of the project. The resulting option value using a barrier price would then presumably be representative of the true value of the project.

Valuation of the barrier put option is nearly identical to the abandonment option. Calculation starts with the NPV of the license and then calculated for each node to the terminal nodes using equations 5 and 6. At each node there is the option to abandon the project for the salvage value if the license value goes below the barrier value or keep the option open until expiration. Then backward induction starting at the intermediate nodes uses the risk neutral probability as in the option to abandon and equation 9 to calculate the option's value back to the present node.

The difference between the license value and the option value is the flexibility incorporated by the barrier option. In addition, comparison of the abandonment option's value and the barrier put option's value will reveal the price paid to justify for emotional and other factors before making the decision to abandon. Determination of the barrier price can be difficult as there are no real quantitative methods to do so. The best alternative is to use stakeholder input.

<u>Estimation of Input Variables</u>

The true life value of a real option cannot be known with complete certainty. Usually you cannot know how long opportunities will exist as there is no decision deadline. The option must be around long enough to clear up some of the uncertainty but it cannot be so long as to render the option worthless. Issues such as late market entry, loss of first mover advantage, and other competitive threats have the potential to reduce option value.

It should be noted that while each type of option has a similar valuation technique the estimation of input parameters are a major challenge in real options analysis (Kodukula, 2006). While the underlying asset value is fairly easy for a financial asset due to it being publicly traded, it is increasingly more difficulty for a real option. The asset value of a real option must be estimated from future cash flows. A discounted cash flow (DCF) analysis provides the present value of future free cash flows.

The strike price for real options is typically the necessary investment and does not happen instantaneously as in financial options. As in the case of Ag Biotech the time it takes to reach commercialization decreases the products actual lifetime. Since this strike price or investment directly affects the option value a sensitivity analysis is important as it helps gain insight into the true option value.

Volatility is an important measure that can have a significant impact on the option value. In real options the higher the volatility the higher the option value. Volatility is a measure of variability of the total value of the underlying asset. This is easy to measure for financial options but more difficult for real options. The logarithm of cash flows method is used in the estimation of volatility by projecting cash flows and calculating relative returns. The volatility is then calculated by taking the natural log of each relative return and calculating the standard deviation of these natural logs (Kodukula, 2006). With real options the underlying value and its forecasted cash flows can be difficult to forecast. One way to do this is using a project proxy. This uses cash flow data from a similar project to calculate volatility. Also, a market proxy can be used. This approach uses the closing stock price of a publicly traded company with cash flow and risk comparable to the project under consideration. Lastly management assumption can be used in estimating volatility. Management makes estimations of optimistic, pessimistic and average expected payoffs. By knowing any two of these and assigning the probabilities – optimistic (Sopt) 98%, pessimistic (Spes) 2% and average (So) 50% the volatility can be calculated using the following formulas.

$$\sigma = \frac{\ln(\frac{S_{opt}}{S_o})}{2*\sqrt{t}} \quad [3.26]$$

$$\sigma = \frac{\ln(\frac{S_o}{S_{pes}})}{2*\sqrt{t}} \quad [3.27]$$

$$\sigma = \frac{\ln(\frac{S_{opt}}{S_{pes}})}{4*\sqrt{t}} \quad [3.28]$$

In conclusion, some options may have specific intricacies however most real options have essentially the same basic framework for valuation.

1. Frame the application
2. Identify Input Parameters
3. Calculation Option Parameters
4. Build binomial tree and calculate the asset values at each node of the tree
5. Calculate option values at each node using backward induction
6. Analyze the results

(Kodukula, 2006)

<u>Compensation Options</u>

Compensation in licensing agreements usually comes in the form of royalties paid by the licensee to the licensor. This may come in many forms and is something that needs to be addressed and fully understood by both parties when entering into the agreement. While this may vary from agreement to agreement the licensing industry has adopted some rules of thumb which have been discussed in chapter 2. However, as Villiger advocates, modern tools provide so much flexibility that there really is no need for these short cut methods. We can therefore appreciate the project in all its detail. He continues to explain that any form of a value share model the 25% and other rules or other fail to explain if the deal makes sense to the licensor.

Villiger's proposed alternative is relevant in sublicensing and/or assignment situations as well. It is designed to get to the roots of licensing by focusing on its main motivation, value creation. This model has value inflection points at predefined times which a new valuation takes place. A risk adjusted net present value (hurdle rate method from Chapter 2) or any other valuation that is able to provide realistic values to what is found in the market will work well here. Any embedded real options can also be revalued at the value inflection points.

Using upfront payment from the licensee establishes "skin in the game" and also acts as a purchase of corresponding shares in the project from the licensor. The licensee now owns part of the project and is typically responsible for the R&D costs associated with pursuing commercialization. In doing so the licensee increases its stake in the project by diluting the licensor (Villiger, 2013). Upon the completion of the development the first value inflection point is initiated. An increase in value means that the next milestone payment and any additional investment in R&D is done so at a higher valuation thus diluting the purchasing power of the licensee. In essence, the licensor is selling shares of the project against milestone payments from the licensee. When the project is ready for commercialization and begins earning profits the royalty rate is calculated as follows.

$$Royalty\ Rate = Licensor\ \ Stake * \frac{NPV\ of\ Profits}{NPV\ of\ Revenues} \qquad [3.29]$$

This model does a couple things. First it emphasizes that royalty rates should be up-tiered. If at a value inflection point the success of the project is much higher than initially anticipated then this must be incorporated into the valuation increasing the value. The licensee is not able to increase its stake as initially thought since its purchasing power has been diluted while the licensor is able to retain a higher stake at launch. Higher sales mean higher royalties while lower sales equate to lower royalties. Second the model provides a platform for sublicensing and/or assignment by the licensee. The two parties can agree that the original terms get replaced by new terms which incorporate the third party. This type of model looks to increase fairness between licensor and licensee as original terms which are agreed upon sometimes years in advance have many assumptions that are highly speculative (Villiger, 2013).

Hybrid germplasm licensing agreements typically depend on the percentage contribution of the licensors germplasm to the commercial hybrid. Another royalty uses the contribution of male or female lines. When negotiations take place sometimes five years or more in advance of commercialization both parties are subject to uncertainties and substantial risk that circumstances will change when the time comes for commercialization. With this in mind it is recommended to use some sort of value share method which Villiger's does quite nicely.

In this study two hybrid germplasm royalty schemes are considered one based on units (bags) sold and the other based on net sales. Both incorporate contribution of lines but in drastically different ways. The units sold method incorporates a multiplier depending on the sex of the contributing lines from the licensor as well as the licensor's varietal rate. The breakdown is below.

$$Licensor's\ Male\ Germplasm\ Royalty = M_m * VR * \#Units\ Sold \quad [3.30]$$

$$Licensor's\ Female\ Germplasm\ Royalty = M_f * VR * \#Units\ Sold \quad [3.31]$$

$$Licensor's\ Male\ \&\ Female\ Germplasm\ Royalty = M_{mf} * VR * \#Units\ Sold \quad [3.32]$$

M_m is the multiplier for male germplasm

M_f is the multiplier for female germplasm

M_{mf} is the multiplier for male & female germplasm

The varietal rate is to be consistent with the licensor's current rate at commercialization. There are a couple of risks here. The varietal rate is subject to volatility and the licensee is incentivized to use the licensor female germplasm in the commercial seed based on the royalty scheme above. To get an estimation of future royalty revenues an analysis can be set up, which uses estimated probabilities of the three possibilities. If there are no historic projects to use as comparisons then these estimates would most likely come from the licensee, increasing the possibility of bias. Lastly, since the royalty is based on units sold there could be an incentive for the licensee to increase the price per unit in an attempt to pay less in royalties to the licensor.

In contrast, a net sales method uses an agreed upon calculation to arrive at net sales to base royalties on. Also, as in the Australian hybrid sorghum program a three tier scheme is introduced based on percentage genetic contribution to the commercial product. The Australian project is based on non-exclusive licenses and the number of lines crossed to make the commercial sorghum hybrid. A similar schemes is used when the license is exclusive however the rates would be higher. Royalty calculations could also be based on the percentage allele contribution in commercial hybrid seed. Villiger's model can then be incorporated into both by setting up value inflection points as well as upfront and milestone payments.

Strategic Interpretation

Any collaborative agreement is a combination of goals, requirements, desires and pressures from both sides. The negotiation process of a licensing agreement, while sometimes tedious, sets the basis for what both sides anticipate to be a profitable partnership. However, there is potential for an advantage to one side due to negotiation skills, better preparation and due diligence, more accurate assumptions, and a less immediate need for cash (Hardy, 2010). This can cause one of the parties to feel slighted. As discussed in chapter two each party involved is seeking to maximize their benefit from the deal. The licensor is wanting to receive as much as possible to license its intellectual property. At the same time the licensee wants to pay as little as possible to have access to the intellectual property. Both sides seek to engage in a strategic alliance to successfully develop or commercialize a product (Hardy, 2010). Valuation of the proposed license is the focal point of the alliance.

Uncertainty and perceived risks are difficult to account for, especially when commercialization is often times several years into the future. Most collaborative deal structures contain licensing fees, R&D funding, milestone payments, as well as royalties. Each component to the deal has definable expected values, variances, and widely varying risk characteristics (Hardy, 2010). While uncertainty can never be fully negated, the valuation techniques described here allow for flexibility in the valuation. Rights, restrictions, and options that may be included within the license have their own strategic value. For example, sublicensing allows the licensee the option to turn to a third party to help with commercialization efforts but it also means one more slice out of the pie. At what point and what value is sublicensing optimal? A real options analysis as described in this chapter opens the door for more strategic insight into answering these questions. The same is true for the other options. If both parties to the deal are on the same page with valuation using real options it can help reduce uncertainty as well as determine what potential options add to the overall value of the license.

A clear strategy to reach the end goal of commercialization and the rewards it brings is essential to the success or failure of the endeavor. The license agreement is the framework for this strategy. Less time spent working on negotiating the license means more time available to work toward commercialization, especially since intellectual property protection has a finite lifetime. It is imperative to both sides that value inflection points are strategically chosen. This helps to better the negotiation process, reduce uncertainty, and give strategic partners a competitive advantage over their competition. To obtain these benefits terms of a strategic alliance can be valued, structured, an optimized using Monte Carlo analysis, stochastic simulation, and real options. This will allow for better collaboration and an increased feeling of fairness between the parties, which in turn increases the chances of success.

Summary

Chapter three has presented the framework for a real options analysis in the valuation of licensing agreements. This type of analysis equips decision makers with a powerful tool to evaluate a wide range possibilities. Evaluating license agreements ex-post is insightful. However, the type of analysis presented in this study is most valuable when done during negotiation in conjunction with negotiators on both sides (Hardy, 2010). A traditional NPV from the discounted cash flow method used in valuing a licensing deal does not take into consideration the various rights, restrictions, and options that are common in Ag Biotech licenses. In the context of valuing options within a licensing agreement, a real options analysis depicts the value each option adds to the original valuation. A real options analysis of licensing terms is not meant to replace the traditional DCF method; it is used to make the analysis more robust.

Commercialization efforts stemming from licensing agreements are subject to high levels of uncertainty such as public acceptance, time to commercialization, and commitment of the licensee. Real options are most valuable under conditions of high uncertainty. There are two main types of risk to be considered: market risk and private risk. Market risk in a project can help determine volatility in the expected payoff function. This volatility is driven by market forces such as demand and consumption. Private risk is an organization’s efficiency in completion of the project as well as the effectiveness of the resulting technology. Risks associated with the project’s cash flow dictate the discount rate used in the analysis.

This study proposes a new way to value licensing agreements in Ag Biotech by dissecting the most common rights, restrictions, and options that add value to the agreement and applying a more in-depth valuation. The addition of an ROA is at the core of this analysis. Each option described above is taken into consideration based on how they may be present in an agreement. For example, how is the value of an exclusive license with the right of first refusal and the option to sublicense different from the exclusive license with the option to sublicense but without a right of first refusal? In addition, Villiger's value share model is used to depict how compensation options focused on specific valuation inflection points makes sense to both parties because the value has a high likelihood to change as the technology nears commercialization. Options embedded within licensing agreements have value that have not traditionally been known or estimated prior to finalization of the agreement. Application of the techniques described in this chapter enable such valuation.

CHAPTER 4. EMPIRICAL MODELS

Strategic partnerships have become much more common in Ag Biotech due to the emergence of seeds and traits as an industry segment. Chapter four takes the framework from chapter three and continues with a more specific and complete analysis by valuing the many types of rights, restrictions, and options traditionally found in Ag Biotech license agreements. This helps to identify the most important options and how they affect the overall value of the agreement. It should be noted that this analysis is from the prospective of one strategic partner.

There are a number of stages in the model which seek to determine the value of an agreement. The first two stages use stochastic simulation to determine variables that are used as input into the third stage. First, yields and seed demand are simulated, followed by an estimation of technology adoption rates. Variables were used to project revenue and future cash flows used in the calculation of the net present value (NPV). The resulting NPV is interpreted as the value of the agreement and is used as the base case for this model. The base case is defined as a likely future scenario. In this research, the base case assumes no agreement is in place (firms operate separately) until it is optimal to license at which point an agreement is entered into.

Upon entering into the agreement there are various rights, restrictions, and options that may be included. Each option was individually incorporated into the base case to determine the value added to the overall agreement. When it is optimal to continue with licensing the other options are valued individually. For this research, all options were combined to determine which options provide the most value to the agreement. These options were subjected to a sensitivity analysis by changing the following critical values: discount rate, technological efficiency, royalty rates, and option volatility.

Stochastic Simulation DCF Model

The model is stylized for illustration of the value and interpretation of licensing options. The analysis uses hard red spring wheat (HRS) for illustration. Conventional breeding is the existing technology. The model includes each of the major HRS wheat producing states, North Dakota, South Dakota, Minnesota, and Montana. Separate models are specified for each state and then are aggregated. Germplasm is provided by land-grant colleges to private firms that may offer more advanced technologies. A technology firm is in the process of developing more advanced technology (e.g., genetic modification, marker assisted breeding, gene-editing, or hybrid). This technology is in the process of being developed, but, to do so requires access to germplasm. The more advanced technology also has different durations for development, expectations of yield increases (expected value and standard deviation of the yield change). Thus, the model is developed from the view of the germplasm developer evaluating alternative technologies and licensing options.

The discounted cash flow model is a combination of models used to estimate adoption rates of the new technology, the yield increase from the new technology, and royalty payments to estimate annual cash flows. These cash flows are then discounted by the weighted average cost of capital (WACC), or discount rate, to arrive at the net present value (NPV). This NPV is then used as the license value in the real options analysis (ROA). Here, the DCF model is described followed by real options in the next section.

The DCF model has two successive sets of derivations. First, grower adoption rates for conventional and new technologies are simulated. This requires a specification using random utility of incomes from expected yields to determine the adoption rate.

The resulting adoption rates are for each technology, in each region, per year. The second component incorporates the adoption rates, area planted, and royalties to estimate revenue for each technology, region, and year. The base case assumes no agreement in place. When the agreement is in place access to technology, royalties, and research funding are incorporated. The public entity receives access to the technologies. Royalty payments are based on the royalty rate, market size, and share each of which are random. Research funding fees are paid over time. Interim payments are made from the private firm after nine years if the yield improvement is greater than or equal to 2%. The private firm, through fee payment has access to germplasm. It will also be required to pay royalties for germplasm. The model assumes the subject firm or university has a competitive advantage in breeding by having superior germplasm. Details for each model are described below.

Component 1

The adoption rate component begins with the average yield (bu/a) for years 2011-2015 as the base for yield projections. Yield growth for the first seven years is at the conventional growth rate of 1.3%. After seven years new technology is introduced. Technology one is incorporated in years 7-10 and technology two in years 15-18. Due to the yield and disease resistance advantage in the new technologies a 10% growth in yield is assumed in those years.

Seed demand is broken down by region (MN, SD, ND, and MT), which is defined as planted area. The average of past five years is used as the seed demand base. A 1% increase per year in the demand over the next twenty years for conventional technology is assumed based on the historical average. Production required to meet demand is then calculated for each state based on percentage share of average production over the past five years. This calculation is done for each state.

The yield per planted acre was estimated for each state by first using a lognormal distribution of the average yield in that year multiplied by expected share of seed supplied. This was done for both the conventional and new technology for each state. The most important equations to the adoption rate estimation are explained in equations 4.1-4.4, starting with standard deviation used in the lognormal distribution and flowing into net income. The coefficient of variation is the variability of yields averaged over time was obtained from seed breeders. Acres planted and seed usage were calculated for each year and state. The distributed yield per year calculations were then used to calculate the share adoption of each technology by year. This was done by determining net income per year. The discount is assumed to be zero for this research.

$$Standard\ Deviation = Mean\ Yield * Coefficient\ of\ Variation\ (CV) \quad [4.1]$$

$$Acres\ Planted = (Production\ Required * 1000) / Estimated\ Yield \quad [4.2]$$

$$Seed\ Usage = Acres\ Planted * Seeding\ Rate\ (State\ Specific) \quad [4.3]$$

$$\pi_i = Yield * (Price - Discount) - Production\ Cost - Seed\ Cost \quad [4.4]$$

i is technology i
π is net income

Next, a Monte Carlo simulation was run for the adoption rate of the technology by segment per year. The mean value of the sum is used as the adoption rate when the variety exceeds the yield of the others. Specifically this is specified as:

$$Pr\ Adopt_{i,k} = Pr\ Yield_{i,k} > Max[Yield_{j \neq \mathrm{I,k}}] \quad [4.5]$$

i is technology (variety type)
k is year

The resulting value is representative of the proportion of time that the new technology variety yield is greater than the conventional yield, resulting in a higher net income. The Monte Carlo simulation was done for each technology, for each region by year. Therefore, as time passes there are shifting adoption rates.

Component 2

The technology adoption rates were then used to estimate new seed demand for each technology, region, and year. This was done by multiplying adoption rates by seed usage by seed saved. Conventional seed use has a proportion that is planted from saved seed, reducing the percentile of total seed sales relative to variety market shares. This new seed demand per region was then added to the average from the other regions to arrive at total seed sales by technology.

Revenue was calculated for each year by multiplying the total seed sales by each technology by the royalty received per unit. This was done for each technology, resulting in revenue per technology per year. The model provides the option for royalties to be incorporated as a fixed fee based on bushels:

*Royalty Rate (0.8) * Strategic Partner's Seed Sales * 1000* [4.6]

The resulting revenue from seed sales and royalties were added together to arrive at the total net income for each year. A Monte Carlo simulation was run to determine cash flows, which were then discounted by the weighted average cost of capital (WACC) to arrive at the NPV. The beginning asset value for the real options analysis is the mean NPV from the DCF.

Tables 4.1 and 4.2 contain the major assumptions in the DCF model as well as the more critical assumptions.

Table 4.1. DCF Model Assumptions

Variable	Value	Data Source(s)
Technological Efficiency	10%	Input from experts
Conventional Yield Growth	1.30%	Seed Breeders
Demand Growth	1.00%	15 year average growth
Seed Demand by Technology		
Conventional	0.35	
NDSU total	0.7	
Seeding Rates by State		Seed Breeders
North Dakota	1.5	
Minnesota	1.88	
South Dakota	1.83	
Montana	1.25	
Production Cost	129.29/acre	NDSU Extension Budget
Seed Cost	14.7/acre	NDSU Extension Budget
Saved Seed		
Conventional	30%	
GM	0	
Revenue per Unit	0.60/bushel	
Royalty on Seed Sales	0.8	
WACC	8%	Private company

Table 4.2. Critical Assumptions

Variable	Base	Sensitivity
Technological Efficiency	10%	2% to 20%
Royalty on Seed Sales	0.8	.50 to 1.00
Discount Rate	8%	3%

Valuation of Licensing Terms (Real Options Analysis)

A drawback to the DCF method it that it doesn't allow for flexibility in the valuation. An Ag Biotech license allows for managerial flexibility in decision making and therefore the valuation should reflect this flexibility. By using real options to value rights, restrictions, and options, flexibility is incorporated into the valuation. Incorporation of options, however, is not random. It should be done logically with the option to wait (option to license) considered first. It is then assumed that some sort of strategic partnership has been established when it is optimal to license.

Base Case

The base case was used to compare how different options add value to the basic license as well as provide a comparison for sensitivity analysis. As the initial base is the DCF model, the first assumption is no agreement is in place. The resulting NPV is considered the value of the license. The discount rate on the NPV is 8% which is meant to be reflective of the Ag Biotech companies in operation today. From this base each option is first valued independently. Then, they are all brought together and valued cumulatively.

Most of the options have common input parameters which would not change throughout the analysis. The underlying asset is the value of the license stemming from the DCF model's NPV. Time to maturity was set at twenty, which is consistent with the time most Intellectual Property (IP) protection is in place for. The United States 10 year Treasury bill rate of 2.25% was used as the risk free rate. The strike price is more subjective and in most cases it represents additional investment necessary to continue the venture. For purposes of the research, the strike price is set at 20 indicating additional investment of $20 million. Volatility of cash flows was used as a sensitivity analysis. For the base case volatility was estimated using the logarithm of cash flows method. This was done by calculating relative returns of the annual cash flows.

Volatility was then calculated by taking the natural log of each relative return and calculating the standard deviation. The first step in the real options analysis is to determine if entering into a strategic partnership through licensing is the optimal decision.

Option to Wait (License)

The option to wait is a very common real option and is the first option considered in this analysis. In order for the licensing agreement to be even considered, it must be optimal for the firm to enter into the agreement in the first place. Without the agreement the other options aren't present, so the option to wait valuation is a logical first step.

Using the NPV from the DCF model as the underlying price, the option is valued using the binomial lattice technique as described in chapter three. The NPV is multiplied by the up factor (equation 3.5) and the down factor (equation 3.6) to obtain the values for the first time step. This up and down factor multiplication is expanded by twenty time periods to complete the binomial tree. (Similar to Figure 3.1.) At the terminal nodes the strike price is subtracted from the asset values. If that resulting calculation is negative, the option value is expressed as zero. Then, through the process of backward induction the remaining option nodes are calculated (equation 3.9). The option to invest is exercised at nodes where the option value is not zero throughout the tree.

The option to wait has one unique assumption, the leakage rate. Because of this the risk-neutral probability calculation is also unique (equation 3.8). It represents value lost to the IP for every period a license agreement is not entered into. Leakage rate is higher if there is rapid changing competition, changes in buyer preferences, competitors working on the same technology. As the rate increases the value of the option decreases thus making licensing more attractive. For this research, the leakage rate is assumed to be 5% stemming from the assumption of 20 years until IP protection expires. This equates to a 5% decrease in valuation each year the option to wait is exercised. The higher leakage rate is also consistent with industry sentiment that licensing is often times more desirable than not.

The option to wait is exercised when the value of the option is greater than the strike price. Alternatively, if the option value is less than the strike price (continued R&D cost), it is optimal to enter into a licensing agreement. The other options would then come into play and it would be necessary to give them a valuation as well. The input parameters for the option to wait are outlined in table 4.3.

Table 4.3. Option to Wait Input Parameters

Underlying Price (NPV of Base Case)	So	Mean NPV
Time To Maturity	T	20
Risk Free Rate of Return	r	1.9%
Time Increments	δt	1
Volatility	σ	25%
Strike Price (Continued R&D Cost)	X	5
Leakage Rate	L	5.00%

Chooser Option

An important option in Ag Biotech is the right of first refusal. This option is essentially a choice for the holder. It is common in Ag Biotech licenses for one party to give the other the first chance to adopt new improvements to the subject technology. Without it the improvement could be licensed by a competitor. Once there has been an improvement the holder of the right then has the choice to adopt or refuse.

A chooser option is the obvious choice to value the right of first refusal. At expiration the holder has the ability to choose the optimal strategy, which is essentially a common options strategy known as the straddle. Option valuation for the chooser is done as described in chapter three. There is no leakage rate as in the option to wait and it includes four additional assumptions: an expansion factor, cost of expansion, a contraction factor, and the cost of contraction. For this research, the expansion factor is representative of the additional investment necessary to adopt the improvement and is set at 20. The contraction savings is set at 10. The firm will save $10 million by not adopting the improvement. In addition, it is assumed that adopting the improvement will expand potential revenues by 30%. If not adopted the assumption is a loss of 30% in revenues due to a potential competitor adopting, which results in a declining market share. Table 4.4 contains the full set of assumptions for the chooser option.

Calculation of the license values to the terminal nodes using equations 3.5 and 3.6 is exactly the same for each option. Valuation of the option value at the terminal nodes is where the process differs. Starting with the chooser, and flowing through rest of the options in this chapter explanation of the option valuation will begin at the terminal nodes. At the terminal nodes the decision to adopt or refused is based upon which decision has the larger value (equations 3.12 & 3.13). Backward induction (equation 3.11) is similar to the other options except an alternative risk-neutral probability is used (equation 3.9).

After the nodes of the binomial tree have been calculated, it is then possible to calculate the value (flexibility) added by the right of first refusal to the original license valuation.

$$Chooser\ Value\ Added = \ Option\ Value\ (S_o) - LV\ (S_0) \qquad [4.7]$$

Table 4.4. Chooser Option Input Parameters

Underlying Price (NPV of Base Case)	So	Mean NPV
Time To Maturity	T	20
Risk Free Rate of Return	r	1.9%
Time Increments	δt	1
Volatility	σ	25%
Strike Price	X	25
Cost of Adoption		25
Adoption Factor		2.5
Refusal Savings		10
Refusal Factor		.5

Option to Expand

Expansion of operations is present in a number of rights, restrictions, or options in an Ag Biotech license agreement. For this research, the option to sublicense was valued using the option to expand. Since sublicensing is the most common, it is used as the focal point. The other options that would follow the same valuation process are: the ability for either party to create new variants to the subject technology, conversion of the license from non-exclusive to exclusive, a license extension option, as well as the assignment of the license to a third party.

Assumptions specific to this option are the cost of expansion and an expansion factor. They have the same purpose as in the chooser option and are kept constant as in the chooser. The cost of expansion was set at 20 and the expansion factor at 1.3 to remain consistent. In other words it will cost $20 million to expand operations and the operations will expand by 30%. Table 4.5 contains the full set of assumptions for the option to expand.

At the terminal nodes the option value is calculated using equation 3.10. Option values are then calculated using the risk-neutral probability (equation 3.9) and backward induction process (equation 3.11). When the binomial tree has been completed it is possible to calculate the value added by using the real options approach. This is done by successively calculating the value added by expanding today, the NPV of expansion, and lastly the value provided from the expansion option.

$$Value\ Added = \left(Expansion\ Factor - LV\ (S_0)\right) - LV\ (S_o) \quad [4.8]$$

$$NPV\ Expansion = Value\ Added - Expansion\ Cost \quad [4.9]$$

$$Expansion\ Value = \left(Option\ Value\ (S_0) - LV\ (S_0)\right) - NPV\ Expansion \quad [4.10]$$

Table 4.5. Option to Expand Inputs Parameters

Underlying Price (NPV of Base Case)	So	Mean NPV
Time To Maturity	T	20
Risk Free Rate of Return	r	1.9%
Time Increments	δt	1
Volatility	σ	25%
Cost of Expansion		25
Expansion Factor		2.5

Option to Abandon

Sometimes things don’t go as originally planned and one party finds its best option is to abandon the project. Abandonment options are present in nearly all real options analysis as is evident in the sequential compound option. (Recall a compound option is one where the successive option’s value comes from its predecessor with the option to abandon built in). It is also possible to value an abandonment option on its own to show the flexibility that it provides to the decision maker.

Valuation of an abandonment option is straightforward. A binomial lattice is constructed as in the other options. The strike price is the investment recovered or saved from walking away, also called the salvage value. At the terminal nodes this value is subtracted from the license value to obtain the value of the option. If a value is zero or negative (negatives are reported as zeros at the terminal nodes) the option is in the money and the project is abandoned. These characteristics are consistent with a vanilla put option. Table 4.6 summarizes the input parameters of the abandonment option.

The overall value of the abandonment option is obtained through backward induction (equation 3.9) using the risk neutral probability (equation 3.11). The resulting difference between the license value and the value of the abandonment option is the added flexibility provided by the real options analysis.

$$Option\ to\ Abandon\ Value\ Added = \ Option\ Value\ (S_o) - LV\ (S_0) \qquad [4.11]$$

Table 4.6. Option to Abandon Inputs Parameters

Underlying Price (NPV of Base Case)	So	Mean NPV
Time To Maturity	T	20
Risk Free Rate of Return	r	1.9%
Time Increments	δt	1
Volatility	σ	25%
Strike Price (Salvage Value)	X	25

Barrier Put Option

Valuation of the barrier put is nearly identical to the abandonment option. The difference is that a barrier price is specified. This price is lower than the salvage value of the abandonment option. At the terminal nodes the barrier price is subtracted from the license value to obtain the option's value. Backward induction is then done the same as in the option to abandon. Once again, the difference between the license value and the option value is the added flexibility from the barrier put.

The difference between the abandonment option's value added and the barrier put's value added is the price paid to account for emotional and political factors when making the abandonment decision. The barrier put takes out these factors and thus the abandonment option valuation will always be higher. The barrier price is the most important element of this option as it can be difficult to quantify. However, it can be arbitrarily defined using stakeholder input.

Table 4.7. Barrier Put Option Inputs Parameters

Underlying Price (NPV of Base Case)	So	Mean NPV
Time To Maturity	T	20
Risk Free Rate of Return	r	1.9%
Time Increments	δt	1
Volatility	σ	25%
Strike Price (Salvage Value)	X	25
Barrier Price	L	10

Learner Option

Exclusivity in an Ag Biotech license comes in many forms as described in previous chapters. In this research, geographic exclusivity is valued using a learner option. The basic premise of the learner is to allow for small investments gain information which may reduce uncertainty. In the Ag Biotech framework, decision makers would be most interested in public acceptance of the new technology in addition to the increase in yield or other active trait in the new seed technology.

The learner options basis is defined by the probability of each expected event. There are thus four distinct outcomes each with their own probability. Since there are two main objectives to be learned (acceptance and technological advancement) conditional probabilities are incorporated. Specifically, a successful outcome would be the result of good news about public acceptance and an increase in yield (equation 3.16). In other words, conditional on receiving good news about public acceptance the technology increases yield with a probability of 60%

The probabilities listed in Table 4.8 are used in the valuation of the learner option in this research. In practice, the probabilities used in the learner option are essentially to be determined based on decision maker's discretion or those close to the project. In addition, it is assumed that it costs I= 20 to expand into a new territory (state). The venture is successful when there was an increase in yield and good geopolitical news on the new technology over the selected timeframe. In this case the timeframe is one year. The conditional probability that there was an increase in yield and good news is used. In the event of an unsuccessful venture P_r [N|B] (no increase in yield and bad news) the revenue generated is X_0=8. Each period this revenue either increases by the up factor (D) or decreases by the down factor (D). The risk adjusted growth factor is defined as K=.99. The equation (K-D)/(U-D) produces the risk neutral probability of up (π_u) moves. Risk neutral probability of down moves (π_d) is calculated by 1/(π_u).

The binomial model in this option consists of the state variable which was calculated and used as the asset value in each of the three binomial trees. The state variable was calculated by starting with revenue generated multiplying it by the up and down factors out to the terminal nodes. The first binomial tree represents if going local has been successful. Equation 3.22 is used to fill in the terminal nods and the predecessor nodes are filled in using equation 3.23. Next, the tree is calculated if going local was unsuccessful. The terminal nodes are calculated using equation 3.23. Predecessor nodes are then calculated using equation 3.24. The third tree reflects the market value of the project at the pre-investment state. Terminal nodes for this tree are equal to zero because this is considered the end of the project's lifetime thus having no investment value. Predecessor nodes are then calculated using equation (3.25). The resulting values allow the decision maker to make the optimal decision of waiting, expanding local (state by state), or going national (the four states at once).

The learner option in practice enables for more flexibility in decision making. In Ag Biotech, it would allow firms involved with seeds and traits to learn about public acceptance of the new technology while observing any increase in productivity. By taking small steps and receiving information (confirmation) to invest on a larger scale exposes the firm(s) to less risk than a full scale investment at the project's onset. This may help avoid large losses such as disapproval and non-acceptance from buyers as well as less than desired results from the technology. The learner option allows decision makers to make optimal decisions thus increasing the probability for success of the new technology.

Table 4.8. Learner Option Probabilities

		Increase in Yield		
		Yes	**No**	Sum
Public Acceptance	**Good**	30%	10%	40%
	Bad	45%	15%	60%
	Sum	75%	25%	100%

Table 4.9. Learner Option Input Parameters

Revenue Generated	X_0	Mean NPV
Risk Free Rate of Return	r	1.9%
Time to Maturity	T	20
Time Increments	δt	4
Volatility	σ	25%
Investment	I	200
Time to Maturity	T	20
Risk Adjusted Growth Factor	K	.99
Risk Adjusted Up Factor	π_u	.37
Risk Adjusted Down Factor	π_d	.63

Compound Options

Traditionally options do not happen exclusive of one another. They are either dependent upon the valuation of another option or are available to exercise simultaneously. These are commonly referred to as compound options, sequential and parallel respectively. Both types are introduced as part of this valuation. Their application in practice is dependent on the framing of the license agreement and the inclusion of specific options. For purposes of this research, assumptions are made to illustrate how compound options add increased flexibility to the valuation of an Ag Biotech licensing agreement.

Sequential Compound Option

Interpretation of compound options depends on the how decisions can be made. In the case of a sequential compound option, exercising one option gives rise to another option. The first decision must be made before the next is even a possibility. Therefore, the second option's value is dependent on the value of the first option. If there are more than two options the same ideology applies.

For this research a sequential compound option was considered. To do this a time line of option availability was determined. Commercialization of the technology will happen after significant R&D, potential sublicensing, as well as the passage of time. Both parties to the license will want to bring the product to commercialization as quickly as possible. Sublicensing (expansion option) is available after the license has been in place for 5 years (option to license). After sublicensing has been exercised the option to create new variants (expansion option) is present. Assuming new variants are found to better the technology, the right of first refusal (chooser option) will be available approximately five years after the new variants option has been exercised. This leaves nearly a five year cushion before expiration of the original IP. As these decisions happen sequentially the options valuation starts with the last option first. That is the decision that will be made furthest into the future. In this case the order of valuation is as follows: right of first refusal, right to create new variants, right to sublicense, option to license. The option to abandon is also included as it is an option at any given time after the license is in place.

Valuation is done in steps. Starting with the ROFR and using the NPV as the license value and performing the up and down calculations for 15 time periods. At the terminal nodes the valuation continues as previously described in the chooser option section. Then the option to expand binomial tree is built for 10 years using the option values from the chooser option as asset values. The terminal node valuation is the same as previously described in the option to expand section. An identical process is used to set up the sublicensing tree which will be for 10 years. Following that, using the same process, is the option to license (option to wait). When all options have been valued, a tree was extracted from the relevant option values. This valuation then provides an insight into the flexibility of the sequential compound option and how each of the option is dependent on the valuation of the predecessor option.

Parallel Compound Option

Not all decisions or options have the luxury of being sequential. Sometimes these decisions are available at the same time. In a real options analysis these types of options are known as parallel compound options. The complete valuation of a parallel option is very similar to the sequential compound option, with the exception that all options included have the same lifetime.

The parallel option was framed with the same options as in the sequential option. All options are active at the same time but the option to license must be exercised before the others are in play. At that time the options to expand through sublicensing and creation of new variants may be exercised when it is optimal to do so. The ROFR is technically active, however the timing for exercising is dependent upon when it is offered. For this research, the valuation was conducted as a continuously active option. This gives an insight into the flexibility and value added from the ROFR.

For the complete valuation, each of the options has an equal binomial lattice timeframes of twenty years. All other assumptions are held constant to the base case. The base case used the NPV from the DCF as the asset value. The option to wait was valued first following the same procedure as described earlier in this chapter. After backward induction has been completed, the option values become the asset values for the other options. Valuation from the terminal nodes is then done using the technique respective to the specific type of option.

Decision makers can take advantage of a parallel when all options are available in the same timeframe. As has been described in both cases the option to license must be exercised before the other options can be considered. The difference is when they are available. All else equal, sequential and parallel option valuation methods yield essentially the same numerical results. The difference lies within the framing of the option.

Sensitivity Analysis

The analysis proceeded by first determining the base DCF, as if no licensing agreement were in place. Then, each of the individual options described above were valued followed by differing forms of compound options. Using these models/results a number of sensitivities were then conducted. These are described in this section.

Options adding the most value to the agreement underwent a sensitivity analysis, which was done by changing important critical values: discount rate, technological efficiency, royalties, and option volatility. It is important to see how the valuation changes as these assumptions differ. For this analysis, a discount rate sensitivity was performed to illustrate the difference between a private and public entity. Technological efficiency refers to the overall yield increase from the subject technology. Varying this assumption illustrates how the license and option values are affected by the effectiveness of the new technology. The sensitivity of royalties and other payments shows how the inclusion of these compensation options affect projected cash flows as well as any of the options included in the license. Volatility of the option sensitivity is based on fluctuations in projected cash flows determined by the invasiveness of the subject technology. To make the valuation more robust a Monte Carlo simulation with 10,000 iterations was introduced and the option value was determined by the mean of the output. Each sensitivity was conducted separately while all other assumptions remain the same as in the base case.

Discount Rate

The discount rate represents an important assumption in the model. It is the rate at which projected cash flows are discounted to arrive at the NPV. Typically a weighted average cost of capital (WACC) to the firm is used as the discount rate. This rate is dictated by market conditions and not by management. The base case assumes a rate of 8%, which is representative of an Ag Biotech firm.

A sensitivity for the discount rate enables insight into different levels of risk. A higher discount rate signifies a decrease in valuation and an increase in risk whereas a lower discount rate is consistent with lower risk and an increase in valuation. By changing the discount rate from 8% to 3%, risk is decreased and the valuation increases. The rationale behind the decrease is to evaluate license and option values from the perspective of a public university, which has a lower discount rate than a company in the private sector. Analysis was done in the same manner as in the base case with only the discount rate being changed.

Technological Efficiency

Seed and trait development has become increasingly important. Advancements in technology has a central focus to the project because without innovation there is no product to commercialize. Innovative technology to resist pests, drought, and other ways to increase yield are breakthroughs that are essential to be able to meet food demand in the coming decades.

To account for increase in yield due to the new technology, the model incorporates a triangular distribution (min, most likely, max). The base case yield advantage for the new technology is as follows: 5% minimum, 10% most likely, 15% maximum divided equally over a three year period. The sensitivity to this is to vary the triangular distribution to observe changes with the most likely value at intervals between 2% and 20%.

By varying expected technological efficiency, changes in option value and flexibility can be observed. There may be a critical threshold necessary for commercialization of the technology to be feasible. In a real time valuation technological innovation estimates should come from those within the potential strategic partnership possessing the most knowledge on the subject technology.

Royalties

Another important aspect of a licensing agreement is the structure for royalties and other compensation options. There may be endless ways for royalties to enter the agreement, which are dependent upon what can be agreed to in negotiations. For this research, the base case assumes no royalties. The sensitivity for royalties is twofold: the firm will receive research funding for the first five years and will also receive royalties based on bushels when the technology has entered the market place. Research funding is a form of upfront payment which establishes investment and helps to solidify the strategic partnership. A sensitivity on the royalty rate based on bushels is performed with that rate ranging from .5 to 1.0.

Royalty structure have a material effect on cash flow projections, which are often ten or more years into the future. As commercialization nears, uncertainty that was present during the negotiation phase may have decreased and the overall picture of cash flows may become clearer. Uncertainty clearing after the agreement is in place may cause some frustration. To combat this, it is recommended to focus on a value creation method with inflection points as proposed by Villiger.

The license agreement has typically two main types of compensation options: milestones, including upfront payments, and royalties. In Villiger's value creation method the upfront payment is used for the licensee to purchase a corresponding amount of the project based on the initial valuation. The next phase is development. As the licensee helps to fund continued R&D and other development, it increases its stake in the project. After the development is completed a value inflection point is reached. In other words, the project has potentially become more valuable. The next milestone payments from the licensee occur at a higher valuation. This continues until commercialization. At this time the royalty rate paid by the licensee will be dependent on the licensor's remaining stake in the project.

Original terms of a license agreement often have numerous variables that are very speculative in nature. In the licensing industry, rules of thumb or short cuts such as the 25% rule have been popular. However, as simplifications they should not generally be applied. Instead the focus should be on the main underlying motivation, value creation, which is done quite nicely by the method proposed by Villiger (equation 3.29). Although this method is not within the scope of this research, it would make for a nice extension where license and option values for two firms are being considered.

Option Volatility

Estimation of input parameters are a major challenge in a real options analysis. Although all input parameters are important, changes in volatility affect the option value at a higher magnitude than the rest. For this reason, volatility was subjected to a sensitivity analysis.. In this research, a combination of project proxy and logarithm of cash flows was used. The base case incorporated the logarithm of cash flow method. Doing this allows for volatility to be built into the model. Using the volatility of cash flows is the most appropriate for this research. However, there are other approaches to capture volatility such as a market proxy, project proxy or managerial estimations. For a more detailed discussion on volatility estimation refer back to the "estimation of input variables" section in chapter three.

In doing a sensitivity analysis, a more invasive technology was introduced, which incurs a volatility measure of 51%. This volatility assumption is a project proxy from a similar technology. The higher volatility measure indicates the real option will be worth more but also has a higher risk of public rejection or market failure. In addition, the standard deviation of the logarithm of cash flows method was used as the standard deviation of returns from projected cash flows in the sensitivity analysis. This enables the Monte Carlo simulation to effectively produce 10,000 option values of which the mean was used to represent the value of each option.

Summary

The purpose of this chapter has been to establish empirical models to value rights, restrictions, and options in Ag Biotech licensing agreements. It also gives a description of the numerous assumptions used and rationalizations for those assumptions. Although each license is different and should be evaluated on a 4case by case basis, this empirical method is the framework for valuation of licensing agreements in Ag Biotech. In addition, it is an excellent example and application of the complementary nature of the discounted cash flow and real options analysis methods.

The discounted cash flow model used for estimating yields, seed demand, adoption rates, and royalties has the ability to incorporate numerous sensitivities. Its flexibility allows for further analysis by deciding upon different strategies, changing inputs, and evaluating the effects on each strategic partner. Changing these assumptions also has an effect on the resulting real options. This type of analysis is important in considering strategic partnerships as well as the value and flexibility from various rights, restriction, and options within a license agreement.

This analysis has covered how each option may be valued separately as well as the valuation process for sequential and parallel compound options. Framing the application of the compound option is essential it doing an accurate valuation. This depends on how the license is structured. Things such as when options are available, how long they are active, and other parameters effect the option valuation framework. Chapter five will evaluate the results of the base analysis from this chapter as well as strategic interpretations of the various sensitivities performed.

CHAPTER 5. RESULTS

Traditional valuation of licensing agreements in Ag Biotech lack analysis of rights, restrictions, and options that are included within the language of the license. A discounted cash flow (DCF) model has been the most common method of valuation. The net present value (NPV) of cash flows from the DCF encapsulates the benefits of future ownership. However, without a method to account for the uncertainty and flexibility of licensing terms the traditional valuation is undervalued.

To properly assess the common rights, restrictions, and options in a license agreement, a real options analysis was introduced using the binomial option pricing method. As a compliment to the DCF model, the real options analysis uses the NPV of cash flows as the underlying asset of the option. The binomial method incorporates uncertainty and flexibility by varying the price of the underlying asset over time. Intellectual property protection typically expires after 20 years, so the underlying asset value was varied over a 20 time period lattice. Option values were calculated using backward induction and analyzed as to the value (flexibility) they provide.

Chapter five includes analysis of a base case with and without a license agreement in place. When an agreement isn't in place the option to wait is analyzed. The base case with the license in place then includes a real options analysis of the most common terms in a license agreement. Compound options were then valued to analyze how combining options vary from the base case. The chapter concludes with a sensitivity analysis of critical variables and summary of important results.

Option to Wait

To properly assess the various rights, restrictions, and options common in an Ag Biotech licensing agreement, the valuation should be done while in negotiations or ex-ante. A valuation with no agreement in place was first done to estimate the NPV of cash flows for an entity operating independently. The main assumption was that only conventional technology would be used since a strategic partnership is commonly necessary to develop and commercialize new technology.

Analyzing the option to wait provides insight into the value of licensing. Pursuing a license agreement is optimal when the option to wait is out-of-the-money. When the option to wait is out-of-the money, there is more value in licensing the new technology than in waiting to do so. There are two important values to consider in the valuation of the option to wait, the strike price and the leakage rate. Both are critical assumptions that affect the outcome of the real option valuation. Leakage is the rate at which the value of the intellectual property (IP) declines due to the finite lifetime of the protection (Kodukula, 2009). The strike price is the increased investment necessary to license the agreement. A majority of that cost is associated with research and development (R&D). For this research, the leakage rate was held constant at 5%. Table 5.1 contains the important base case assumptions. Evaluation of the critical strike price, which indicates when the option is in- or out-of-the money, is essential for decision makers.

Figure 5.1 illustrates the results of the NPV when nothing is done in terms of licensing. This assumed the firms operate independently and only had access to conventional technology. There may be circumstances that indicate waiting to let uncertainty clear before entering into a strategic partnership to develop new technology. When the option value is greater than the strike price, the option is considered in-the-money and the option to wait should be exercised.

Table 5.1. Base Case Assumptions

Variable	Value
Technological Efficiency	10%
Conventional Yield Growth	1.30%
Revenue on Seed Sales	$0.60/bushel
WACC	8%
Underlying Asset Value	NPV of Cash Flows
Strike Price (Option to Wait)	$5 Million
Strike Price (Other Options)	$25 Million
Barrier Price	$10 Million
Time to Maturity	20 Years
Option Volatility	St. Dev of Cash Flows (~28%)
Risk-Free Rate of Return	1.90%
Leakage Rate	5%

Distribution of the license to wait option values are depicted in Figure 5.2. Analyzing the critical strike price is insightful in determining where the decision cut-off point is. This provides decision makers with additional flexibility not present in the traditional NPV analysis.

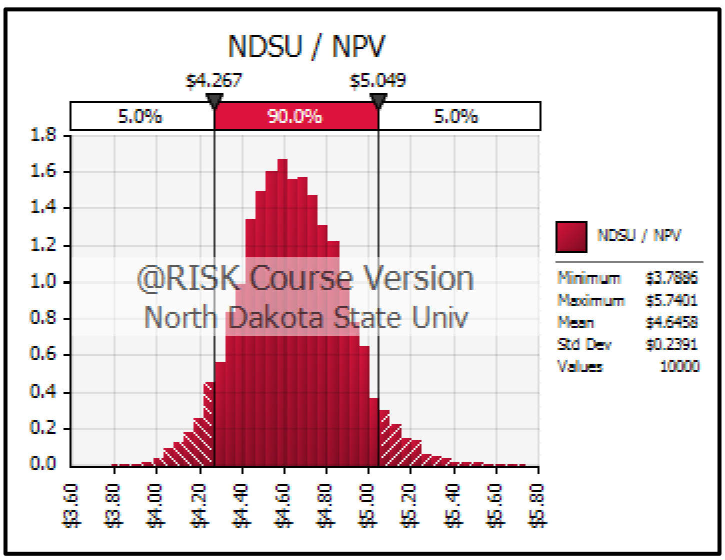


Figure 5.1. NPV No License ($millions)

From the Monte Carlo simulation of the DCF the mean NPV of the future cash flows was $4.65 million (Figure 5.1), which is the underlying asset value for the option to wait. A binomial lattice valuation revealed the mean real option value was $518,800 (Figure 5.2). Figure A1 in the Appendix depicts the complete lattice. This option was out-of-the-money since the strike price is greater than the option value. Therefore, a licensing agreement should be pursued.

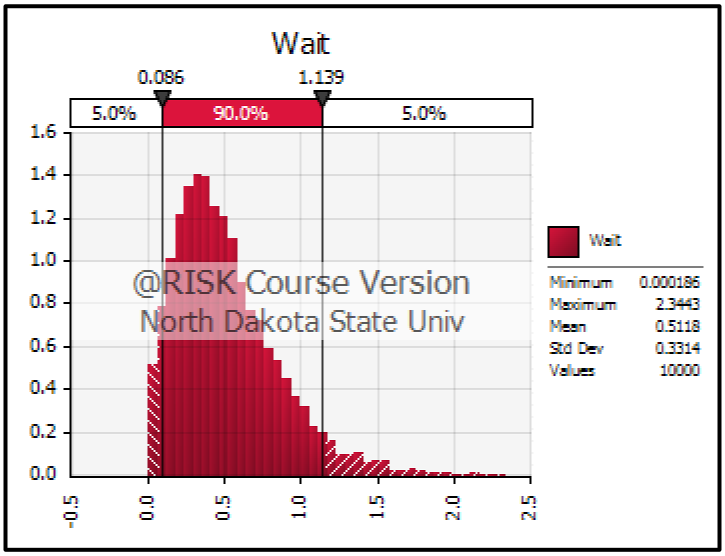


Figure 5.2. Value of Option to Wait (No License Agreement)

In this example the value of the option to wait was considerably low due to the high strike price of $5 million. The optimal decision would be to enter into a licensing agreement to help offset the high cost of continued research and development. Figure 5.3 depicts the critical strike price and how variations of that price affect the option value.

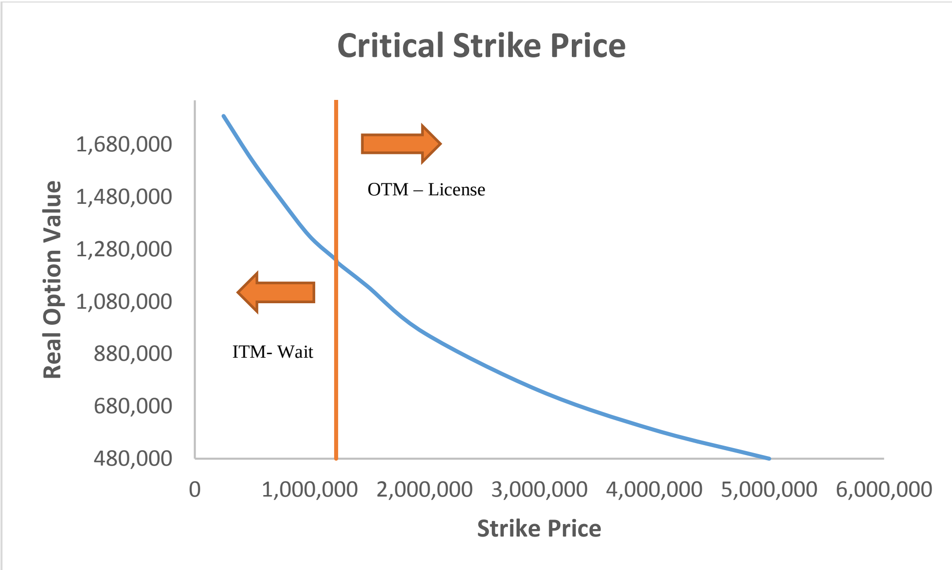


Figure 5.3. Critical Strike for Option to Wait

The critical strike price was $1.23 million. Therefore, with everything else held equal, if continued R&D costs are greater than $1.23 million it would be optimal to enter into a licensing agreement. Anything below that threshold would indicate the optimal decision would be to wait on licensing. Since new technologies in Ag Biotech tend to have high costs associated with R&D, entering into a strategic partnership is usually the optimal decision.

As the real options analysis confirms, it would be optimal to enter into a licensing agreement. At this point the firm would pursue potential strategic partners and enters into negotiations. The remaining analysis depicts how the most common options in Ag Biotech license agreements add value by considering the optionality they provide.

Base Case Licensing Agreement

Previously, the firms were operating independently. Next, a base case licensing agreement assumed an initial agreement had been entered into. Doing so enables new technology to be developed and commercialized, which was reflected in the NPV of future cash flows. In the base case license agreement analysis the mean NPV was $11.86 million (Figure 5.4), a considerable increase from $4.86 million, which was the NPV with no license in place. This is due to the incorporation of the new technology with a higher yield efficiency. Common options included in Ag Biotech license agreements were then analyzed individually to show how their optionality adds value and flexibility to the license. Table 5.2 displays results of the Monte Carlo simulation.

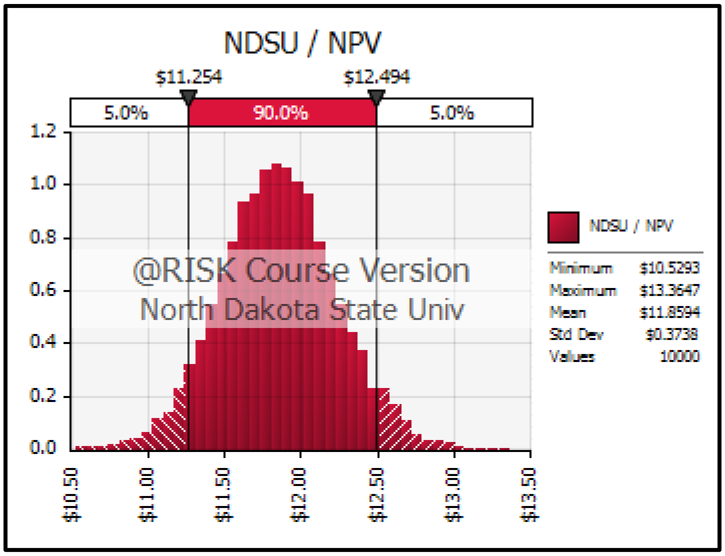


Figure 5.4. NPV Base Case License

<u>Option to Wait</u>

Although the license was already in place the option to wait provides valuable insight into continuing with the operation. Without a license in place there were no instances where waiting was the optimal decision. However, with a higher NPV and the option input parameters kept constant, in only 1.6% of cases (Figure 5.5) would waiting be optimal (option value greater than the strike price). Since patent protection has a finite lifetime, waiting even one year to license the new technology causes a loss in value of future cash flows, decreasing the NPV. Higher strike prices (higher continued R&D costs) mean less chance of the option to wait being in-the-money resulting in a license deal not being signed. Ag Biotech has significantly high R&D costs and most breeders lack the capability to advance their new technology to commercialization. The small possibility the option to wait is in-the money is further confirmation that collaboration within Ag Biotech is not only necessary, but the optimal decision as well.

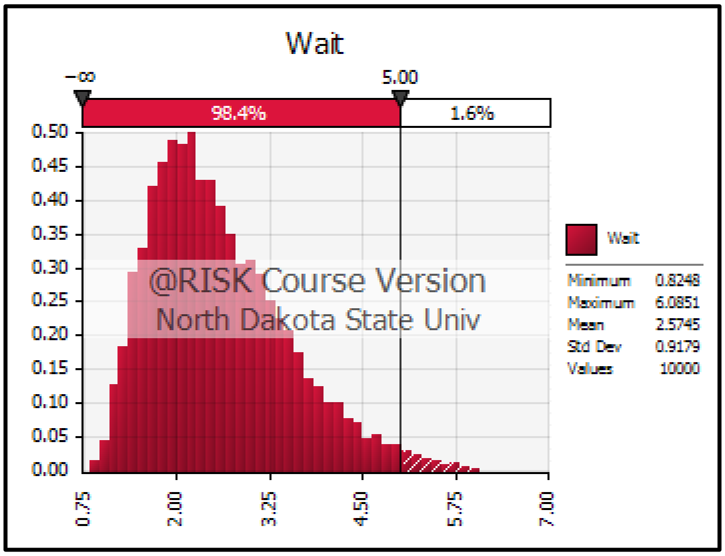


Figure 5.5. Value of Option to Wait (Base Case)

Expansion Option

The option to expand can be used to value numerous options within Ag Biotech (sublicensing, creating new variants, assignability, etc.). For the individual analysis the option to expand was framed as a sublicensing option. The main objective was to assess the value added from having an option within the licensing agreement that allows for expansion (Figure 5.6). On average the analysis revealed the expansion option adds $13.855 million in value to the license. Since the expansion option is a call option, it would be exercised when the strike price is greater than the underlying price. This can be seen in the binomial lattice for the expansion option (Appendix Figure A2). Expansion costs and the factor by which management thinks the expansion will grow the project are very important input parameters in this option and like most of the parameters in this thesis should be determined with negotiators and decision makers during the deal making process.

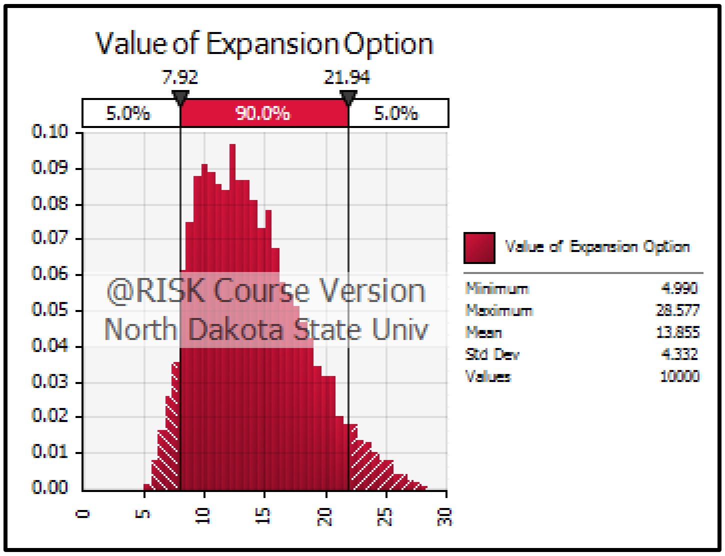


Figure 5.6. Value Added from Expansion Option (Base Option)

Sublicensing can be a crucial option in a license agreement. Including it gives the licensee the ability to seek other strategic partners. Since the end result is commercialization of the new technology as quickly as possible, having the ability to sublicense adds considerable value. The licensor is technically selling the option to sublicense to the licensee. Therefore, the licensee should be prepared to assign a value to license above the underlying NPV of projected cash flows. This analysis enables the quantification of that value.

<u>Chooser Option (Right of First Refusal)</u>

A right of first refusal adds considerable value because of its nature as a straddle strategy. This essentially gives the option holder a choice at expiration. In the Ag Biotech sense the choice entails either adopting or refusing an improvement to the patented technology. Results indicate that the mean value added by this option was $18.335 million (Figure 5.7). Thus, the buyer of this option, typically the licensee, should be willing to pay a premium for the flexibility it provides. Figure A3 in the Appendix depicts optimal decision for the chooser option at it terminal nodes.

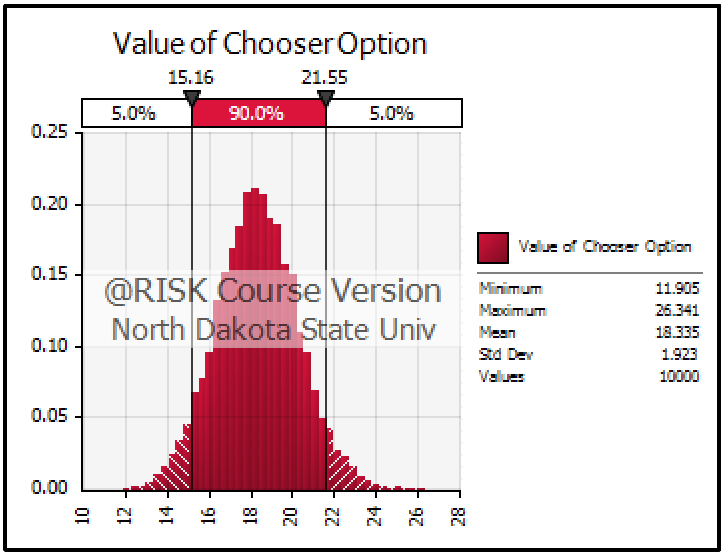


Figure 5.7. Value Added from Chooser Option (Base Case)

The right of first refusal is extremely complex and requires numerous considerations ex-ante. Most specifically how the process works when the ROFR is offered. The licensee is gaining the ability to choose whether they adopt or refuse any new improvements to the subject technology. Chooser options have unique variables pertaining to adoption or refusal. These are captured in an adoption cost, an adoption factor, a refusal savings, and a refusal factor. Valuation of the right of first refusal is highly dependent upon these factors. Consideration of the refusal variables is dependent on how decision makers view the monetary savings as well as the erosion of market share if a competitor were to adopt the new technology. Higher adoption costs decrease the option value while a higher adoption factor increases the option value. Higher refusal savings increase the option value. As the refusal factor is closer to one, less market share is expected to be lost, resulting in a higher option value.

Option to Abandon

The ability to completely abandon the project is present in every real options analysis. In an Ag Biotech license agreement, that option may have restrictions placed on it. For example, the agreement must be in place for at least five years before either party can completely abandon the project. In the presence of adverse conditions, the option to abandon provides flexibility by allowing a portion of the original investment to be recovered. Recovered investment is referred to as the salvage value and is the strike price for the option to abandon.

The additional flexibility provided by the option to abandon in this analysis was $15.98 million (Figure 5.8). At any point on the binomial lattice where the underlying asset value fell below the salvage value, the option to abandon would be exercised. This is depicted in Figure A4 of the Appendix. The value of the option to abandon was $27.84 million, which is higher than the salvage value of $25 million. Therefore, the option to abandon was out-of-the-money because would not be exercised. As with the option to wait, a critical strike analysis was done for the option to abandon (Figure 5.9).

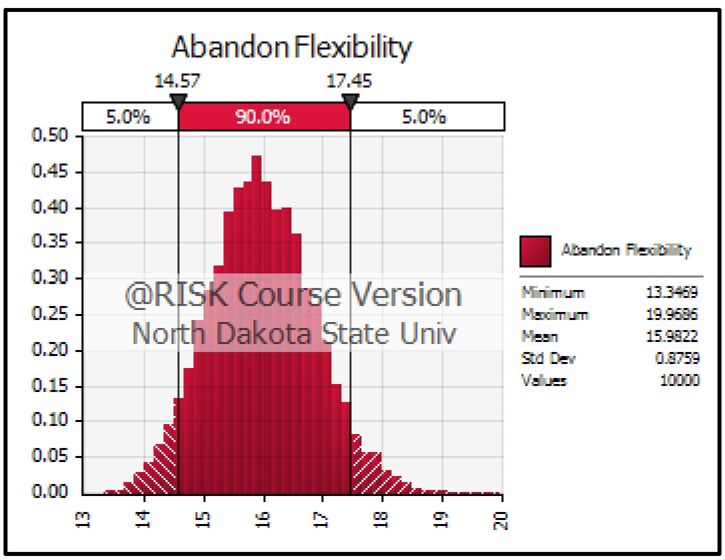


Figure 5.8. Flexibility from Abandonment Option (Base Case)

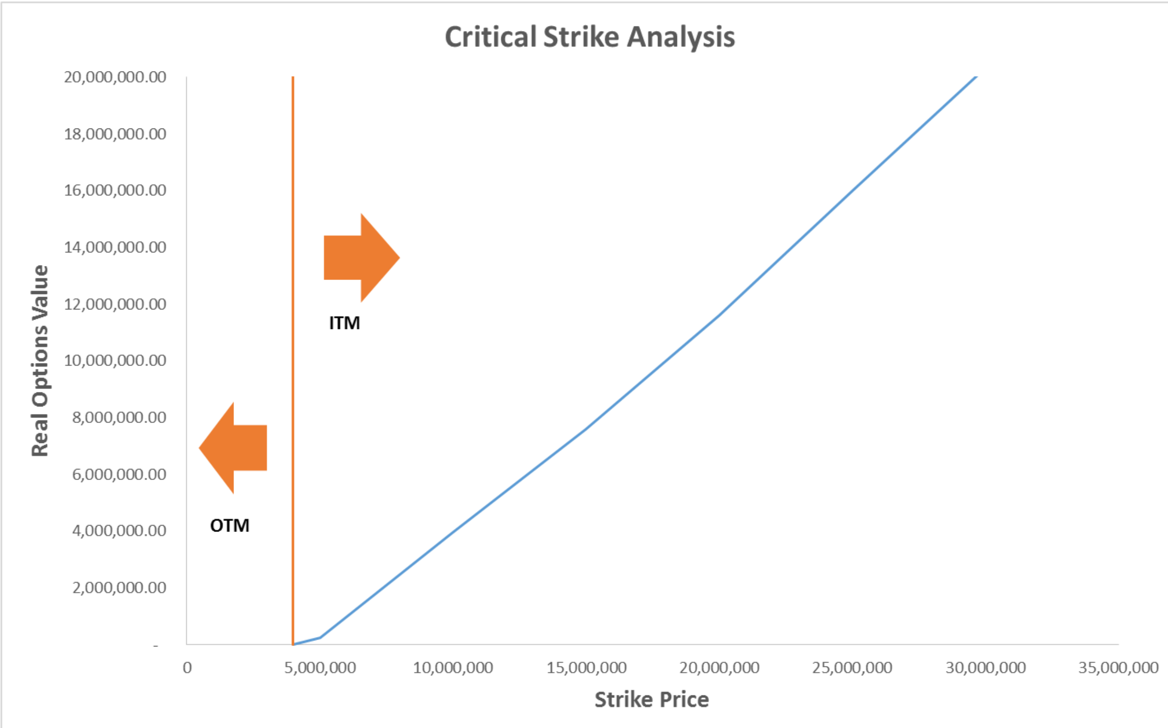


Figure 5.9. Critical Strike Price for Abandonment Option (Base Case)

Since the option to abandon is a put option, it has value when the value of the underlying asset falls below the strike price. Its value increases as the strike price increases. In this analysis, if the value falls below $25 million, the company would sell off the intellectual property to decrease its downside risk. If the expected payoff is above $25 million, the firm would continue with commercialization efforts. Abandonment should be a last resort for decision makers, especially for projects with large upfront costs. Completely abandoning a project sets back commercialization progress as well as loss of patent life. To offset premature abandonment due to short term volatility, decision makers may want to consider the barrier put option.

<u>Barrier Put Option</u>

Temporary setbacks towards commercialization may put the option to abandon in-the-money. Abandoning the project prematurely can be a big issue as these setbacks may be temporary. Decision makers may instead opt to insert a barrier put option in place of the option to abandon. In practice, there is often a reluctance to abandon a project if the expected value falls below the salvage value. There are many factors which contribute to this "project stickiness". Assumed in the abandonment option is that decision making will be completely rational. One way to account for these factors is to introduce a barrier put option. Stakeholders agree on a barrier price (lower than the salvage value) where the project will definitely be abandoned.

The difference between the real option value of the abandonment option and the barrier put is the cost of the barrier put (Figure 5.10), which is the cost to take away emotional and political factors in making the abandonment decision. In summary, this ex ante analysis of the abandonment and barrier put option, with the salvage value $25 million and the barrier price $10 million, would cost $3.82 million to eliminate emotional and/or politically driven decision making.

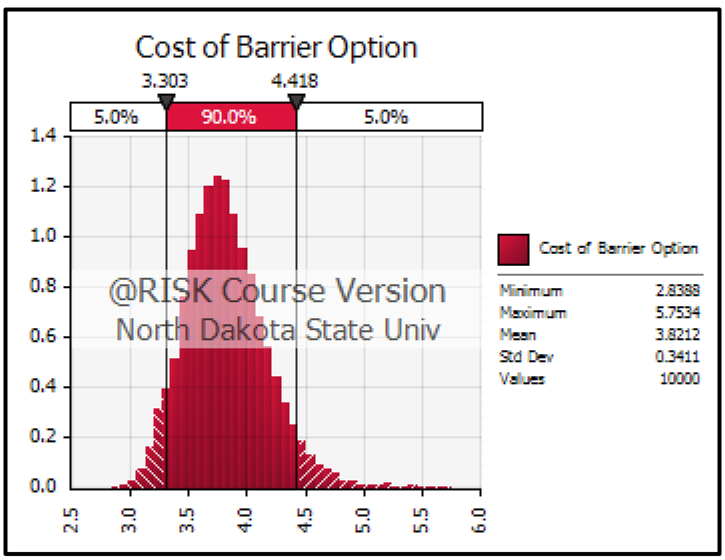


Figure 5.10. Barrier Option Cost (Base Case)

Table 5.2 summarizes the results of the analysis thus far. Notice the difference in NPV when no license is in place compared to when a strategic partnership is entered into, $7 million! Collaboration enables value creation, which is reflected in that comparison. The value of the option to wait is $2.57 million, which is lower than the strike price of $5 million. This is important as it indicates the option to wait is out-of-the money and licensing is the optimal decision. A license with an expansion option has a value of $25.71 million. Subtracting that value from the NPV with a license agreement ($11.86 million) reveals the value added from the expansion option, $13.85 million. A license with a right of first refusal has a value of $30.20 million. The same logic applies to calculate the value added from the ROFR as in the expansion option. A ROFR adds more value to a license than the sublicensing option because there is more flexibility in decision making (straddle strategy). The abandonment option is valued in the same manner as the expansion and chooser options. Lastly, the cost of the barrier put is determined simply by subtracting the option to abandon from the barrier put's real option value. In this case it costs $3.82 million to eliminate premature abandonment of the project due to emotional or political factors and/or short term market fluctuations.

Table 5.2. Base Case Results

in $millions	Base Case
Base Case NPV no License Agreement	4.86
Base Case NPV with License Agreement	11.86
Option to Wait (Real Option Value)	2.57
Sublicensing Option (Real Option Value)	25.71
Value Added from Expansion Option	13.85
Right of First Refusal (Real Option Value)	30.20
Value added from ROFR	18.34
Option to Abandon (Real Option Value)	27.84
Flexibility added from Abandonment Option	15.98
Barrier Put Option (Real Option Value)	24.02
Cost of Barrier Put Option	3.82

Learner Option

An ex-ante analysis for a geographic exclusivity option was modeled using a learner option. Here the licensor has the option to expand locally before going national in an effort to gain valuable information on the productivity (yield increase) as well the public's acceptance of the new technology. Results of the learner option allow decision makers to only go national when conditions warrant.

Beginning with the pre-investment state, there is the option to release the new technology nationwide, stay in a local area (state level), or wait for more information. Monte Carlo simulation of the learner option indicated it would be optimal to start local 94% of the time. Going national was never the best option and waiting was optimal 6% of the time. Figure 5.11 depicts the probability distribution for going local in the base case. Therefore, releasing the new technology into one state or region as a test market would be the best approach.

Upon completion of the first learning period, information (increase in yield and public acceptance) has been collected and the next decision is made. If in the first period the new technology was released on the local level, decision makers now are faced with either going national, staying local, or abandoning the project. When the first period was successful on the local level and the value of the underlying technology increased, it was optimal 100% of the time to go national with the new technology. However, if the period was successful and the value of the underlying decreased, it was only optimal to go national 48% of the time. After an unsuccessful first period and an increase in the value of the underlying technology, it was optimal go national 43% of the time. When the value of the underlying declined going national was only optimal in 5% of situations. A decision tree for the learner option base case can be found in the Appendix Figure A5.

The learner option allows for a revision of probabilities upon learning new information. Doing so enables more accurate projections and better informed decision making. Choosing to abandon the project would be in response to adverse conditions and revised probabilities, which indicate the project is unlikely to experience success moving forward. As with the other options analyzed, the learner options inputs are subjective on a case-by-case basis and would be of most value during the negotiation phase.

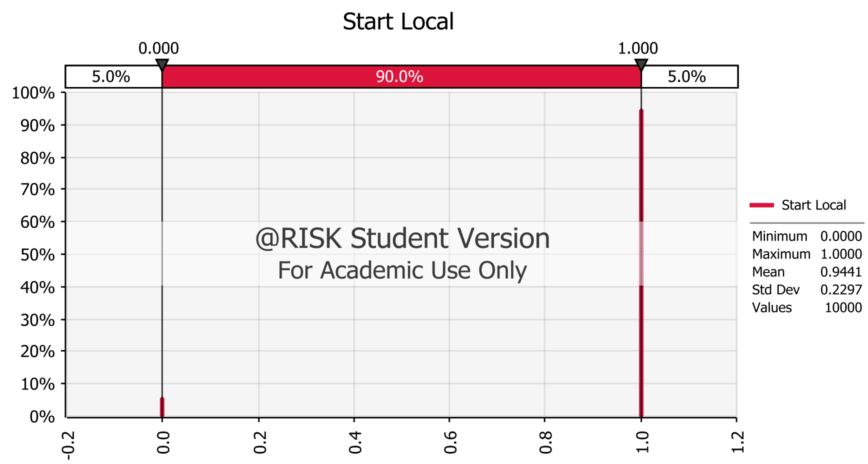


Figure 5.11. Probability Distribution Function of Learner Option

Compound Options

A license agreement contains numerous terms that do not necessarily operate independently of each other. A compound option is one in which a successive option is dependent upon the option values of the prior option. In essence, an option on an option. Application of compound options in practice depends on the framing each license and the terms within it. Next, are the results of the sequential and parallel option along with the framing of each, illustrating how compound options add increased flexibility to an Ag Biotech license agreement.

Sequential

A probable scenario for a sequential option is described followed by the results of the Monte Carlo simulation. It was assumed that any intellectual property protection would expire after 20 years. The licensor would have up to five years to license their intellectual property. After the agreement is in place the licensee has the option to create new variants of the subject technology. Sublicensing is only available after the creation of any new variants and must be completed five years before expiration of the intellectual property protection. This is to ensure some market power with the ability to stay a step ahead of any new entrants. The royalty assumption in the sequential option was automatically incorporated when it was determined it would be optimal to enter into a license agreement. Not surprisingly, this was almost immediately because of the R&D intensive nature of Ag Biotech. With the incorporation of royalties, option values for the sequential options are much higher than the base case individual option analysis. Therefore, comparisons were made to the royalty sensitivity analysis. Results of the sequential option simulations are in Table 5.8, which includes a comparison to the base case. Notice the option values in the sequential options are higher than the individual option analysis. Since is because each option is sequentially exercised the option values are dependent upon the previous option's values and not the NPV as in the original analysis. The option to abandon is embedded in the compound option and is optimal at decision nodes in red on the binomial tree. A binomial trees for the sequential option base case can be found in the Appendix Figure A6.

Table 5.3. Sequential Option Results

in $millions	Sequential with Royalties	Base Case with Royalties
Net Present Value of License Agreement	44.99	44.99
Value Added from Expansion Option	67.36	58.06
Value added from ROFR	112.34	92.20

Parallel

The parallel compound option is used when all options have the ability to be exercised at any point in time for the duration of the agreement. Unlike the sequential option, the options included in the parallel option have the same binomial structure. Here the option to wait is the independent option and was valued first. Any other options are dependent on the strategic partnership. Asset values for the dependent options are the option values from the independent option, whereas the beginning asset value for the independent option is the NPV from the DCF model. Input parameters were held constant to the original base case. Each option was valued using techniques specific to the option type.

There are more instances in the parallel base case in which the right of first refusal would be refused than in the original base case. This is because the chooser option was tied to the value of the option to wait in the parallel case. Tying the chooser option to the option to wait drastically decreases the underlying asset value which leads to lower values at the terminal nodes. Thus, making it more advantageous to refuse the new improvements. However, it should be noted that the four unique variables to the chooser are critical and may vary depending on circumstances from case to case. Table 5.9 outlines the results from the base case parallel option Monte Carlo simulation compared to the sequential results. The sequential option had royalties as a main assumption for illustration purposes. As can be seen in Table 5.9 sequential option values are much higher than the parallel case. This is due to that fact that each successive option is valued from the previous option in the sequential option. In the parallel option each option value is dependent upon the option to license. Unless there are other option within the agreement dependent upon one another the parallel option is the better method. An example would be the right of first refusal dependent upon the creation of new variants. In that instance a sequential option would be the method of choice.

Table 5.4. Parallel Compound Option Base Case Results

in $millions	Parallel Base	Sequential Base
Net Present Value of License Agreement	11.86	11.86
Option to License	3.52	33.42
New Variants (Expansion Option)	10.63	41.71
Value Added from Expansion Option	7.11	2.17
Sublicensing (Expansion Option)	10.63	43.88
Value Added from Expansion Option	7.11	10.91
Right of First Refusal (Chooser Option)	23.11	22.77
Value added from ROFR	19.56	18.95

Values for the two expansion options are identical due to identical inputs. In practice, these options would likely have different inputs, specifically the expansion cost and expansion factor. A right of first refusal adds slightly more value to the license when it is priced as a compound option than an individual option as seen when comparing Table 5.1 and 5.9 (18.34 vs. 19.56 respectively). The difference is a reflection of the underlying asset value being the value of the option to license as opposed to the NPV. Critical strike analysis is the same as in Figure 5.3. However, the number used for the strike is of more importance to the parallel option as the value of the option to wait (license) determined the value added from the other options. For this reason, decision makers must pay careful attention to their continued R&D cost estimations.

Sensitivity Analysis

A sensitivity analysis of selected variables was performed to see how such changes affect the value of the options within the agreement. `Sensitivities were performed on four crucial variables: WACC, technological efficiency, option volatility, and the incorporation of a royalty scheme. Decreasing the WACC is reflective of a public entity such as a university, which has less risk associated with its cost of capital. The base case assumed a mean increase in yield (technological efficiency) of 10%. Since new technologies may display wide variances in yield, the sensitivities incorporated a mean increase in yield from 0% to 20% in 5% intervals. Additionally, a standard deviation was added to represent uncertainty of how efficient new technologies are in Ag Biotech. Option volatility is the main driver of option values. New technologies in Ag Biotech have high uncertainty, leading to an increased level of volatility. The sensitivity incorporated a volatility measure double the base case. The results indicated that this uncertainty added value to all options considered in this thesis. Finally, royalty structures play a key role in negotiations. The royalty sensitivity incorporated upfront payments from the licensee with a per bushel royalty rate on sales. The royalty included a range of per bushel royalties from 0.5-1.0. Doing so naturally increases cash flows. A cash flow comparison by strategy is depicted in Figure 5.12. Notice there was a pronounced increase in cash flows when royalties and a larger technological efficiency were incorporated. Next is a more in-depth analysis of each sensitivity.

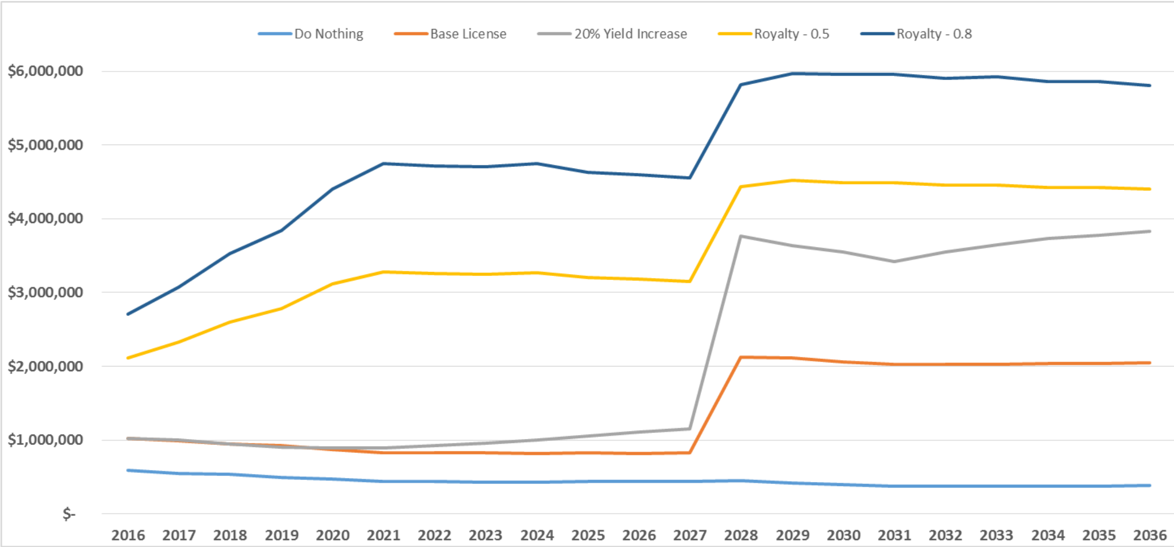


Figure 5.12. Comparison of Cash Flows

Weighted Average Cost of Capital (WACC)

The WACC sensitivity provided results that would be indicative of a public institution, most likely a land-grant university. These universities have breeding programs to develop high quality germplasm. However, they do not have the capability to continue development of the new technology all the way to commercialization. For this reason these institutions routinely form strategic partnerships with private companies having large R&D programs and resources.

Land-grant universities are subjected to less risk than their private counterparts. Therefore, their WACC is lower resulting in a higher NPV. This in turn leads to a significantly higher value of the options in this analysis as shown in Table 5.3. The purpose of this sensitivity was to demonstrate how the option values change depending on the amount of risk to the underlying cash flows to the firm, which is dependent upon the nature of that firm.

Table 5.5. WACC Sensitivity Results

in $millions	Base Case	WACC - 3%
Net Present Value of License Agreement	11.86	20.04
Expansion Option	25.71	48.99
Value Added from Expansion Option	13.86	28.95
Right of First Refusal (Chooser Option)	30.20	52.07
Value added from ROFR	18.34	32.03
Option to Abandon	27.84	34.72
Flexibility added from Abandonment Option	15.98	14.68
Barrier Put Option	24.02	31.38
Cost of Barrier Put Option	3.82	3.34

Since a land-grant university is subjected to a lower WACC, flexibility from the abandonment option also declines. Throughout the life of the agreement, there is a lower probability the option will be in-the-money due to less uncertainty associated with a 3% WACC. In addition, the cost of the barrier put is lower than the base case for the same reason.

Technological Efficiency

In order to properly assess changes in technological efficiency the base case underwent a slight modification. Originally the model assumed that the new technology would be commercialized after 15 years at which point the increase in yield from the new technology was incorporated. To more accurately reflect how increases in yield affect adoption rates, cash flows, and license options the assumption was relaxed to allow the new technology to appear in year 5.

A number of sensitivity were performed on technological efficiency. Recall, the base case assumed a triangular distribution (5%, 10%, 15%) with 10% being the most likely outcome. First, the growth rate was set at a static number and Monte Carlo simulations were ran for no increase in yield to a 20% increase in yield in intervals of 5%. Next, the 10% yield increase was used with the introduction of a standard deviation. Three Monte Carlo simulations were then ran with the standard deviation set a 5%, 10%, and 15%. Results of the simulations are in Tables 5.4 and 5.5 Introduction of the numerous yield estimations along with the standard deviation was to demonstrate the high uncertainty of the technological efficiency of a new technology especially during license negotiations, which are often times years before commercialization. This makes the technological efficiency estimation extremely difficult to predict.

Table 5.6. Technological Efficiency Sensitivity Results

in $millions	5% Growth	20% Growth	Difference
Net Present Value of License Agreement	11.51	16.43	4.92
Option to Wait	2.77	5.2	2.43
Expansion Option	24.62	40.58	15.96
Value Added from Expansion Option	13.11	24.14	11.03
Right of First Refusal (Chooser Option)	29.01	45.37	16.36
Value added from ROFR	17.55	28.94	11.39
Option to Abandon	27.49	33.47	5.98
Flexibility added from Abandonment Option	15.97	17.03	1.06
Barrier Put Option	23.46	31.14	7.68
Cost of Barrier Put Option	4.02	2.33	-1.69

Table 5.7. Technological Efficiency Incorporation of Standard Deviation

in $millions	5% St Dev	10% St Dev	15% St Dev
Net Present Value of License Agreement	14.09	13.99	13.84
Option to Wait	3.99	3.95	3.89
Expansion Option	32.82	32.51	32.09
Value Added from Expansion Option	18.78	18.52	18.25
Right of First Refusal (Chooser Option)	37.43	37.12	36.72
Value added from ROFR	23.33	23.14	22.88
Option to Abandon	30.28	30.18	30.05
Flexibility added from Abandonment Option	16.19	16.19	16.2
Barrier Put Option	27.44	27.3	27.12
Cost of Barrier Put Option	2.85	2.88	2.93

As can be seen in Table 5.4 the effectiveness of the new technology had a profound effect on not only the NPV of the license, but the option values as well. A sensitivity of potential technological efficiencies is important to consider during negotiations. By allowing stakeholders to envision a range of values based on how well the technology has performed, it won’t be as much of a shock when the technology only increases yield by 5% when it was expected to increase by 10%. A standard deviation sensitivity was also applied to the 10% yield growth assumption. Focusing on the NPV of the three standard deviation sensitivities, it is evident that an increase in standard deviation slightly decreases the mean NPV of the agreement. So standard deviation around the technological efficiency doesn't have as much of an impact on the value of the license or the options within that license as does large changes in the expected technological efficiency.

Option Volatility

Using the logarithm of cash flow methods in the base case is a good way to measure option volatility, especially when there are no similar deals or previous data available. To perform the volatility sensitivity a project proxy was introduced. Plant breeders consistently experience high volatility in the advancement of new technology. Setbacks include but are not limited to funding delays, various research difficulties, and public acceptance issues. Due to their more volatile nature, new technologies are much more likely to experience swings in value. Knowing this, the volatility was set at 51% and allowed to deviate by the standard deviation of volatility from cash flows. A comparison of the volatilities used in the base case and sensitivity analysis is depicted in Figure 5.13. In addition, Table 5.6 displays the results of the Monte Carlo simulation, focusing on option volatility. The increase in volatility causes an increase in the option values, which is consistent with options pricing. It should be noted that the NPV, or the underlying, is the same in both cases. Nevertheless, higher volatility from new technologies substantially increased the value added from options within the agreement.

Table 5.8. Volatility Sensitivity Results

in $millions	Base Case	Option Volatility - 51%
Net Present Value of License Agreement	11.86	11.86
Expansion Option	25.71	32.48
Value Added from Expansion Option	13.86	20.62
Right of First Refusal (Chooser Option)	30.20	38.46
Value added from ROFR	18.34	26.6
Option to Abandon	27.84	32.48
Flexibility added from Abandonment Option	15.98	20.62
Barrier Put Option	24.02	29.39
Cost of Barrier Put Option	3.82	3.09

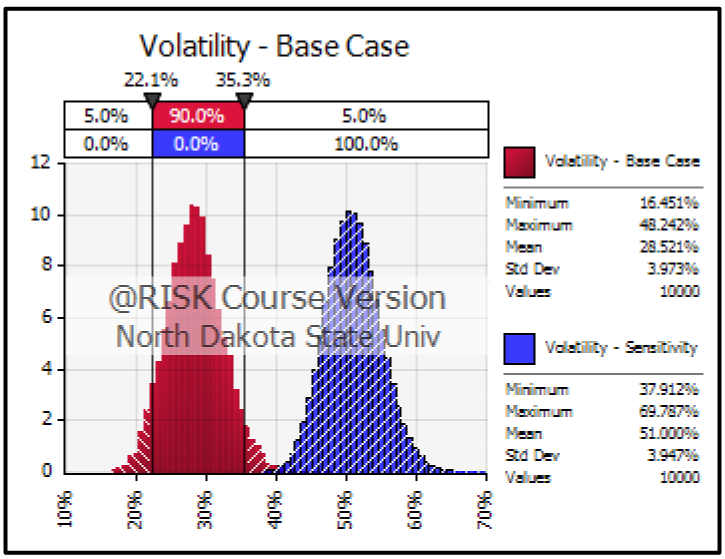


Figure 5.13. Volatility Comparison

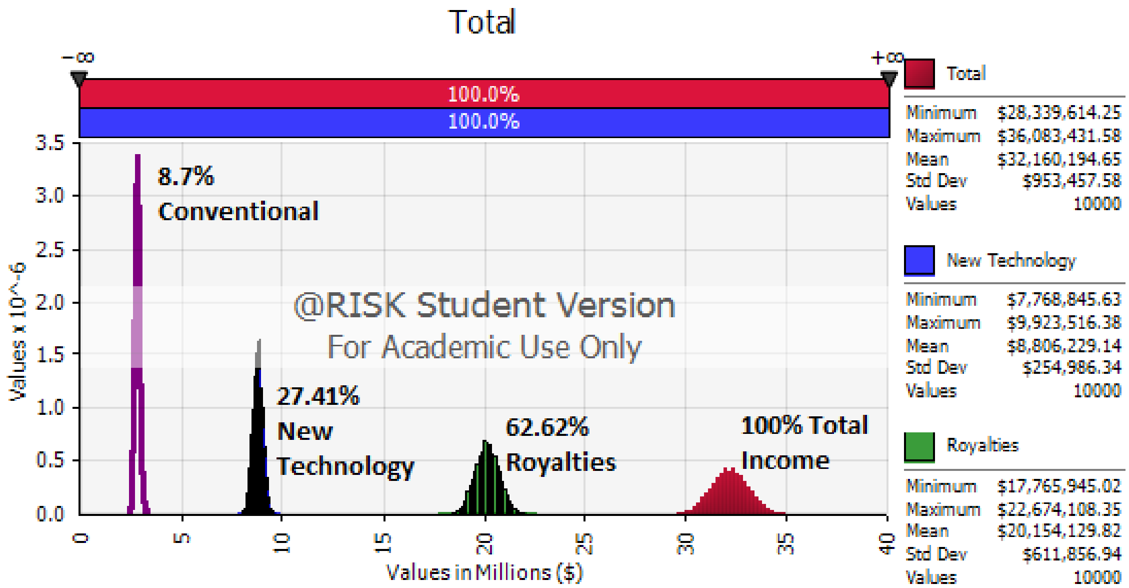
Royalties

Royalties are usually the most important compensation option discussed during negotiations. While an upfront fee provides commitment, royalty rates can have a material effect on the NPV as well as any options within the agreement. Effects from adding royalties to the Monte Carlo simulation can be seen in Table 5.7. A higher per bushel royalty rate increases the NPV as well as the options within the analysis. Increasing royalties also increased the flexibility and value added from these options. The cost of the barrier put is once again lower than the base case. As the underlying asset's value (NPV) increases, the probability its value decreases to barrier price declines. For this reason the cost of the barrier put declines as NPV increases.

Table 5.9. Royalty Sensitivity Results

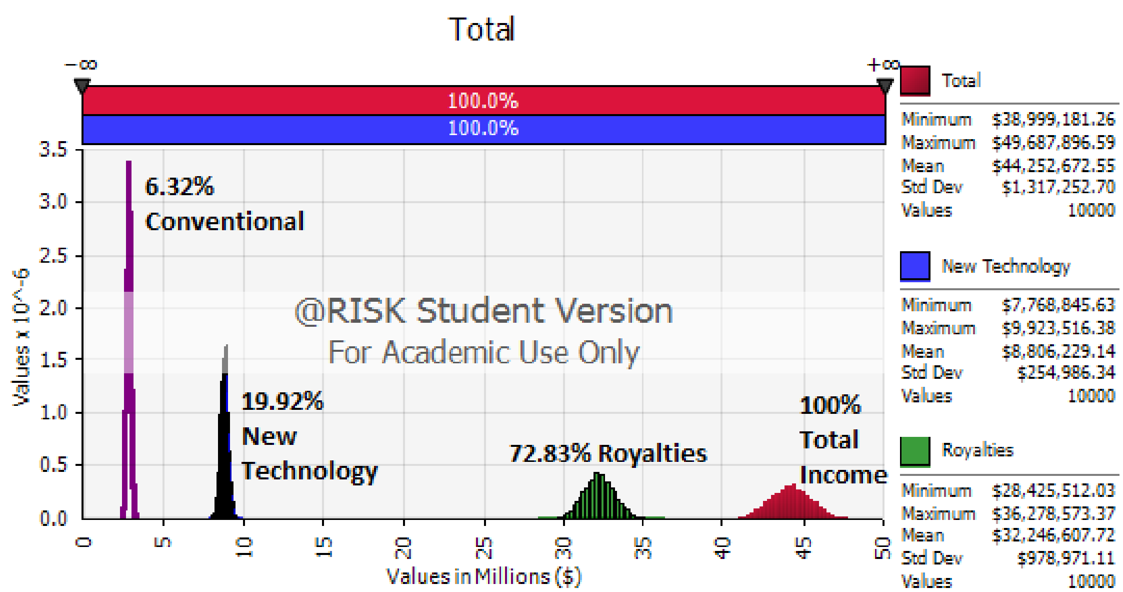
in $millions	Base Case	0.5/bu	0.6/bu	0.7/bu	0.8/bu	0.9/bu	1.0/bu
Net Present Value of License Agreement	11.86	32.16	36.19	40.22	44.25	48.28	52.31
Expansion Option	25.71	81.97	94.25	106.65	119.12	131.64	144.18
Value Added from Expansion Option	13.86	49.81	58.06	66.43	74.87	83.36	91.87
Right of First Refusal (Chooser Option)	30.20	82.84	94.95	107.20	119.57	132.02	144.51
Value added from ROFR	18.34	50.68	58.76	66.98	75.32	83.74	92.20
Option to Abandon	27.84	43.83	48.21	52.80	57.52	62.30	67.13
Flexibility added from Abandonment Option	15.98	11.67	12.02	12.58	13.27	14.02	14.82
Barrier Put Option	24.02	41.82	46.56	51.38	56.28	61.22	66.19
Cost of Barrier Put Option	3.82	2.01	1.65	1.42	1.24	1.08	0.94

Figures 5.14 and 5.15 show graphically the percentage of revenues coming from conventional technology, the new technology, as well as from royalties. A higher royalty rate increases the percentage of revenue coming from royalties. As each party in a negotiation has the goal of maximizing their value from the deal, analysis on royalty rates provides key information. In order to get a full sense of the royalty's effects, a companion analysis can be done from the vantage point of the firm paying the royalties. However, that is beyond the scope of this thesis. Royalty rates and alternatives are an important ex-ante analyses during license negotiations because such a large percentage of expected revenues are from royalties.



*Approximately 1.25% of income is from research funding.

Figure 5.14. Distribution of Income Sources (Royalty Rate 0.5)



*Approximately 1% of income is from research funding.

Figure 5.15. Distribution of Income Sources (Royalty Rate 0.8)

Interestingly, cash flow volatility declined with the incorporation of royalties. Although royalties cannot be known with full certainty, they are a steady income stream when licensing is in place. Assumption in the DCF adoption model were made as to incorporate these royalties based on estimated adoption rates of the new technology. Since royalties were based on per bushel sales of sales and calculated in accordance to the adoption rate, there was less volatility in the cash flows because of the more steady and predictable income stream. The volatility used in options pricing of the royalty sensitivities is depicted in Figure 5.16. Results then continue into the compound option analysis where two hypothetical licensing scenarios were considered.

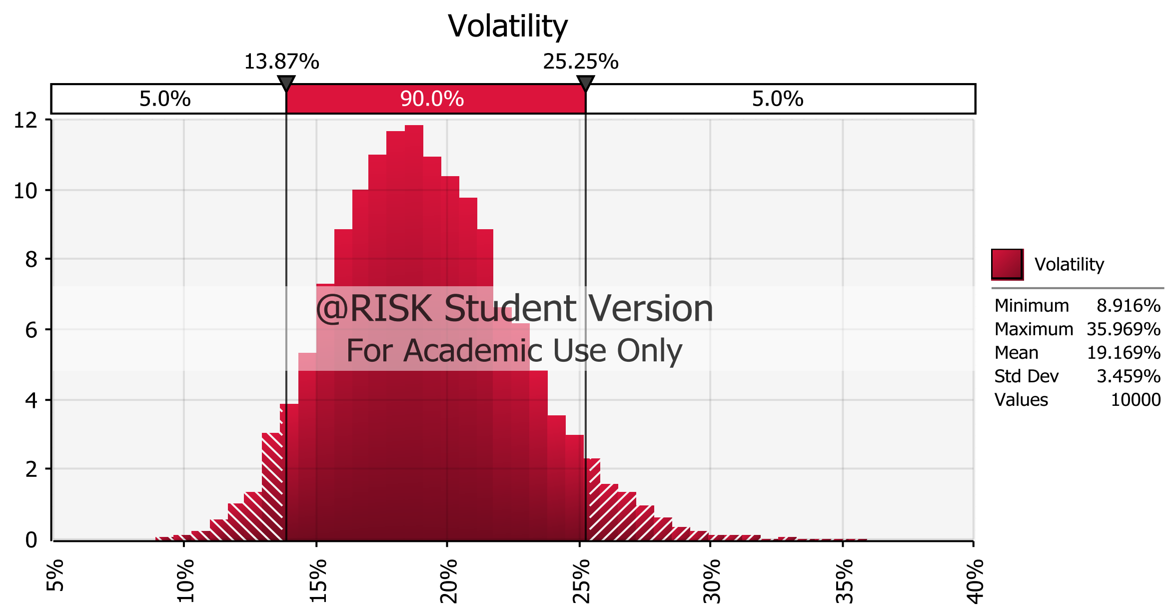


Figure 5.16. Cash Flow Volatility with Royalties

<u>Sensitivity Analysis – Compound Options</u>

The compound options underwent the same sensitivity analysis as the individual options. Parameters for the sensitivities as well as the inputs were identical as in the individual options as well. Changes in option values are in turn similar to individual options as well. Tables 5.10 and 5.11 show the sensitivity results. Accompanying decision trees for the parallel compound option base case can be found in the Appendix Figures A7 and A8.

Table 5.10. Sequential Compound Option Sensitivity Results

in $millions	Base	WACC 3%	Option Volatility 51%	Royalty 0.8
Net Present Value of License Agreement	11.86	20.04	11.86	44.99
Option to License	33.42	77.07	57.77	242.49
Value Added from Expansion Option	2.17	3.88	4.2	8.09
Value Added from Sublicensing Option	10.91	23.99	16.83	67.36
Value added from Right of First Refusal	18.95	47.44	34.5	112.34

Table 5.11. Parallel Compound Option Sensitivity Results

in $millions	Base	WACC 3%	Option Volatility 51%	Royalty 0.8
Net Present Value of License Agreement	11.86	20.04	11.86	44.99
Option to License	3.52	7.49	4.97	20.12
New Variants (Expansion Option)	10.63	23.33	18.51	63.24
Value Added from Expansion Option	7.11	15.84	26.1	43.12
Sublicensing (Expansion Option)	10.63	23.33	18.51	63.24
Value Added from Expansion Option	7.11	15.84	26.1	43.12
Right of First Refusal (Chooser Option)	23.11	41.43	33.77	102.99
Value added from ROFR	19.56	33.94	28.80	82.87

Option values behaved similarly in the parallel sensitivity analysis as they did in the prior sensitivities. Again the value of the right of first refusal stands out as the one adding the most value to the agreement. It is much higher for all three sensitivities. As the option to license increases from an increased NPV, the right of first refusal also become more valuable. This is from the perceived capabilities and increased revenue that would be associated with adoption of new technology. As has been shown throughout this analysis the inclusion of rights, restrictions, and options into a licensing agreements adds significant value above the traditional NPV calculation.

Technological Efficiency

Using the redefined base case for technological efficiency in the individual options analysis, the same type of sensitivity analysis was performed on the parallel compound option. Table 5.12 outlines the change from a 0% yield increase to a 20% yield increase. Significant value is created not only in the NPV but in the value added from the real options as well. For example the right of first refusal adds $18.81 million to the value of the license when the new technology doesn't provide a significant technological efficiency. When the new technology increases yield by 20% the value added is $30.25 to the license, a difference of $11.44 million. A larger than expected technological efficiency nearly doubles the value of a base license, displaying the value added by incorporating flexibility into the analysis

Table 5.12. Parallel Option Technological Efficiency Sensitivity Results

in $millions	0% Yield Increase	20% Yield Increase	Difference
Net Present Value of License Agreement	11.51	16.43	4.92
Option to License	3.33	6.20	2.87
New Variants (Expansion Option)	9.96	20.2	10.24
Value Added from Expansion Option	6.64	13.99	7.35
Sublicensing (Expansion Option)	9.96	20.2	10.24
Value Added from Expansion Option	6.64	13.99	7.35
Right of First Refusal (Chooser Option)	22.14	36.46	14.32
Value added from ROFR	18.81	30.25	11.44

Summary

The anlysis of a licensing agreement in Ag Biotechnology began with a DCF model that estimated adoption rates of a new technology. Developted from the view of a germplasm evaluating alternative technologies and licensing options, cash flows were then estimated over a 20 year time frame and discounted to arrive at a NPV. The NPV was interpreted as the value of a license and is typically what is used for negotiating a strategic partnership. This type of analysis neglects to account for flexibility in the license due to the presense of various rights, restrictions, and options. To value this flexibility a real options analysis was performed using the binomial options pricing model and Monte Carlo Simulations. Resulting option values account for the value that is added from incorporating flexibility into the model.

A base case was defined as first having no license agreemnt and was followed by an analysis with a licensing agreement in place. The purpose was to illustrate how entering into a strategic partnership makes the return profile much more attractive. From the viewpoint of a germplasm developer who doesn't have the ability to fully develop their new technology and bring it to commercialization entering into a license agreement is the optimal decision. The option to wait revealed no instances where waiting to license was optimal. Comparing the NPVs revealed that having a license in place adds considerable value to the license, $7 million in this analysis.

Numerous rights, restrictions, and options were evaluated in this analysis. First, as individual options then as sequential and parallel options. Figure 5.17 illustrates the value added from by the various options in the base case. The individual analysis valued the following options with the NPV as the underlying asset:

- Option to Wait (License)
- Expansion Option (Sublicensing)
- Chooser Option (Right of First Refusal)
- Abandonment Option
- Barrier Put Option
- Learner Option

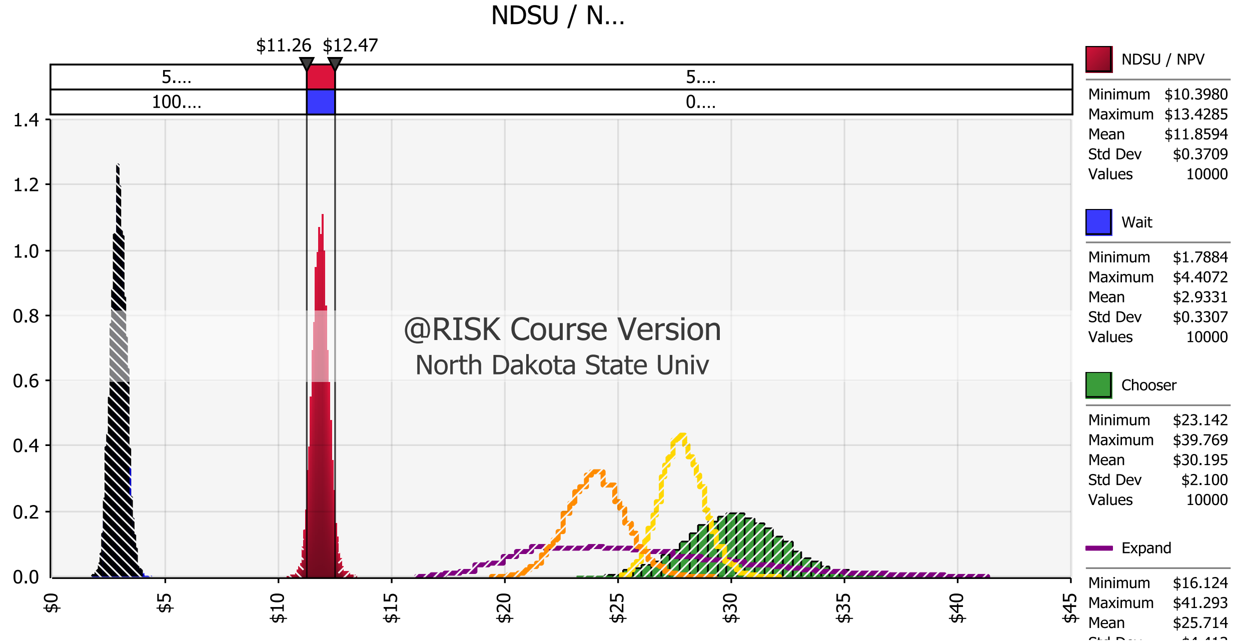


Figure 5.17. Comparison of Option Values (Base Case)

The sequential compound option was analyzed in sequential order with each succesive option's underlying value stemming from the previous option values. The option to wait (license) underlying value was the NPV. A parallel compound option was analyzed with each option occuring simultaneously. Underlying values for the dependent options were from the option values of the independent option. The option to wait (license) was the independent option with the underlying value coming from the NPV. The following options were included in the sequential and parallel compound option valuation.

- Option to Wait (License)
- Expansion Option (Right to Create New Variants)
- Expansion Option (Sublicensing)
- Chooser Option (Right of First Refusal)

Sensitivity analysis was then performed on critical variables. These variables include the WACC, inclusion of royalties, option volatility, and changing technological efficiency. These sensitivities give insight into what to expect in different scenarios. The WACC measure was changed from 8% to 3% to estimate values for a private entity such as a University that is subjected to less risk. This in turn added more value to the NPV and resulting option values. Royalties although not present in the base case, typically add the most value to a license agreement. Their exclusion from the base case was intentional to estimate how the inclusion of a royalty scheme based on per bushel sales would enhance the deal, greatly increasing the NPV. Option volatility was modeled as the standard deviation of cash flows in the base case, which was roughly 28%. Incorporation of a higher volatility was used to represent higher potential volatility from the introduction of a new, irreversible technology. Technological efficiency and option volatility are closely related. As the technological efficiency increased the volatility of cash flow did as well. As reflected in the analysis higher levels of technological efficiency increase the value added from terms within the agreement. Although the exact rate of efficiency is difficult to predict ex-ante, estimations of different efficiency levels and their impacts are valuable considerations for decision makers.

CHAPTER 6. SUMMARY AND CONCLUSIONS

Negotiators in Ag Biotech licensing agreements may be undervaluing their licensing deals because they currently do not analyze the value of rights, restrictions, and options within the agreement. The main focus of valuation has traditionally been on the incorporation of a royalty scheme and how it will evolve over the life of the license using a DCF model. However, the DCF method has significant flaws, especially when dealing with new technologies with a high level of uncertainty and a high degree of managerial flexibility in decision making. Agriculture Biotechnology, more specifically seeds and traits, falls into this category. Ag Biotech licensing is similar to other forms of licensing, but has unique aspects such as the right of first refusal and the option to create new variants from previously patent protected material. Any right, restriction, or option included into the license provides the agreement with varying degrees of optionality.

In terms of dealmaking and in regards to a licensing agreement, a good deal can be characterized as one that is completely understandable to both parties, can be articulated by parties who aren't present, and has the ability to respond to future events as originally intended (Razgaitis, 2003). Agriculture biotechnology licensing shares common themes with other types of licensing. However, the complex nature of agriculture biotechnology makes each license agreement unique, often having special built in mechanisms mutually agreed upon by the licensor and licensee. The complexity and specificity that make up Agricultural Biotechnology licensing is a prime stage for real options analysis.

Importance of the Strategic Partnership

Organizations involved in the Ag Biotech industry are under extreme pressures ranging from depressed commodity prices to public outcry about anything that has been genetically modified. These challenges are leading to consolidation and strategic partnerships amongst the players in the industry. Firms look to take advantage of synergies created by entering into a licensing agreement. A university or other entity solely focused on the research and development of new traits often finds it nearly impossible to take their newly created traits to a mass market. Large agricultural firms have the capability to continue R&D on a new technology advancing development to commercialization.

Dealmaking encompasses two or more parties who have something to offer each other in exchange for money or other form of compensation. Suppose a land-grant university has made a breakthrough in germplasm technology, which has the potential to increase the yield profile of a certain crop. To enable the technology to reach its full potential, a company with a superior breeding program is sought to license the university's germplasm. The next step is to formalize the agreement into a legally binding contract, hopefully one that is beneficial to both sides in the end. Negotiations for these types of technology license agreements have a tendency to take considerable time and effort. In the end both parties agree to the contract, sign on the line, and the work begins. A strategic partnership is born.

Has either party considered the value of the options that are part of the agreement? For example, has either party considered the value of the option to sublicense or the right of first refusal? If the licensee has the ability to seek other partners to sublicense to, how much value does that potentially add? In other words, how much value is the licensor giving up by granting this right? Is the licensor being compensated for this or is it just a passive part of the agreement? In the Ag Biotech industry these questions are rarely addressed, either because the parties feel the tools necessary to accomplish this are too complicated or they are not necessary. Each term adds a degree of optionality to the license valuation. Unlocking these values is important to decision makers, especially in the currently operating environment of the Ag Biotech industry.

The more information discovered on a potential deal ex-ante enables more informed decision making, which leads to a more desired outcome. Operating in the Ag Biotech industry is extremely competitive and the large players have consolidated in the past (Du Pont's purchase of Pioneer) and continue to do so (ChemChina's pending purchase of Syngenta). The development of new traits will continue and only time will tell what the impact of new mergers will have on the industry. Entering into a strategic partnership is not a riskless endeavor as all sides face incredible uncertainty. Developing, negotiating, and closing deals to better articulate sustainable food systems across the globe is a major focus. All parties involved are doing themselves, their counterparts, as well as those dependent on sustainable agriculture a disservice by not considering the value of the rights, restrictions, and options in the licenses they sign. Incorporation of the best technology is used to develop traits. Therefore, the best methods to value strategic partnerships exploiting new traits should be used, which undoubtedly includes a real options analysis.

Real Options

A conventional net present value (NPV) analysis doesn't take into consideration the value of growth options and cannot capture the multitude of contingencies arising from investment. In recent years the real options approach to valuation has gained traction for being a more reliable way to value investment decisions. The notion behind real options is based on three factors; flexibility, irreversibility, and uncertainty. The reason uncertainty creates value is because it creates options and flexibility. A more holistic approach to project analysis is achieved through real options as the fundamentals of the initial analysis (discounted cash flow method) do not need to be changed. Real options valuation is synonymous with the value of the flexibly it provides and the real options in this analysis that provided the flexibility is were those with the largest values.

A real options approach offers a fresh perspective on the management of a technology-intensive company. Compared to the heavily used DCF valuation, a real options analysis of early state technology does not punish substantial but distant cash flows with a high and compounded cost of capital. This can be achieved through the analysis provided in this thesis and through the management of the options within the license agreement. In addition, real options allow for evaluation of growth opportunities based on the "gut feel" of individuals with a considerable amount of industry experience, which can be incorporated into assumptions in the option model. In addition, a real options analysis breaks down certain risks by valuing the opportunity stage by stage and risk by risk as investments are made.

Rights, Restrictions, and Options in Ag Biotech License Agreements as Real Options

Common licensing terms in Ag Biotech licensing agreements were the main focus of this thesis. Terms were identified as specific real options and then valued according to their classification. Rights, restriction, and options evaluated along with their corresponding real option are reviewed in Table 6.1.

Table 6.1. Licensing Terms as Real Options

Licensing Term	Real Option
Option to License	Option to Wait
Sublicensing	Option to Expand
Assignability	Option to Expand
Geographic Exclusivity	Learner Option
Right of First Refusal	Chooser Option
Term Length	Abandonment Option
Term Length	Barrier Put Option
Royalty (Units Sold)	Compensation Option

Overview

A stochastic Monte Carlo simulation model was developed to value various terms in an Ag Biotech licensing agreement. First, a technology adoption model was used to estimate adoption rates amongst producers. Adoption rates were then incorporated into demand estimations to estimate future cash flow relative to each technology. Cash flows were discounted to arrive at a net present value. To estimate option values, a real options analysis in the form of a binomial option pricing method was developed. The binomial options pricing model was chosen over the Black-Scholes formula because it is more accurate with long-dated options as used in this thesis. Monte Carlo simulation helps to decrease sampling error.

The net present value from the DCF was used as the underlying asset value in the option valuation. Option values were estimated individually depending on their type. Options (right of first refusal and expansion options) providing the most value were then introduced into compound option valuations. Incorporation of a sensitivity analysis was done by changing critical variables. Discount rates of 8% and 3%, representative of a private and public entity respectively, were analyzed. Next, cash flow volatility was increased to emulate the high level of uncertainty present when introducing irreversible technology. In addition, a royalty scheme was introduced on a per bushel basis as a compensation option. Finally, technological efficiency (increase in yield) of the new technology was varied from a 0% increase up to 20%.

In this analysis the mean NPV without a license agreement in place was $4.86 million. Monte Carlo simulation on the option to wait indicated it was optimal to enter into a licensing agreement 98.4% of the time. With a license agreement in place the mean NPV increased to $11.86 million. Analysis then proceeded to the other options listed in table 6.1. Results indicated that the sublicensing (expansion) option and the right of first refusal (chooser option) added the most value to the license at $13.86 and $18.34 million respectively. The inclusion of the royalty scheme increased the mean NPV to $44.25 million, which increased the option value of sublicensing to $74.87 million and the right of first refusal's value to $75.32 million. Variation of the technological efficiency from 0% to 20% moved the mean NPV from $11.51 to $16.43 with option values increasing as well. Analysis then continued to the parallel compound option. The option to wait (license) was the independent option with the sublicensing, right to create new variants, right of first refusal valued as the dependent options. Option values were lower than the individual analysis because they are dependent upon the independent option having a lower initial value. As this analysis was from the licensor's point of view, the value added (option value) is what the licensee might expect to pay for the increased flexibility from inclusion of those terms in the agreement.

Summary, Implications, and Contributions to the Literature

The main objective of this thesis has been to answer those questions relating to the value provided by the rights, restrictions, and options included in an Ag Biotech licensing agreement. In short, yes they do provide value. How much value depends on assumptions that are best determined ex-ante or during negotiations by those closely involved with the project. While both sides are ultimately responsible for their valuation, negotiations work much quicker when both parties are using agreed upon techniques as well as some mutually agreed upon input values. Considerations and compromises from both sides of the negotiating table are necessary to close the deal.

Pricing intellectual property and licensing agreement is a process, not a one-time event. Parties involved must be fully committed to getting the deal done in the quickest, most efficient manner. Failure to do so may compromise progress towards commercialization as well as future revenues. When a deal is completely understandable to all parties involved, can be articulated by parties who weren't present during negotiations, and can respond to future events as originally intended it can be characterized as a good deal.

This thesis has established a foundation for the incorporation and enhancement of a real options analysis into negotiations of Ag Biotech license agreements. Although perceived to be a difficult concept, real options incorporate flexibility and uncertainty not present in the traditional discounted cash flow model. As demonstrated in this thesis, using real options as a compliment to the DCF, the rights, restrictions, and options included in an Ag Biotech license add considerable value to that license. Failure to value these terms may undervalue the project. Evaluation of optionality provided by the license terms is important in understanding the value they are adding to the deal. In addition, using the binomial pricing model allows for visualization of potential outcomes and the flexibility involved in the decision making process. Firms who are able to adopt these techniques into license valuation will be at an advantage over those who do not.

Estimation of a new technology's efficiency has a high level of uncertainty. Using a static number throughout the valuation can cause a significant change in expected revenue when efficiency is over estimated. This thesis did an extensive sensitivity using numerous estimations for technological efficiency. Doing so demonstrated that increased levels of efficiency have the ability to move the expected revenue value to a higher frontier. Analysis on the technology itself and its potential is best done during negotiations with experts who are familiar with plant genetics and/or will be involved in the research and development. Sensitivities should still be performed demonstrating to shareholders how the efficiency of the new technology may affect revenues.

Limitations

This research is limiting in that it does not value a specific license deal during the negotiation phase. Some of the assumptions in this analysis are purely hypothetical, especially the real option inputs. While this provides a guide as to how this type of analysis should be done, due to the subjectivity of each deal, practitioners must approach each license agreement separately.

Another limitation to this research is that only one side of the deal was considered. Analysis focused on one firm having superior germplasm development techniques, which is only part of the full negotiations. The strategic partner's valuations of the licensing terms based upon their projected cash flows is an important aspect of the negotiation process. From valuations done on both sides, parties are then able to negotiate on a fair price for the inclusion of terms in the final agreement.

A full analysis of all option input parameters is lacking in this research. Doing so would enable decision makers to envision how small changes in their input assumptions may have profound impacts on the valuation. Estimation of option input parameters plays a pivotal role in the analysis and may have a material effect on option values. Volatility, the variable which drives the option price the most, was the only full option input sensitivity done in this research. In addition, a brief analysis on the critical strike for the option to wait and abandon were also done.

There are other options that could be included in a license not considered in this thesis such as purely exclusive contracts (no other licensing partners may be sought), field of use restrictions, royalty stacking, and the option for the licensee to convert to a non-exclusive license. Although there may be other options within a license that haven't been formally valued in this thesis the valuation techniques would be similar to the techniques used here.

In-depth probability analysis is not addressed in this thesis. For example, simulation to determine the probability that options are in- or out-of-the money. Even more prevalent is a probability analysis of an extreme outlier event. Commonly referred to as the black swan theory, extreme outliers are hard-to predict, rare events beyond normal expectations. Consider a technology perceived to have little value, which could be represented by one of the nodes in the binomial lattice where it is optimal to abandon. When a black swan event occurs that technology would suddenly become extremely valuable, moving to a more attractive valuation on the lattice. Therefore, a probability analysis of an extreme outlier event would be valuable to incorporate into the valuation.

Negative publicity on GMOs and consumer acceptance are two of the most prevalent risks associated with Ag Biotech. These risks were briefly analyzed with the learner option valuation of geographic exclusivity. However, a more advanced analysis of the learner option with revision of probabilities was not provided in this thesis. This is extremely important considering the nature of the Ag Biotech industry. For example, even if a new technology has demonstrated high efficiency gains and approved for use it may be rejected by growers and/or consumers due to negative publicity. Using the test market approach (learner option) provides for small scale developments to learn about public perception and technological efficiency.

Suggestions for Further Research

This thesis has established the framework for continued real options analysis of licensing agreements in Ag Biotech. There are numerous enhancements to incorporate making the analysis more robust. Doing so will better enable decision makers to negotiate optimal contract terms while increasing the level of perceived fairness amongst all parties.

The weighted average cost of capital (WACC) used to discount cash flows in this thesis was indicative of private and public entities. The public entity, such as a land-grant university is subjected to less risk and thus uses a lower WACC than their private counterparts. Alternatively, practitioners may incorporate a risk-adjusted hurdle rate (RAHR) in place of the WACC. A RAHR establishes a minimum level of return deemed necessary by stakeholders to move forward with the project. Only those projects having attractive valuations using the RAHR would be considered. In addition, in-depth analysis on a firm's capital structure can help gain insight into WACC calculations.

Parties involved in the formation of a strategic partnership are establishing that relationship to achieve something unattainable independently. When royalties are established ten or more years in advance there is an increased level of risk for adverse conditions that may drastically change the valuation. Villiger's model provides an excellent framework for establishing royalties. Incorporation of value inflection points is at the heart of this model. Each inflection point allows for a re-valuation of the project. The licensee is then able to increase their share in the project based on investments they have contributed in accordance with the new valuation of the commercialization activity. As the technology is commercialized, the licensor's royalty stream is based on the ratio of profits to revenues multiplied by their remaining stake in the project (equation 3.29). Incorporation of this type of royalty scheme keeps the focus on value creation, which in turn benefits stakeholders.

Technological efficiency in the form of yield increases was the only trait specification considered in this thesis. Analysis of option values for end user or consumer traits was not addressed and is a topic for further research. For example, what value does a trait that allows for a longer shelf life after harvest and production provide to the end user? A complete analysis will focus not only on traits associated with increasing yield but also on those providing value to consumers. Doing so will enable valuation of numerous traits simultaneously. In addition, a firm could incorporate results into the marketing of new traits thus enhancing commercialization progress.

There are numerous structural revisions that could be made to the model used in this thesis making it more robust. Most specifically the real option inputs. Continued R&D is sometimes difficult to predict with complete accuracy. Thus, the model could be revised to include randomization of strike prices. Identifying a range of possibilities would be identified, assigned a distribution, and included as a stochastic variable in the Monte Carlo simulation. In addition, a revision to allow for perceived volatility jumps could be incorporated. Another revision would be to extend the analysis to other parties involved in negotiations. Valuations in this thesis solely focused on one party but, in practice there is more than one side to a deal. An important extension is to include other strategic partners into the valuation. Doing so would create the necessity for game theoretic models. Expanding the real options framework using game theory with two or more parties is an excellent way make sure all parties involved would have agreed upon valuation techniques, thus decreasing the level of information asymmetry.

Another extension of the analysis in this thesis is to continue with the learner option valuation. As with all other options and a license agreement in general, doing an ex-post analysis isn’t nearly as valuable as an ex-ante analysis. The geographic exclusivity option may become very important in the future, especially with increasing public pressures in regards to anything genetically modified. To enhance the learner option in this analysis it should be valued in conjunction with ongoing operations, similar to how they are used in the oil exploration industry. Doing so will enable the revision of probabilities after each learning period to assist in choosing the right expansion option for the new technology. Using the learner option in this fashion will be beneficial to gain insight into any negative publicity as well as consumer acceptance of the new technology.

A natural extension and application of the valuation techniques in this thesis is to do a valuation in real-time (ex-ante) in conjunction with a license negotiation. To do so would entail having both sides to a negotiation agree to allow for the inclusion of the new valuation approach. This could be accomplished either by using a neutral party to incorporate the analysis or to have someone from both sides do the valuation. Initially having a third party with experience in real options valuations may be of most value to all sides in the negotiation. Throughout the negotiation this consultant would work with both sides to estimate input parameters and the best ways to frame the application of the real options analysis. In addition, negotiators would become more versed in real options and potentially be able to apply them on their own in future deals. Making real options less intimidating by showing first-hand how valuable the flexibility they provide is the best way to increase awareness and decrease the aura that they are too complex to be used. As this thesis has shown, incorporation of real options as an enhancement to the traditional valuation methods enables a more robust valuation of the right, restrictions, and options in an Ag Biotech license agreement.

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APPENDIX

- Option is out-of-the money. Licensing should be pursued.
- Optimal decision is to abandon where nodes are red.

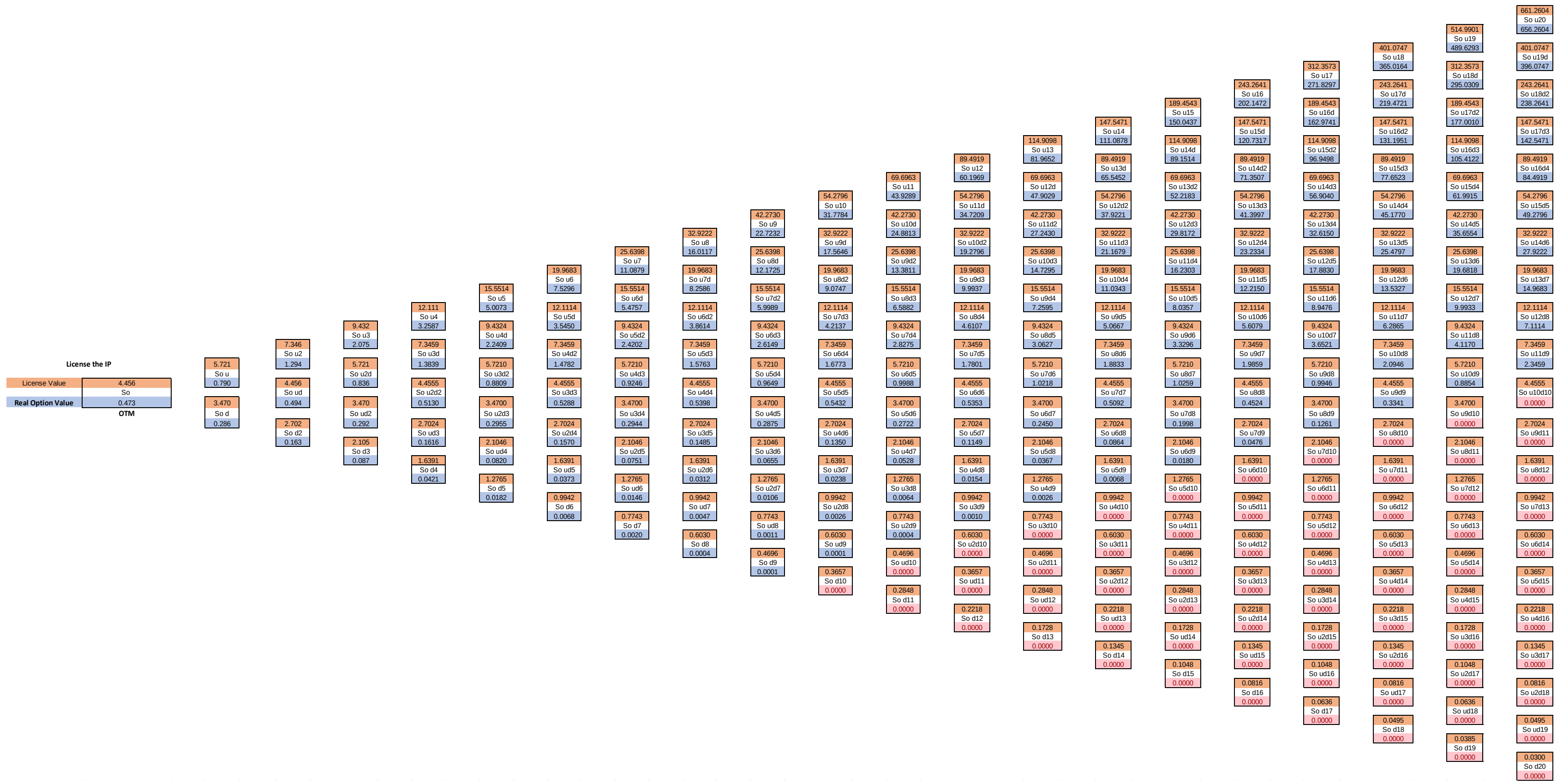

Figure A1. Binomial Lattice for Option to Wait (No License)

- Final nodes with green are where the expansion option should be exercised.

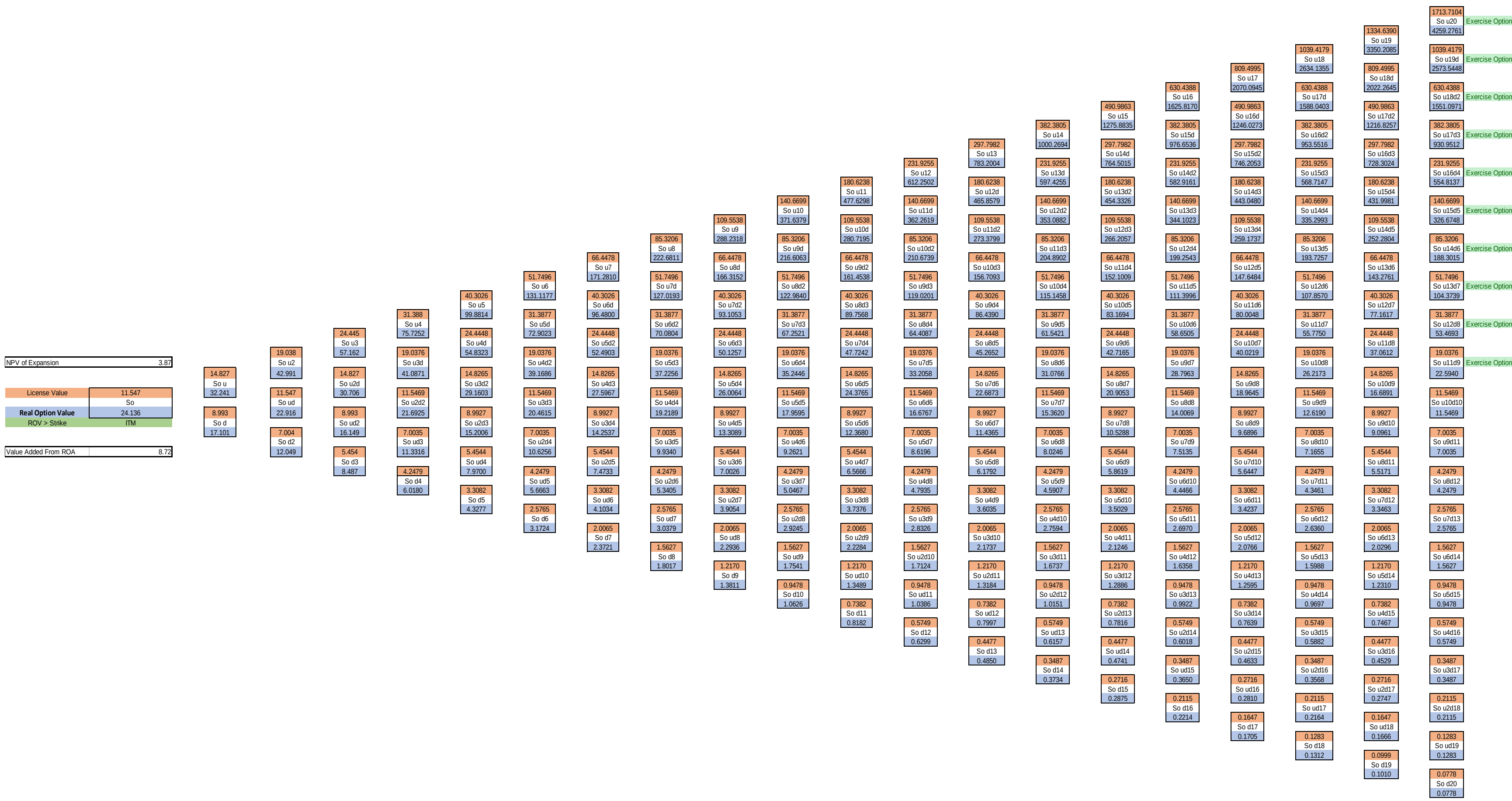

Figure A2. Binomial Lattice for Option to Expand (Base Case)

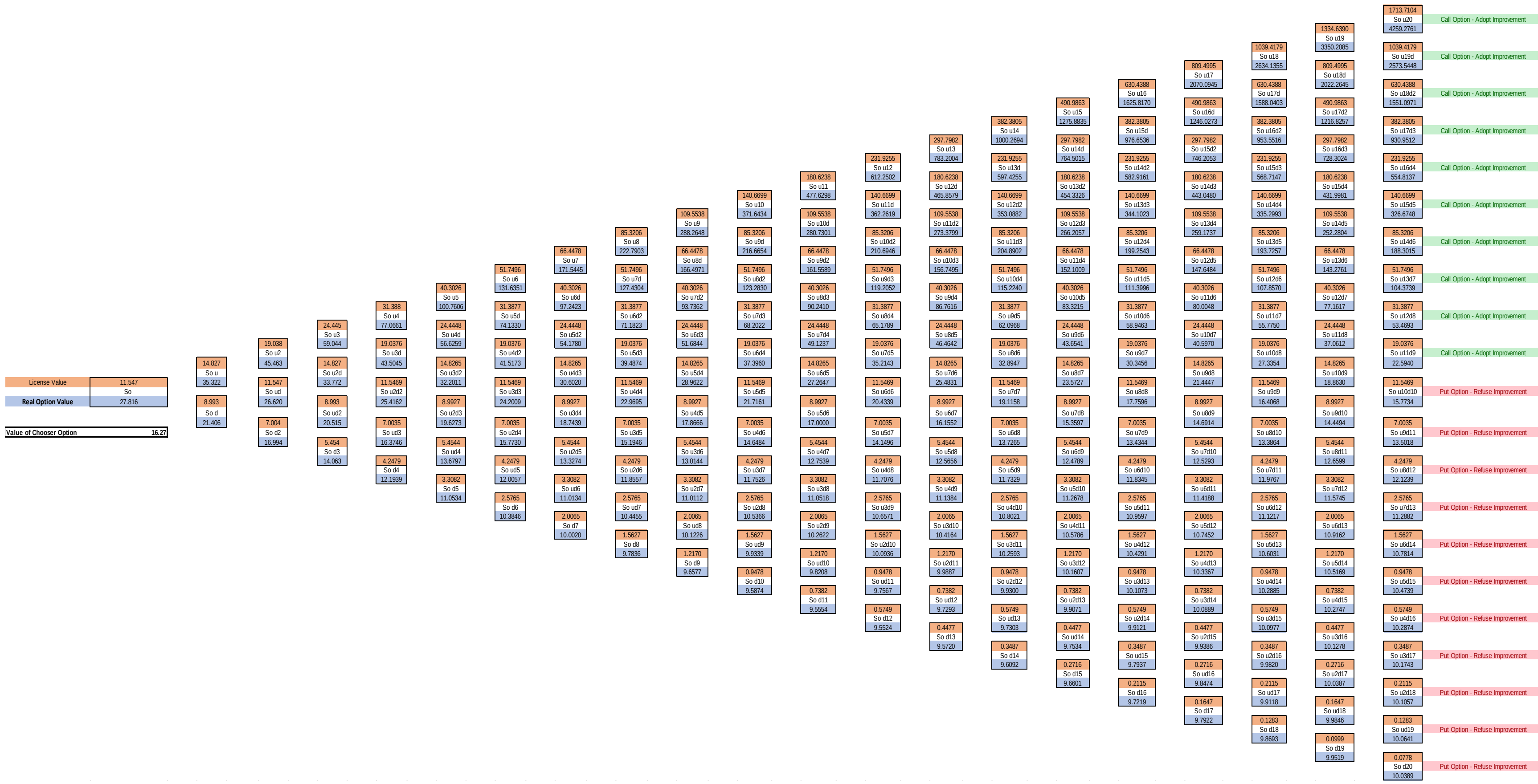

Figure A3. Binomial Lattice for Chooser Option (Base Case)

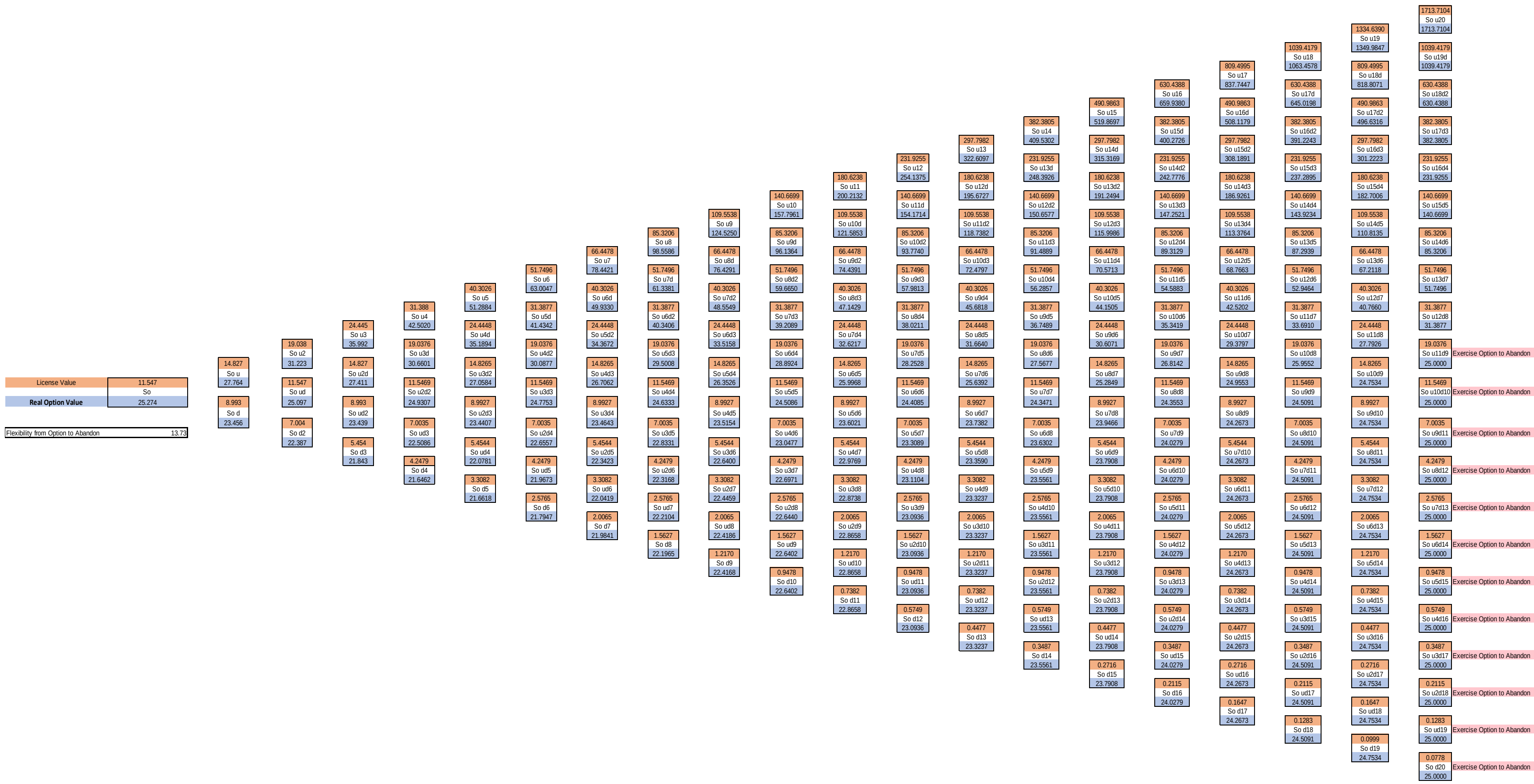

Figure A4. Binomial Lattice for Option to Abandon (Base Case)

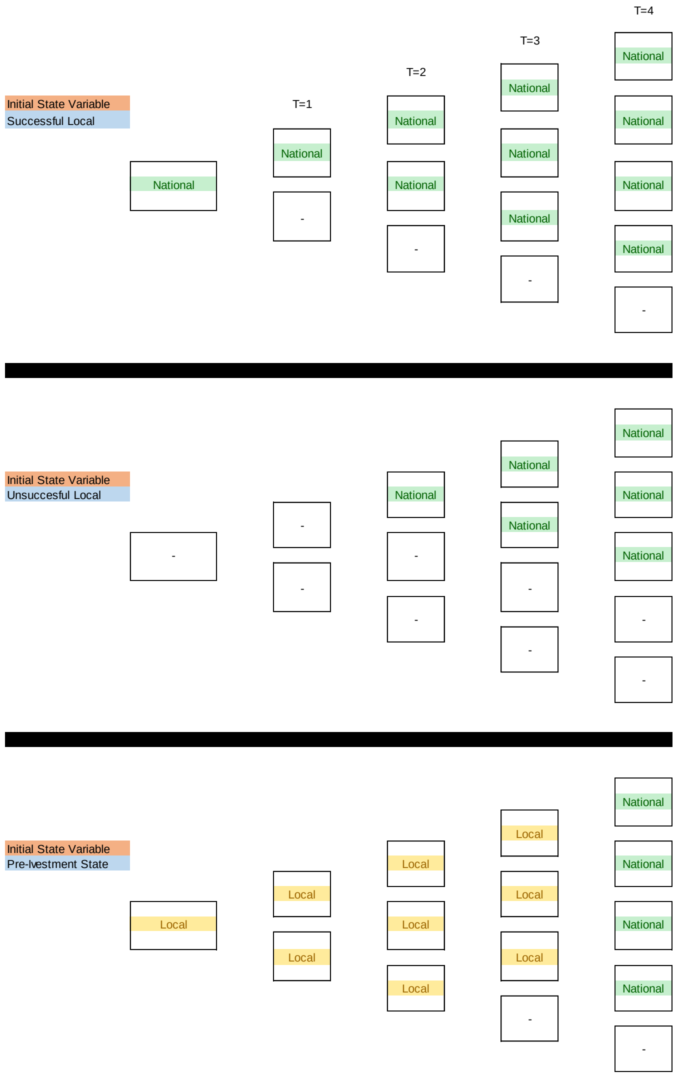

Figure A5. Binomial Lattice for Learner Option (Base Case)

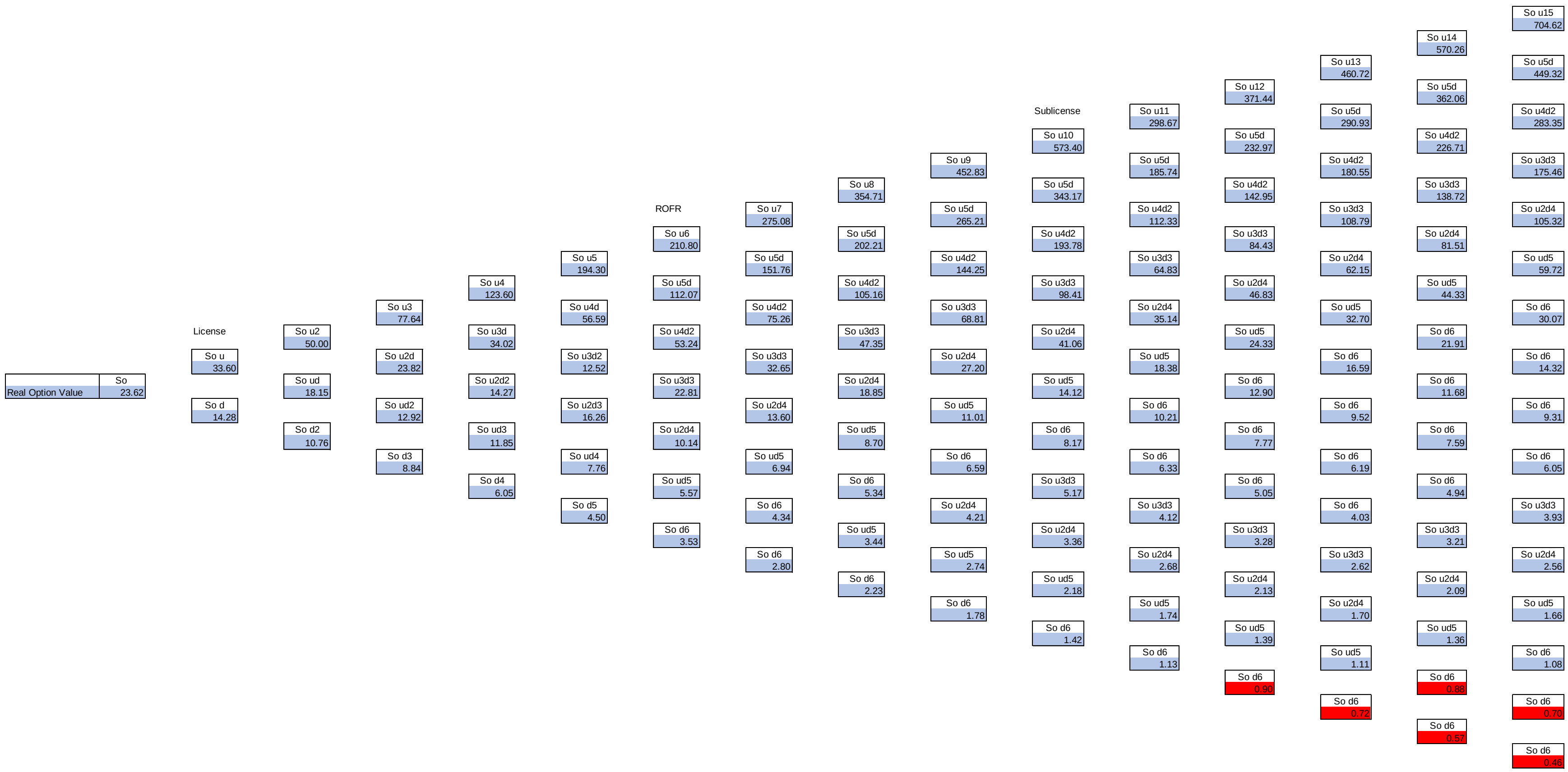

Figure A6. Binomial Lattice for Sequential Compound Option (Base Case)

- Optimal decision is to abandon where nodes are red.

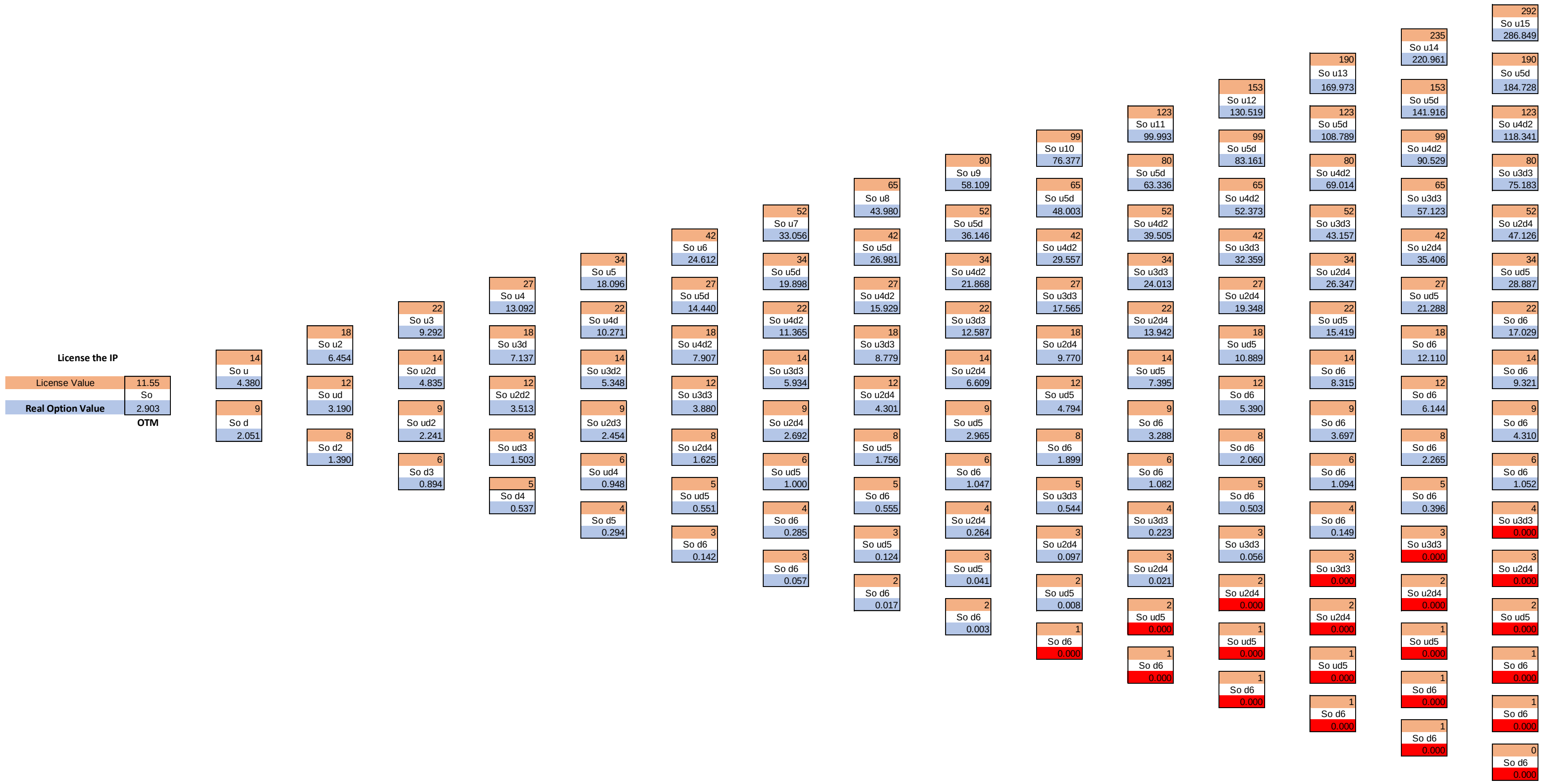

Figure A7. Binomial Lattice for Parallel Compound Option (Independent Option)

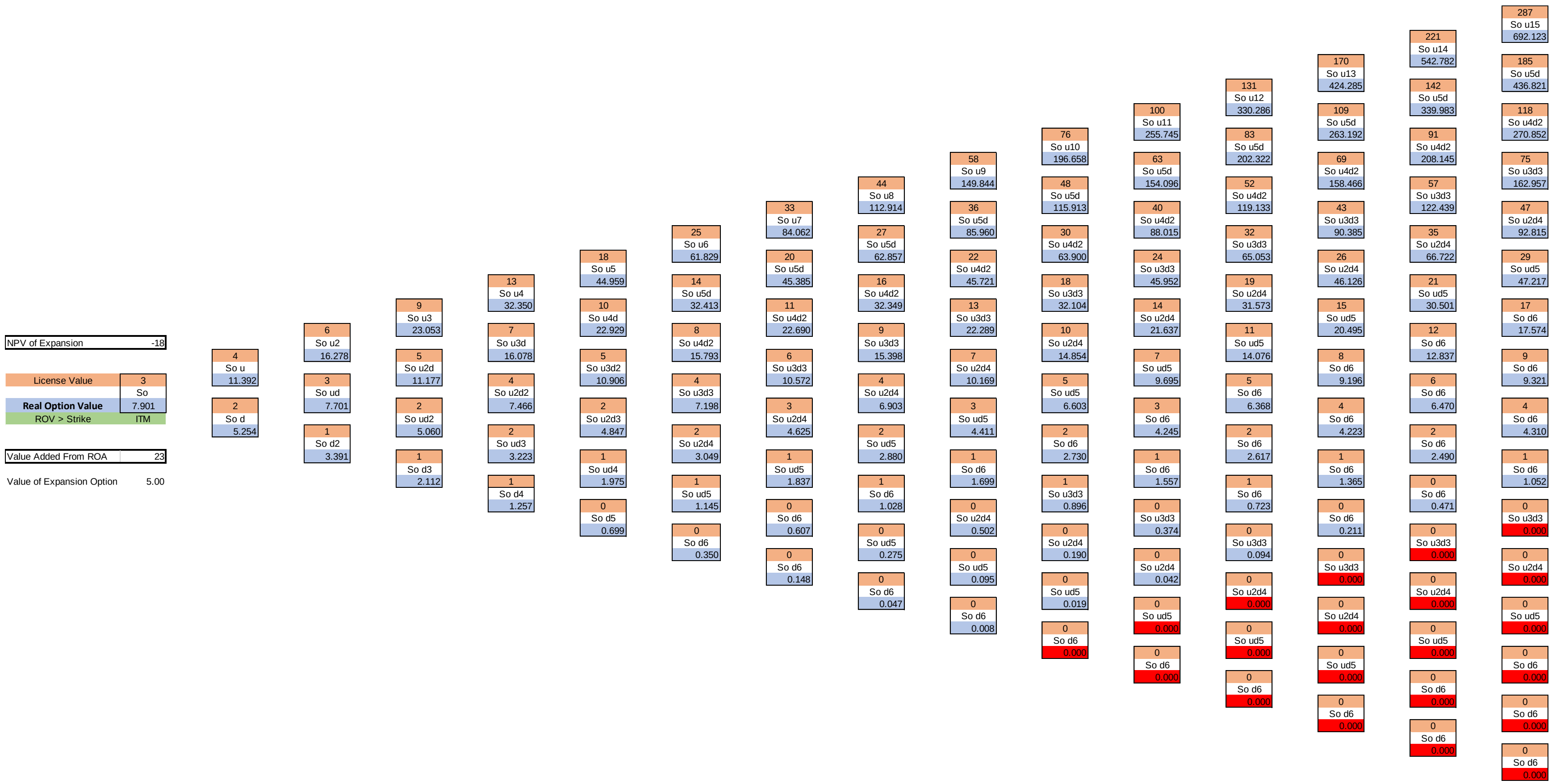

Figure A8. Binomial Lattice for Parallel Compound Option (Dependent Option)