Decision under uncertainty - Investment in a human resource

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"With extremely few exceptions, nothing is worth the trouble."

-Epstein's axiom-

ABSTRACT

Title:	Decision under uncertainty - Investment in a human resource
Authors:	Emil Numminen & Fredrik Falkenback
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Purpose:	To determine how well models for decisions under uncertainty can describe an investment in a human resource.
Method:	A standardized structured expert interview with a decision maker of human resources investments was made. The empirical material from the interview is then compared against the main properties of the two models.
Conclusions:	The traditional decision analysis can describe the process of investments made in human resources where absence of management exists and the investment has limited time duration. The real option analysis can describe the process of investments made in human resources where process is characterized by sequential decisions made about the investment.

PREFACE

A long journey was started at the break of dawn. Several paths have been wandered, several crossroads has been passed to the rhythm of enchanting pipes.

We will like to thank Anders Hederstierna for providing us with the kerosene lamp and the map, for without them we would still have been wandering in the dark.

We would also like to thank all the other persons who have given us insightful comments of how to cross the rivers of which wrong sides we many times have felt and seen.

Another thanks goes out to our families and friends. Without your ability to amuse us time would still have stood still.

Finally we would like to thank the man with the grand parasol…

Ronneby 2003-06-30

Emil & Fredrik

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SETTINGS

This section will cover the purpose of the study and method by which the study was conducted. We will also discuss the delimitations of the study and finally a structure of the rest of the paper is given.

PURPOSE

The purpose of this study is to determine how well models for decision-making under uncertainty can describe an investment process in a human resource.

The models we are going go compare with the information from the empirical study are the traditional decision analysis (TDA) and the real option analysis (ROA). With the term describe we mean to evaluate the underlying assumptions that the two models rely on in comparison with the actual handling of an human resource investment decision by a decision maker.

The process of an investment in a human resource (i.e. hire an employee) is defined by an initial decision followed by new decisions later made. Between these decisions more information is gathered to base the next decision upon. The consequence from a

made decision could be to manage the investment. To manage the investment is to take active measures for maximizing the net value from it.

METHOD

The empirical material was collected by means of a standardized structured expert interview[1] with an actual decision-maker in an organization. We chose this approach because we wanted to collect the motivations and considerations behind an actual process of investing in a human resource. The interview was conducted with pre-made up questions as a base for the conversation with the decision-maker. The interview questions were tested on two persons before the actual interview in order to test if our intent with the questions was perceived correctly or not. We did this so that the questions would not be misinterpreted. After the test we rewrote the questions that were commented and tested them again with the same procedure as described above.

These questions were used as a reminder for us not to forget any aspects of the area of our interest. If we did not get a clear answer we reformulated the question and asked it again. We did not send out the questions in advance because we wanted the decision makers spontaneous response. In other words, more time would give the decision maker time to carefully think through his answers and remove illogic etc, which would conceal the actual behavior of the decision maker. We also wanted to avoid getting well-prepared short answers without the actual motivations and considerations behind the decision.

For the interview we used a tape-recorder to get his exact responses and in what way he gave them. This way we could also get

[1] For more about the method see Lundahl & Skärvad (1999)

the time it took him to respond to the different questions, which we thought, was of great interest. This data was then rewritten to the material presented in this study.

The interview with the decision maker lasted approximately an hour.

THE STRUCTURE OF THE PAPER

In this part we will describe how this study is organized. The next part that follows is a background discussion. In that discussion we try to show that there is several relevant aspects in a decision to invest in a human resource. The aim of the discussion is to show that this decision is similar to any investment decision or more general, any decision under uncertainty.

After the background discussion we will present the two models (TDA and ROA). The presentation of each model will be ended with a part where the main properties of the model are summed up. These are the properties that are mainly going to be analyzed in the comparison with the empirical study to se how well it is possible to describe the investment process with the help of the models.

After the presentation of the two models the empirical study will be presented. This presentation is divided into three sections based on three stages that became clear in the interview with the decision maker. The text in the empirical section is a reformulation of the transcription and thus the decision makers own views. This section will be continued with a discussion about how well the two models can describe the investment decision. This will be done be discussing which aspects of the decision can be described by one, both or none of the two models. The discussion will however be

started by a motivation of why the decision maker is categorized as rational in his investment process in a human resource.

After this discussion we will present the main findings of the study and discuss whether these findings can be generalized.

We will then conclude with a discussion about future research recommended by the authors. This recommendation is based on the leanings' from doing this study.

However, we will now go on to the background discussion.

BACKGROUND

How do organizations evaluate an investment in a human resource?

The hiring of a person can be seen as an investment. To show this we are first going to discuss what an ordinary investment is and its main characteristics. After we have done that we are going to show that the same characteristics can be found in the decision of hiring a person.

Oxford reference dictionary defines the word investment as "Employment of money with the object of providing profit or income."[2]

The basic characteristics of an investment are thus that it involves expenditure for the organization today (employment of money) and expectations of getting that money back (future revenues) and a return. The expenditure for the organization is often substantial and the future revenues from the asset will come for more than one year. It is thereby a long-term venture. When the organization has bought the asset, they cannot be sure to recover the expenditure for it. The expenditure is thus a sunk cost for the organization. Depending on what kind of an investment the organization has done it is more or less reversible. If it is an organization specific investment it can be hard to sell it if the market turns down. If it is a more general investment it can be sold off to an actor in

[2] Oxford reference dictionary

another market. The grade of reversibility can hence be measured by the degree of how much of the principal expenditure that can be regained by selling off the investment.

The final result from the investment is uncertain at the time the decision is to be made. The calculated result is based on projections made by the organization. It is hard to be absolutely certain about the future, i.e. it is very hard to capture every possible outcome that can occur. If one of them is misinterpreted the rest of the projection could turn wrong because the outcomes may depend on each other. If the cash flows from the investment are below projections, new decisions will be made to recover as much as possible of the expenditure for the investment. This action will be taken several times during the life length of the investment. The investment decision is thus an iterative process made up by several contingent decisions.

When an organization makes an investment in a human resource it has the same characteristics as above. The expenditure for the organization consists mainly of the cost for time and the activities put in the process of hiring a person. As always there exists an opportunity cost for doing this. The revenue for the organization consists of the utility the person performs for the organization. The process that the organization goes through in the hiring decision can never be undone and therefore it is an irreversible process. The organization can of course afterwards make decisions to neutralize the first decision (i.e. hire an other person or change the terms for the employment) but it is still irreversible. Because of this the process could be viewed as a sunk cost (i.e. the organization will have the cost for the hiring process whether an person is hired or not in the end).

So the main characteristics of a hiring decision and an ordinary investment decision is the same; an up front negative cash flow for

the organization that is followed by expected positive cash flows to the organization. New decisions should be made when needed to maximize the utility from the employee for the organization. Hence, the hiring decision could be described as an investment in a human resource.

As any investment, the investment in a human resource is a complex and uncertain decision to make, due to its characteristics. To be able to make the best decision concerning the investment before it is done, the organization must have some procedures/models (e.g. TDA or ROA) for making the right decision.

TDA & ROA

In this section we will discuss two models, TDA and ROA, by which investment decisions can be evaluated with. The discussion will be started with TDA after which the discussion about ROA will follow.

TRADITIONAL DECISION ANALYSIS - TDA

The traditional decision analysis evaluates an investment decision under uncertainty through relative comparison between available investment opportunities (acts). The analysis requires information about factors that relate to market climate and so forth. These factors are combined into states, which in turn determine the payoff or consequence (Z) from the investment. The payoff from the investment usually is a discounted cash flow. The likelihood that a certain state will be the true state is expressed with a probability. All of these parameters could be visualized in a decision tree. A decision matrix structures the decision problem in the same way apart from displaying the probabilities.

To show how the model is used in practice an example will be provided below. A corporation is to choose among three different investment opportunities: A and B are investment opportunities that require investment expenses while investment opportunity C does not require any investment expense since no investment is done.

Market climate / Investment opportunity	Good	Poor
A	Z_{11}	Z_{12}
B	Z_{21}	Z_{22}
C	0	0

Table 1 Decision matrix.

The likelihood that a certain market climate is to occur is described by a probability (P). The individual probabilities that describe the likelihood of the market climate are called a probability distribution. As we can see in the decision matrix all acts meet the same set of states. This means that the states are defined in such a way that the probabilities do not depend on the act chosen.

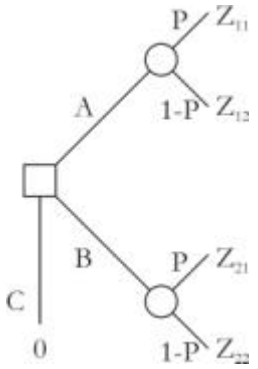

Figure 1 Decision tree.

TDA evaluates the best investment opportunity to choose, by calculating its expected value (1) and comparing it with the other investment opportunities available.

$$\begin{aligned} E(A) &= P * Z_{11} + (1 - P) * Z_{12} \\ E(B) &= P * Z_{21} + (1 - P) * Z_{22} \\ E(C) &= 0 \end{aligned} \quad (1)$$

Depending on the payoff values (Z), the maximum expected values from the investment opportunities will either be achieved by either A, B or C.

This short example relies on assumptions that will be covered in the next section.

A HERITAGE FROM GAME THEORY

TDA deal with problems that are very similar to a game where every player has limited control over the variables that determine what payoff he shall receive. The difference from game theory is that the opponent player is not an individual but non-other than a whole range of opponents or "Nature" with conflicting interest treated as one player (i.e. a market). The goal for every player is to maximize his return.

MODEL PREREQUISITES

A game is defined by rules, which describes, "who moves when, what information he has when he moves, what alternatives are available to him, and the ultimate outcome to each sequence of choices."[3] Apart from the rules of the game, two additional assumptions also apply. Firstly that the players know the game rules in detail and also knows the competitors payoff functions. Secondly that every player will always choose the act that maximizes his utility. This definition of a game is known as a game in the extensive form[4].

A simplification of the extensive form approach and the two last assumptions can be made by assuming that each player knows how to act in every eventuality he could find himself in. This would simplify the complex game trees by excluding strategies not following the strategy rules set up by the player. Strategies following the strategy rules set up by the player are called pure strategies[5] and are the key part in the simplification of a game in extensive form.

[3] Luce & Raiffa (1989) p 54
[4] Luce & Raiffa (1989)
[5] Luce & Raiffa (1989)

A game relying on pure strategies is said to be in the normal form. For a more elaborate presentation see Luce & Raiffa (1989, Chapter 3).

DEFINITION OF TDA

"A choice must be made from a set of acts $A_1, A_2, \ldots, A_m$, but the relative desirability of each act depends upon which "state of nature" $S_1, S_2, \ldots, S_n$ that prevails."[6] The act and a state result in a consequence or utility (u_{ij}), which each player tries to maximize. (2)

$$\{A_i, S_j\} ? \quad MAX[u_{ij}] \quad (2)$$

ACTS

An act can be viewed from a game perspective as a strategy. A strategy is a set of decision rules over how one will act in the future as a function of the information one has at that time[7].

STATES OF NATURE

The normal form of a game introduced the concept of pure strategies, which implies that every player knows what do in each eventuality. This is a very strong assumption because then he knows exactly how many states needed to fully describe the decision at hand. Hence the model assumes that the states are mutually exclusive and exhaustive[8], which is necessary to be able to effectively model decisions. The precision in the description of the decision could be viewed through the concept of a world according to L. J. Savage[9]. The idea is to describe the world in which the decision is going to be made as accurately and economically as possible by "neglecting some distinctions between states, not by ignoring some

6 Luce & Raiffa (1989) p 276
7 Elvestedt (1979)
8 Luce & Raiffa (1957)
9 Savage (1972)

states outright."[10] This is a description over a small world, which corresponds to a large world by being a part of a set of states in the larger world. The initial corporate investment decision example presented previously could be described by a small world since only three states describe the world.

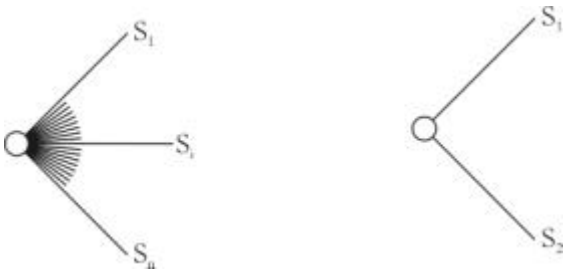

Figure 2 Large and small worlds. A great number of states describe the larger world while the small world is described by a small number of states.

PROBABILITIES

The decision matrix structured the decision problem but do not solve the problem of which act to choose to maximize the outcome or utility from the decision. The pure strategies suggested that all relevant states were known. However the likelihood of their occurrence is not known. A decision, which has an a priori probability distribution over the states is said to be a decision under risk[11]. However, if the probability that an act lead to a specific outcome is not known, the decision is said to be under uncertainty[12]. In those cases, two techniques could be used to evaluate the decision such as decision randomization (see section further on) or some decision criteria (e.g. minimax). For a presentation of other decision criteria see Luce & Raiffa (1989, Chapter 13).

[10] Savage (1972) p 9
[11] Knight (1921)
[12] Ibid

The models use of probabilities as a measurement of uncertainty in a decision is treated in a neutral way and the model is not biased in any way. This fact has become apparent by scholars of the past in the discussion of the spread in a probability distribution as a measurement of uncertainty. See Elvestedt (1979, Chapter 3) for a presentation of arguments for and against this view.

EVALUATION OF ACTS

The evaluation method to rank acts in TDA uses the concept of expected utility as suggested by the 18th century mathematician D. Bernoulli. He gave a solution to the famous St Petersburg paradox[13], which introduced the concept of diminishing marginal utility or value. In other words, the utility of another $1 million for a billionaire is not very high since people's value (utility) from money is non-linear. The formula for expected value (3) is also called the Bernoulli principle although Gabriel Cramer a Swiss mathematician provided the same solution a decade earlier[14].

$$E(u|p,Z) = \sum_{i=1}^{n} p_i u_i(z) \quad (3)$$

The straight line in $E(u|p,Z)$ should be read as utility (u) "given" probability (p) and the range of consequences (Z) where z ∈ Z.

TDA aim to maximize the expected consequence (i.e. utility) from list of acts, which depend upon states with uncertain occurrence. The consequences are often expressed in monetary form as expected monetary values, (EMV[15]). However EMV is not the actual utility a person assign to a consequence. EMV must be transformed to utility through the concept of certainty monetary

[13] Luce & Raiffa (1989)
[14] Paulsson (2001)
[15] Also called Expected Monetary Value (EMV) in Raiffa (1968)

equivalent, (CME[16]). This means that EMV does not have to be equal to CME, the utility in monetary form a person assigns to it.

Many axiomatic treatments over how people rank consequences (i.e. applying a utility function) have been given. A widely used approach is the one suggested by J. von Neumann and O. Morgenstern, which is based upon probabilities that generate a utility function. This approach is logical in the sense that decision-makers often determine the consequences in a decision before identifying the probability for them to occur. For a more detailed description of the J. von Neumann and O. Morgenstern utility function see appendix.

DIFFERENT TYPES OF PROBABILITY

In short, two different types of probability types exist, objective probabilities and subjective probabilities.

OBJECTIVE PROBABILITIES

Objective probabilities are probabilities that can be deduced through relative frequencies in experiments or through the ratio of physically described possibilities. A simple example of an experiment with objective probability assessment is tossing a dice and hoping to receive six eyes. After tossing the dice many times, the result will show that it is equally likely to receive just one to six eyes. You would also come to the same conclusion after studying the physical shape of the dice. Physical symmetry indicates equal probabilities and is said to follow the principle of cogent reason[17].

In the 18th century a scholar called J. Bernoulli[18] contributed to the probability assessment technique when he formulated his principle

16 Raiffa (1968)
17 History of economic thought
18 D. Bernoulli's uncle

of insufficient reason[19] which states that if we have complete ignorance over the frequency distribution one should treat the probability according to a priori probability distribution by asserting equal probabilities to each event[20]. He also argued that one could think of probability as "a degree of confidence"[21]

SUBJECTIVE PROBABILITIES

If probabilities could be viewed as a measurement of the "confidence" as J. Bernoulli suggested, it could also be viewed the other way around. The 18th century scholar S. de Laplace argued that probability also could be viewed as the "expression of man's ignorance"[22]. In other words, the more knowledge you have the more confidence in the hypothesis. Later scholars such as F. P. Ramsey redefined probability as an individual's belief in a hypothesis. It is clear from the presentation of ideas that the degree of belief that a certain event could occur is connected to the preference in the different events. Individuals will always prefer a high probability for a highly preferred state to occur before an event with high probability and a state that is not preferred[23]. For deeper discussion over subjective probabilities see Savage (1954, Chapter 4).

Subjective probability is driven by the Strong Independence Axiom[24], which in short terms say that if an individual are to choose between two states that are mutually exclusive. The individual cannot then claim that those two states are equally likely to occur due to the individual's preference ordering of the states. Subjective probability also follows the same laws as objective probabilities, which is that the total probability is always 1. B. de

19 Luce & Raiffa (1989)
20 Ibid
21 Bernoulli, Jacob., Ars Conjectandi (1713) in Raiffa (1968)
22 Raiffa (1968)
23 Elvestedt (1979)
24 Ibid

Finetti first showed this in his theorem of total probability in 1937[25].

CONDITIONAL PROBABILITIES

After having discussed the lack of full knowledge in a decision it is a sound conclusion that new knowledge[26] could alter the probability distribution and maybe alter the preference orderings (utility function) from the decision analysis as well. The 18th century mathematician Reverend T. Bayes[27] postulated this notion of compounding probabilities. See appendix for a formal example.

DECISION RANDOMIZATION

As previously stated decision under uncertainty incur that we cannot always distinguish probabilities or payoffs to certain events in a clear way as Savage's "Sure thing principle"[28] suggests: A decision between two strategies should not be affected by two different states of nature that lead to the same payoff. The Ellsberg paradox[29] showed that we often break this principle. Individuals cannot assess probabilities in a correct way. This conclusion is supported by empirical research by Tversky & Kahneman[30], who have shown that humans in general rely on much simpler rules of rationality than the axioms of rational behavior suggests. The solution to this difficulty is to randomize a decision; this process transforms a decision under uncertainty to one under risk instead. However the randomization technique is only applicable when a decision must be made immediately[31]. This is obvious because time give us the opportunity to gather more information to base our decision on.

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[25] Ibid
[26] It is important to distinguish between knowledge and information. To know something is a specification from the term having information about something.
[27] Raiffa (1968)
[28] Savage (1954) in Elvestedt (1979)
[29] Elvestedt (1979)
[30] Tversky & Kahneman (1974)
[31] Ibid

Either using a direct or an indirect approach can assess a subjective probability. The direct approach requires the assessor to answer questions in numerical form. This approach also requires the assessor to be able to interpret the personal probability concept. There is a problem here; not everyone is familiar with this concept. The person interviewed must answer the questions asked according to his/hers true beliefs. Experimental psychologists have used scoring rules to get accurate assessments from the interviewed person. Looking at the difference between the answer given and the observed behavior determine the score[32]. The indirect approach estimates the personal probability from choices made in a real or hypothetical situation. In this approach we can use binary lotteries and urns or probability wheels for calibrating the personal probability[33]. For a more elaborate presentation of methods for measuring probabilities and utilities see Von Neumann & Morgenstern's utility function in Appendix or Elvestedt (1979, chapter 4).

MAIN PROPERTIES OF TDA

TDA is a general framework over how to evaluate decisions under uncertainty. It is quick and easy to use. However, it is based upon assumptions that can be viewed as naïve such as the assumption of pure strategies. However this is not really an assumption but a tautology from the rationality assumption, which in short states that strategies not following the consistent strategy rule should be removed. The knowledge assumption also imply that new information do not have any value since it is a prerequisite in the model. This stands in contradiction to the intuitive approach that new information could be useful and valuable. Elvestedt[34] discusses this problem in his dissertation where he concludes that either we have a preference ordering (utility function) over the list of acts available and hence a probability function and additional information

[32] Hederstierna (1981)
[33] Ibid
[34] Elvestedt (1979)

have no value or that no unambiguous preference ordering exists and therefore no unambiguous probability function. This implies that time itself have no value since the decision could be made right away with the information at hand. The timing of an investment decision, which is often crucial are therefore not taken into account. Concepts like learning by doing and so forth cannot be included in the model.

REAL OPTION

This part will illustrate the methodology behind the option approach in real investments. We will however start with a short discussion about the shortcomings of the more traditionally NPV-approach (Net Present Value-approach) and by that develop the need for another view on investments. The discussion aims to show the added value in using an option approach instead of the NPV-approach in both valuing the investment and the decision making prior to an investment.

"If financial managers treat investments as black boxes, they may be tempted to think only of the first accept – reject decision and ignore the subsequent investment decisions that may be tied to it. But if subsequent investment decision depend on those mad today, then today's decision may depend on what you plan to do tomorrow"[35].

What is described above is the difference in views on an investment. When we use the NPV-approach[36] we tempt to treat investments as black boxes that managers cannot alter ones the decision has been made. If we use this approach we make two implicit assumptions. First, the investment is fully reversible. If market conditions changes in an unfavorable direction we can sell of the

[35] Brealey & Myers (2003)
[36] About the NPV-approach see Ibid.

investment and fully recover our expenditure. Second, if the investment is irreversible the decision is a now or never decision. We must make the decision now based on the information we have[37]. The future cash flows from the investment are therefore treated as they were "true". Another problem with the NPV-approach is that it tends to undervalue investments because of usage of hurdle rates to compensate for the lack of flexibility[38]. By using the same discount rate in the NPV-approach we disobey the law of one price[39]. The final argument against usage of the NPV-approach is that it ignores the possibility to wait with the investment decision until we have sufficient information. It is unreasonable to make decisions about tomorrow without tomorrow's information. To base tomorrows actions with today's information would be irrational[40].

THE HISTORY OF REAL OPTIONS

The fact that NPV undervalued most projects and did not give managers any means of flexibility got researchers to start thinking differently. The research about option theory in real investments started with a paper written by S. C. Myers[41]. In this paper he discussed why companies did not maximize it's borrowing although the benefits from the tax shield. His conclusion was as follow. A firm's value is based on the present value of its assets and on the present value of the company's future investment opportunities. As the company gives out more debts (bonds) the more risk/costs will be attached to them. This leads to a decrease in which strategies the company can undertake due to the cost of capital. If on the other hand a company has not maximized its borrowing it does not meet the same cost of capital and can therefore more freely

37 Dixit & Pindyck (1994)
38 Trigeorgis (2000), Feinststein & Lander (2002)
39 For a more thorough explanation of the law of one price see for example Parkin et al (1997)
40 Dixit & Pindyck (1995)
41 Myers (1977)

choose its investment strategies in the future. The latter results in keeping more options "alive".

The research about an option approach in valuing an investment in real assets has since then been an active research genre. Some say that theory about real option analysis is most important finding for decision making in a business environment[42]. For a more thorough discussion about the history of real option approach see Trigeorgis (2000).

DIFFERENCE BETWEEN REAL OPTIONS AND FINANCIAL OPTIONS

The approach of seeing investments as options is not however new, in financial markets options has been an instrument since 26/4-1973 when the first financial option was traded on the Chicago board of option exchange[43]. Shortly after this F. Black and M. S. Scholes presented their work of how to price a financial option[44]. Prior to their work the valuation of financial derivatives were viewed on as warrants[45] and did not therefore provide a complete result.

Their result cannot however be used when we are going to value a real option. The reason for this is that a financial and a real option differ in some important aspects[46]. First of all the underlying asset in a real option is not a financial paper but a real asset. In the financial option there is only one source of uncertainty while a real option might have several (e.g. output prices, input prices). The financial option is dependent on a single underlying asset while a real option can be based on several or options.

42 Howell et al (2001)
43 Chicago board option exchange (CBOE)
44 Black & Scholes (1973)
45 For an explanation about warrants see Hull (2003)
46 Copeland & Antikarov (2001)

The fact that financial options are traded on a market makes it easier to monitor its parameters. The price of the underlying asset is observable. Given this we can estimate the variance of the expected rate of return by either using historical data or estimate implicit volatility by other options on the same underlying asset. With the real option the situation is entirely different. The asset is not necessarily traded on an open market (e.g. research projects) and therefore we do not have historical data or other options on the same asset to rely on in a valuation.

In the case of financial options the options are issued as side bets. The company which shares the option is based on do not issue the option, this is done by an independent agent. Thereby the agent has no influence over the company or its actions. With a real option this differs because management controls the asset and can control the value of it.

With both financial and real options the risk is assumed to be exogenous. The individual stockbroker cannot control or influence the rate of return from a share. The company that possesses a real option may however by its actions influence the competitors and thus the uncertainty it faces.

REAL OPTION – DEFINITION

To define the option approach one can use a garden as an example[47]. From the beginning we have a lot choices of what to plant in that garden. If we devote some of this garden to grow tomatoes on we have made a decision that is more or less irreversible. With the decision made we will do our most to get as much out of it as possible. The traditional gardener shows up at the last day of the season to pick the ripe tomatoes. The active gardener would show up more frequently to see how the tomatoes are growing. He would

[47] Luehrman (1998)

then at each visit decide which ones to pick and which ones to leave for further ripening. The rotten tomatoes he would not pay any attention to. Between being rotten and not yet ripe the gardener has to make a harder decision. Some of the tomatoes are not ripe yet but could rotten before his next visit due to too much rain or sun.

Before we plant something in our garden we have an option, when we decided to grow tomatoes we made a decision that killed our option[48]. Before we would plant these tomatoes we will know that this field is suited for growing tomatoes and that there will be a market for tomatoes. The active gardener does what managers should do with their investments, monitor/reduce the uncertainty and time when to collect the cash flows, tomatoes. His is also reducing the irreversibility by not growing tomatoes in the entire garden. If the output price on tomatoes goes down for long he can devote the rest of the garden to some other plant. The traditional gardener however does what a manager has been doing; hoping for a good result after the decision is made.

With the example of the garden we can come to a conclusion, though there exists several differences between a financial and a real option the bottom line is still the same. With a real option as well as with the financial option the owner has an opportunity to take action, which are the right but not the obligation to do so. For example, we have the right to buy the underlying asset but not the obligation to do so if the value of the asset goes below the exercise price of the call option[49].

[48] Dixit & Pindyck (1995)
[49] More on different types of options will follow.

REAL OPTION – FRAMEWORK

When analyzing an investment there are three aspects that have the main focus, irreversibility, timing and uncertainty[50]. The degree of irreversibility is dependent of the nature of the investment. If the investment is company specific it is hard to recover the sunk cost by selling of the investment if the market turns unfavorable. If we do not have any use of the investment it is likely that our competitors wouldn't either. But if it is a more general investment we could sell it off to some other actor in another industry where the market is more favorable. The irreversibility is thus dependant of the degree we can regain the sunk cost of the investment.

The amount of the sunk cost we can regain is uncertain before the investment decision is made. We do not entirely know how the market will turn out and thereby we do not know precisely the cash flow we can expect from the investment. The longer we are going to have the investment the harder it is to monitor the uncertainty involved. Therefore there is always a level of uncertainty in making an investment. The amount of uncertainty will be reduced along the way as we learn more about the investment and the market for it. Yet it will most likely not be reduced completely. It is because of this the timing of the investment is of great value. If we can wait and collect more information about the investment and the market for it we will have a better basis for making the final decision about the investment. Not all investments aloud the manager the opportunity to decide totally freely of the timing of the investment but in most situations we can manage to widen the time horizon concerning the investment decision. So when to exercise the option becomes of great value for the total net value of the investment[51].

[50] Dixit & Pindyck (1994)
[51] Rhys et al (2002)

SPOTTING OPTIONS

How will a company go about to find their real options? The option approach is based on a more strategic view of the company's investment opportunities. They may be the result of R&D or from managerial resources of predicting the future and acting on those predictions[52]. A company can thus create their own options. A real option approach is by other words not only a valuation process of a real asset but more a way of thinking in terms of making final decisions after we know how future events unfolds[53] and thereby taking tomorrows information into account for decisions concerning tomorrow[54].

DIFFERENT TYPES OF REAL OPTIONS

There exist many different categorizations of the different types of real options. However the basic idea is that they are defined after the amount of flexibility the offer[55]. Many of these options have counterparts in the financial market. This section will be based on the categorization done in Copeland & Antikarov (2001).

A deferral option is like an American call option[56] found in most projects where one has the ability to delay the start of the project where the exercise price is the money invested to get the project started. An option to abandon for a fixed price is like an American put option. A similar option is the option to scale down a project by selling of a fraction of the project. The opposite of an option to scale down would be an option to expand a project by paying a fixed amount of money. This could be seen as an American call option. One might have the option to prolong the time for the project with an option to extend. This option is also like an American call option.

52 Dixit & Pindyck (1995)
53 Park & Herath (2000)
54 For an example of practical use of real options see Coy (1999)
55 Copeland & Antikarov (2001)
56 For more information about financial options see Hull (2003)

There are also more complex options, switching options for example. This option is a portfolio of American puts and calls that allows the owner to switch at a fixed cost(s) and between two modes of operations. The option to exit an unfavorable market and the to re-enter it when it turns favorable is an example of a switching option. We can also construct options based on underlying options. These options are called compounded options.

The last set of options is called rainbow options. These options are based on several sources of uncertainty. Most real options would fall into this set because most investments are driven by uncertainty about quantity sold, output prices, input prices and more. As we can combine several ordinary options we combine multiple rainbow options into one option, a compounded rainbow option.

VALUE DRIVERS IN REAL OPTIONS

The value of a real option depends on several aspects[57]. Most of these variables also change the value of a financial option as well. The first parameter that provides the option with value is the underlying asset (the investment). If the value of the underlying asset goes up so does the value of the option. The next aspect that determines the value of an option is the exercise price. If we hold an abandon option and the exercise price increase we will get an increase in the value of the option. The longer time we have to make our decision about execution of the option will increase its value due to the flexibility and the chance of more information received prior the decision. The amount of risk (the standard deviation of the value of the underlying asset) in the underlying asset provides value to the option because the value of the option is dependent if the cash flow of the underlying asset reaches the exercise price or not and the probability of it. The last variable that determines the

[57] Copeland & Antikarov (2001)

value of the option is the risk-free interest through out the lifetime of the option. The greater the interest is the greater value is the option going to have.

REAL OPTION ANALYSIS

The basic premise behind a real option valuation is as follow: Value each states flexibility value towards the exercise price. That is; value the different states to se where we profit from keeping the option alive and where we profit from exercising it. As long as the value created by the flexibility is greater than the exercise price the option is kept alive. Thereby the value of the option will be the difference between the project with flexibility and the project without flexibility[58].

To value the real option we a benchmark to monitor a risk-adjusted discount rate for our investment. If we can find a replicating portfolio that has perfect correlated cash flows with our investment, then these two investments must have the same risk and value according to the law of one price. This replicating portfolio contains *m* (4) shares of a twin security and *B* (5) numbers of risk-free bonds. The formula for a replicating portfolio (6) looks as follow[59]:

$$C_0 ? mV_0 ? B \quad (6)$$

C_0 = the value of the option

m = the number of the twin security

V_0 = the value of the underlying asset with no flexibility

B = the number of risk-free bonds

where

[58] Feinstein & Lander (2002)
[59] Copeland & Antikarov (2001)

$$m ? \frac{C_u ? C_d}{V_0(u ? d)} \quad (4)$$

m = the number of the twin security

C_u = the value of the option in the up state

C_d = the value of the option in the down state

u = the percentage up movement

d = the percentage down movement

and

$$B ? \frac{C_u ? muV_0}{1 ? r_f} \quad (5)$$

B = the number of risk-free bonds

C_u = the value of the option in the up state

m = the number of the twin security

u = the percentage up movement

V_0 = the value of the underlying asset with no flexibility

r_f = the risk-free rate of return

However, it is hard to find a portfolio in market that has this perfect correlation. We use the market asset disclaimer (MAD) instead. The MAD states that nothing will be more correlated with the investment than the investment itself[60]. We can therefore use the NPV of our investment without flexibility as the twin security in our replicating portfolio when we value the real option[61].

ROA – AN EXAMPLE

To concretize the valuation process of a real option we shall now exemplify this[62]. A company is thinking about undertaking an investment that can be viewed as a compound option. The company has to invest $50 today to start up the project and an additional

[60] Ibid

[61] For other ways of valuing a real option, see for example Copeland & Antikarov (2001), Herath & Park (2000) (2001), Smith & Nau (1995).

[62] The example is based on an example from Copeland & Antikarov (2001).

$70 in the beginning of the next period. We assume a discount rate at 25% and a risk-free rate at 5%. There is a probability of 0,5 that the project will generate $100 in the first period if the project turns out well. Otherwise the project will generate $44 in the same period. In the second period the project can generate $150, $67 or $30, all with the probably of 0,5. See the figure 3 for a graphical presentation of the investment decision.

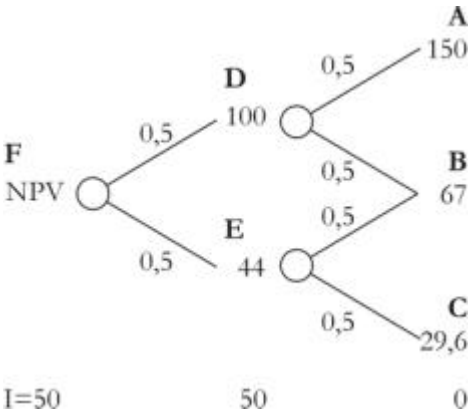

Figure 3 Graphical presentation of the framework for the investment decision.

To go ahead with the valuation of our option we need to perform a value based calculation for the different nodes in a pre-commitment scenario. By doing so we can se what the total value of the cash flows are at every node, the nodes total value. The calculation is done by summing the cash flow from the present node with the expected future cash flows divided by the capital cost. So for node D (see figure below) the total value will be:

$$D = \frac{(0,5 * 150 + 0,5 * 66,7)}{1,25} + 100 = 186,7$$

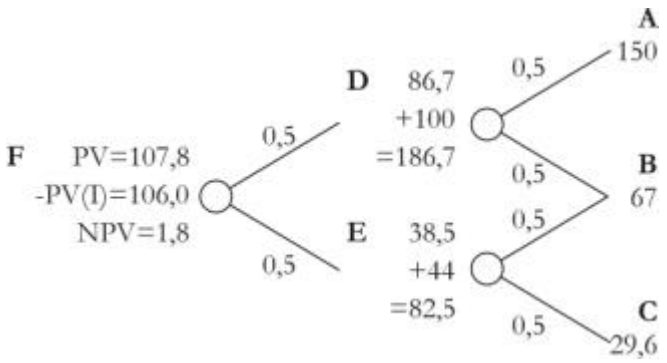

Figure 4 Graphical presentation of the value-based calculation for every node.

With the above done we can now finish our valuation of the compound option. A graphical framework for the solution of our valuation is presented in figure 5 below.

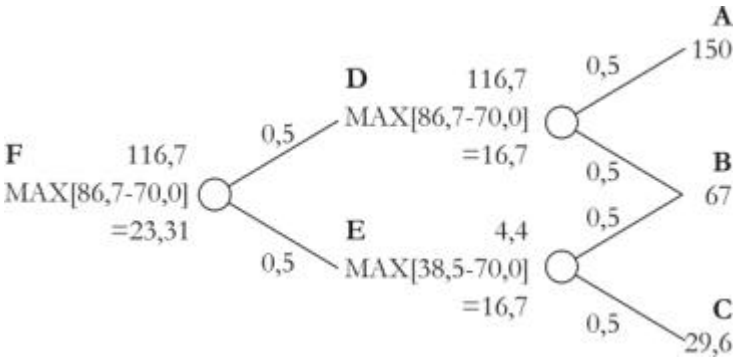

Figure 5 Graphical presentation of ROA of the investment decision.

We need to remember that the valuation is done by compare the value of the flexibility towards the exercise price. In node A, B and C no decision is made and therefore their values will remain the same. In node D and E we have the flexibility to either keep investing or kill the project. To decide which to do we will value the option here to make the correct decision. Lets start with node D. In node D we have to decide a pone investing $70 to receive an expected discounted cash flow of $86,7. We will also receive the $100 that node D generates. Thus, the total value of node D in a none pre-commitment scenario will be the surplus of the expected discounted cash flow plus the cash flow from node D minus the investment cost in the node, $86,7+$100-$70=$116,7.

The total value of node E in a none-pre-commitment scenario is 0. The reason for this is that we have to invest $70 to receive an expected cash flow of $38,5. This we will of course not do. So if the cash flow from the investment happens to turn to node E we will not go forward with the investment because we want to maximize the value of the investment.

So by having calculated the value of node D and E we now calculate the value of the option by using the replicating portfolio.

$$m ? \frac{116,7 ? 44,4}{107,8(1,5 ?,67)} ? 0,805$$

and

$$B ? \frac{116,7 ? 0,805(1,5)107,8}{1,05} ? 13,47$$

therefore

$$C_0 ? 0,805(107,8) ? 13,47 ? 73,31$$

The value of the option is thus $73,31 and the discounted net value of the project when valued with an option approach is: $73,31-$50=23,31.

MAIN PROPERTIES OF ROA

The main property of ROA to be kept in mind is how the model views an investment. It sees the investment more like a chain of decisions rather than one absolute decision. ROA is thus more a view on strategies than just an approach used for valuation of real

investments[63]. The exact view depends on which option is used and what information is used as the base for the decision. From this idea we can derive another important issue, the timing of the investment. If we can delay the final decision we might get more information. More information gives a more complete foundation to base the final decision on. The more relevant information we have the less uncertain will the investment be. One way to gather more information is to stage the investment. Another aspect of staging an investment is that it then becomes more reversible and thus less uncertain.

[63] Beinhocker (1999)

CASE DISCUSSION

In this section we are going to present the empirical material of the study. This empirical material was collected through an interview with a head of a department at Blekinge Institute of Technology. After it is presented we will discuss how well the two models can describe the investments made in a human resource. The empirical material will be divided into three stages due to the chronological ordering their appearance in the investment decision.

FIRST STAGE

Grounds for hiring new staff in the organization is:

?? A resource shortage due to an employee's decision to quit

?? A Ph. D. student that is externally financed

?? A pure growth in the number of students taking courses at the department

Depending on the type of staff that is going to be hired, three different types of internal rules apply.

The Ph. D. positions at the department are often highly specified by the director of research. The hiring of Ph. D. students is made on a continuous basis since financing is the only obstacle with an initial employment time of one year, which is dictated by law. An application to a vacant position as a Ph. D. student does not have to follow a specified form. However certain information must be included in the application:

- The relevant academic background
- Area of research
- Exam work
- General level of grades
- Personal letter, other qualifications, experience and leadership qualities

The information provided by the applicant is verified by references or a personal valuation of the background material.

A numerical scale grade point is given to each individual criterion. The total sum of grade points is used to create a ranking order to sort the applicants. If a multidisciplinary academic background is required, the individual criterion in the list will be evaluated through a pre-decided weighted scale so that the most important areas have the most impact in the ordering of the applicants. Before the hiring, a consultation is done with the director of the research project and with the supervisor. For a teacher the teaching experience and attitude towards teaching are included in the fifth criterion in the list.

Teachers and administrative staff are subjects to internal rules, dictated in application forms, which specify the information needed from the applicants such as a CV. Decisions to hire is

made by the department itself. The need to hire this type of staff is indicated by the director of studies at the department. The hiring of teachers is based on the need from a semester perspective. The department do not time limit the employment time for a teacher. However teaching assistants are hired on a time limited basis. They carry out miscellaneous present tasks in the department. These tasks do not however include teaching in class. The hiring administrative personnel start with a test period after which a none-time limited position is offered if the test period went well.

The hiring of senior lecturers and professors take time and are highly structured in internal rules and application forms. Applicants to a vacant position are subjects to evaluation by a committee of experts in the research field. These experts are in turn appointed by the faculty board. The expert committee concludes a preference ordering of the applicants. The decision to hire is made by the faculty board and not the department. However the department has wishes of certain specific fields of research that could be useful for the department now or in the future. The hiring of senior lecturers and professors do not coincide with semesters.

SECOND STAGE

The second stage is the management of the employee during his employment time within the organization. The mechanism used to manage the different staff types will be presented below.

Ph. D. students have evaluation talks with his supervisor, examiner and the department prefect. The talk's purpose is to convey if there is a gap between displayed performance and expectations or not. If expectations are not fulfilled by the Ph. D. student the supervisor, examiner and the department prefect have an option not to prolong the Ph. D. studies. The employment time for a Ph. D.

student can be prolonged from one to a maximum of two years at a time.

Teachers, senior lecturers and administrative staff are subjects for annual development talks. Teachers and senior lecturers are given a list of five-six points in advance, where one of the points could be based upon course evaluations that will be a basis for a salary discussion. Course evaluations are used with caution since all courses are not given by a single teacher or senior lecturer. It is thus hard to know which information is directed towards one individual in the party. Other topics for these development talks for teachers and senior lecturers could be to deepen or broaden the knowledge in a subject or to take extension courses in pedagogy. Disciplinary measures could also be the topic for development talks. For teachers and senior lecturers this could be the case after remarks made by other colleagues or students. Administrative staff uses the annual development talks to take extension courses in e.g. web technologies or business administration.

THIRD STAGE

The third stage is described by the work associated with the disinvesting process of an employee. If the organization realizes that the Ph. D. student is not performing according to the pre-agreed objectives it may not want to prolong Ph. D. studies for the student. However, this has never been done although the head of the department, the director of the research project and the supervisor have all agreed upon that the Ph. D student's performance is below objectives. The reason why the never have let a Ph. D. student go is that the do not know how to proceed with the process due to legal issues and lack of praxis.

For teachers and senior lecturers there is a well-organized procedure for how to terminate an employment. The errand is treated in

the disciplinary board. Thereby the decision is made above department level. There have been cases where teachers have been fired. The disinvestments of administrative personnel are done in the same way as teachers and senior teachers. The process is dictated by legal framework and is handled by the human resources department if the person has a none-time limited position.

DISCUSSION

In section we will discuss how well it is possible to describe the above three stages of an investments in a human resources by the two models. The three stages of the investment were presented in the previous section.

When the head of the department makes his decision about the investment it is has to be an open and structured process because the institute is a public authority. This fact gives more people a chance to apply to the different positions. In making his decision the head of the department has legal and union issues that he must obey. During the investment time he manages the investment by the means available. This means are evaluation talks and person-based efforts to improve the productivity when needed.

When the investment process is started it is done with a longer time period than a semester. He has at least a three-year period in mind because this is the minimum length of the educational programs. If the market turns down he has a three-year period in which he cannot act. Once the asset is held for a time the uncertainty is reduces a lot. If he disinvest and the market turns good again he faces three problems: 1) He has to find a new investment worth doing, this takes time. 2) The investment will be uncertain for a while before it settles to the organization. 3) It is costly and uncertain process to invest, disinvest and finally invest again.

Under the premises the investments must be made, we think the process is done in rationale matter. By being a rationale process we can go on trying to describe the process with the two rationale models.

The decision to invest in a human resource can be categorized as a decision under uncertainty. When the decision has to be made to start the process the foundation for it is not complete. The final student numbers will not be known until the semester starts. The process must however be started long before that.

THE INVESTMENT DECISIONS

The discussion whether the models can describe the investment decision will be done as follows: We will discuss the three different investment types separately (i.e. the investment in a Ph. D. student, teacher/senior lecturer and administrative personnel). Under each of these discussions DTA and ROA will be discussed separately. The discussion will be concluded with a total discussion of the two models fit for the investment decisions. See table 2 below on the next page for a graphical presentation of how the discussion will be organized.

All three stages will be discussed with both of the models although there will be a more comprehensive discussion of stage two and three with ROA for reasons given below in the discussions.

Stages/position	Ph. D student	Teacher/Senior lecturer	Administrative personnel
First stage	TDA/ROA	TDA/ROA	TDA/ROA
Second stage			
Third stage			
General	TDA/ROA		

Table 2 Structure of the discussion.

PH. D STUDENT

TDA

The decision to hire a Ph. D student according to the traditional analysis approach incur that we must accept the knowledge assumption previously described. This means that we should only make one big decision since we have all the information needed. This also incur that we do not need to manage the decision by means of a new decision to incorporate new information. This view is only applicable if we make a strict distinction between the initial decision and the decisions that follow. A Ph. D student is hired on a yearly or two-year basis, which translates the original big decision into an iterative decision process where a new decision is made at those points in time.

TDA does not take time into account, however this makes no difference since the decision has a predestinated duration time on before hand, under which no uncertainty are managed. Because of this fact the decision to hire a Ph. D student could be evaluated through TDA from a yearly perspective. The Ph D studies last four years and can therefore be seen as a sequential (staged) investment decision with yearly opportunities to evaluate and revise probabilities, states and outcomes before the new decision is made for an additional year or two. It is thus an iterative process where original decision changes over time into a completely new decision.

Given the fact that the Ph. D student investment is not managed during the four-year duration time, the decision as a whole could have been made at the start of the employment with TDA. The decision to prolong the employment is always made after evaluation talks since no new information is incorporated in the basis for the decision.

ROA

The Ph. D study time is four years full time. Given that fact it is wise of the department not to make the final decision at once. The result from the study time is not certain from the beginning. That is; the department cannot at day one determine whether the Ph. Student will fulfill the studies. It is in other words an uncertain decision. It makes more sense to sequence the investment by one year at the time. After every one-year interval an evaluation is done over the investment. This evaluation is made by using the collected information from the year past by. A decision is then made about whether to proceed to the next stage of the investment (i.e. to continue the employment for an additional year or two), or not. The timing ability of the investment is thus an important aspect because of the irreversibility of the part-investments (i.e. one or two years of employment) made by department. The timing and the irreversibility arguments could be flipped into counterarguments. By sequencing the investment, the investment as whole becomes more reversible (i.e. the four-year employment). E.g. if the Ph. D student fails to meet the pre-agreed objectives after one year, the department does not have to prolong the employment.

The only issue that limits the practical use ROA in this example is the degree of reversibility. In a strict sense an investment must have a natural secondary market to complete reversible. This is the case in a financial market but not fully in a real market. A Ph. D

student cannot be "sold off" if the market turns down like a bond could.

The process of evaluation/information gathering is repeated during the entire life of the investment. Every year the same comparison is made against the exercise cost for the option, pre-decided objectives to achieve against the cost for letting someone go, to see whether to go on with the investment or to disinvest, buy out/sell of the investment. The same process can be described by the department's process of scaling up the investment (expand option) as time goes by. This decision can thus be described as a chain of decisions rather than by a total decision.

The possibility to scale down (scale down option) or to sell of the investment (abandonment option) at a pre-decided cost before exercise time is nothing the department uses today. By using such strategy the department could easier value the investments the make in Ph. D students. However, to be able to use this tool they must work out procedures for how to let Ph. D students go prior to their exam.

In the case of a Ph. D student the uncertainty derives only from one source, the Ph. D student's ability. Thereby it is a case of simple options.

TEACHER/SENIOR LECTURER

TDA

A thorough process of selecting the right applicant to a vacant position as a teacher or senior lecturer is important since they are hired on a on a non-time limited basis. Their performance is managed in a number of ways with at least one scheduled evaluation talk. The fact that the decision is managed is contrary to the knowledge assumption TDA rests upon. In this sense the decision to hire a teacher or senior lecturer is not suitable to be described

by TDA. That is if a clear distinction is to be made between the initial decision and the decisions that follow since they do not share the same properties. To be able to describe the decision with TDA the evaluation talks should be used as decision time-points to make a new decision.

ROA

The process of hiring a teacher/senior lecturer can be viewed as a rainbow option based on an abandonment option. The reason why it cannot be viewed as a compounded option is that the teacher/senior lecturer is not test-hired; they are directly hired at a non-time limited bases agreement. The department does not thereby get the option to scale up. This could result in a more irreversible investment and thus more uncertain. However, instead of having the chance of ending the employment after the test period the department can at a pre-decided cost disinvest (abandonment option). This pre-decided cost is the cost of letting someone go e.g. the salary during the dismissal time.

The difficulty with this option is to time the exercise optimally. To do so the head of the department has evaluation talks for help. These evaluation talks are held with one-year interval. The head of the department does thus get new information continuously about the performance of the investment. One area in these evaluation talks is based on course evaluations done by students. These evaluations provide the manager with information about how the teacher/senior lecturer performs. So the investment is well managed during its life length. This management provides a good base for making sequential decision concerning the investment. Keeping the option alive could in this case be viewed as a made decision as much as a decision made to kill the option, i.e. disinvest.

The reason why this investment can be viewed as a rainbow option is because the option does not suffer from just one source of un-

certainty. There are several sources of uncertainty determining the value of the option e.g. the future number of students, the performance of the teacher/senior lecturer.

ADMINISTRATIVE PERSONNEL

TDA

The decision to hire administrative staff is done in a similar way to teachers and senior lecturers. Their initial employment time is however time limited to six months. After this time the finite decision is taken to hire or not. The first six months could however be evaluated through TDA since the decision is not managed during this time. The decision after this evaluation time is a finite one, managed through yearly evaluation talks. This finite decision could therefore not be described by the traditional decision analysis since management of the decision is needed. If the decision is to be described by TDA the model must be used in an iterative way as described under the teacher/senior lecturer case.

ROA

The process of investing in administrative personnel could be described as a compounded option based on an option to expand and an option to abandon. Administrative personnel are first test hired. This gives the department an opportunity to sample. If this sample is good (i.e. the applicant has performed well) the department has the option to expand the employment to none-time limited. By doing the investment in this staged way the investment becomes more reversible and thereby less uncertain.

As in the case with the teacher/senior lecturer evaluation talks is held. These talks give the head of the department continuously new information of how the investment is performing. By receiving new information the head of the department can more easily manage the investment.

As in the case with the teacher/senior lecturer the optimal timing of the option exercise is the hardest aspect in this case. However the department has a pre-decided exercise cost for the option, whereby this uncertainty is resolved. The remaining task is to find a benchmark for it to see when to exercise the option. Information from the evaluation talks could be a source for this.

GENERAL DISCUSSION

To be able to describe the process used by the decisions maker with TDA and ROA, the three stages had to be transformed into discrete decision points. See figure 6.

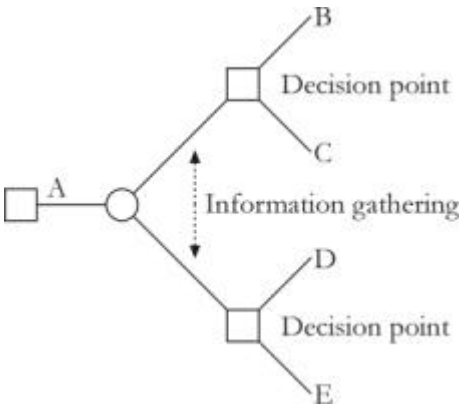

Figure 6 Graphical presentation of the relationship between two decisions.

When the decision about the investment is made the decision maker describes it as a process where information is gathered between the decision points. The two models cannot describe this process and hence assume that the information needed is at hand when the decision is to be made. How the foundation for the decision is established from the received information and how it is used, will not directly be captured by the models.

The next task to solve if any of the models is to be used making these decisions is how to quantify the process. It is for example hard to measure the cash flow from the investment because it does

not come in a clear appearance. It is hard to determine which revenues from a course the teacher has created and which performances is strictly due to the students own work. It could be even harder to measure the direct cash flows created by the administrative personnel. It is hard to measure the causality with their work and the cash flows generated by students. It could however be measured by the opportunity cost for e.g. a computer system break down. When using ROA, the benchmark used against the exercise price/cost must also be quantified; otherwise the decision maker will not know when to exercise the option. These variables are hard to measure because they are not expressed in cash flows.

CONCLUSIONS

An investment decision can generally be described as a contingent decision relying on information gatherings from a previous decision or decisions made concerning the investment at hand. It is thus like the same investment decision is made over and over again. The difficulty in applying this tactic in human resource decisions is that the decision is transformed over time into another type of investment decision with other properties than the original one. Reasons for this could be that conditions for the investment decision have changed.

From the case discussion a pattern emerged that revealed that two factors drive the usefulness of TDA when making investment decisions in a human resource.

?? The absence of management in an investment decision.
?? The investment decision has limited time duration.

The first point is relevant since TDA rests upon a knowledge assumption driven by the notion of pure strategies. This is a sound assumption because otherwise the definition of a decision problem would have to be redefined all the time to cope with new events. Neglecting to manage a decision could either be intuitively viewed

as a bad practice or as proof of a high level of knowledge about a decision, since no management is applied or needed. The second point is derived from the first point in that a decision in practice eventually could need to be managed. By limiting the duration time of a decision, new information could be taken into account. In this sense a decision's duration time should be a short as possible to be able to incorporate new information when making a new decision.

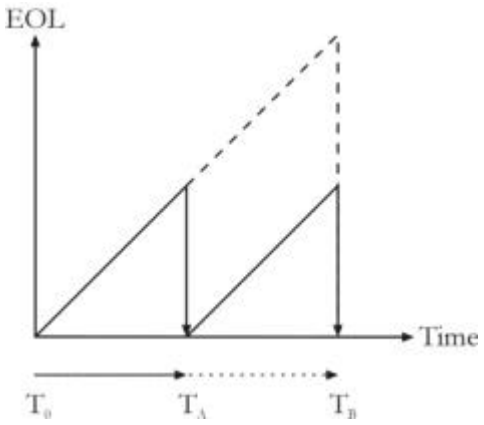

Figure 7 EOL and its relationship to decision duration time.

If new information is present we want to make a new decision that incorporates that information to minimize the expected opportunity loss (EOL[64]). This could be done by minimizing the decision duration time. Consider figure 7 where a decision is made at point T_0 in time. Uncertainty about the outcome of the investment decision is present. The effect from this uncertainty is a rise in EOL under the duration time of the investment decision since a better decision could have been made. The longer the decision duration time is, the greater will the probability be for new information arriving that could influence EOL. The negative effects from an increase in EOL (point T_B), could be halted by taking corrective action with a new investment decision (point T_A). In other words by managing the decision through incorporating new information about the investment decision, EOL could be lowered. The point

64 Raiffa (1968)

in time where corrective action could be taken is determined by the decision duration time. If the decision duration time last from T_0 to T_B a considerable EOL could be present. However if corrective action could have been taken earlier at point T_A in time the possibility for a high EOL should be less.

So in most cases it would be better to make two smaller sequential decisions (decisions with shorter duration time) where the first decision lasts from time T_0 to T_A (see figure 7) and the second decision lasts from T_A to T_B, than one decision with a longer duration time such as the big decision that lasts from T_0 to T_B. These decision time-points (and hence the decision duration time) cannot be created or altered in most cases by management, since they arise from the world of the investment decision where new information appears due to unexpected events. However if no new information is present the decision duration time can be longer because EOL is not significant.

By the above said, TDA describes the decision made in the investment of a Ph. D student well because of how the process was described by the decision maker. The annual decision time-points are natural time-points in the Ph. D student investment decision. Actually these time-points cannot be pre-decided in practice because they are a result of the world and are unknown beforehand. However the Ph. D employment time is subject for legal constraints and therefore natural decision time-point exists within one or two year's basis. Techniques to enhance the ability to find decision time-points are referred to the concept of decision engineering[65]. The result from decision engineering can be a more elaborate decision tree (see figure 8) with more decision time-points and a more detailed distribution of states of nature (a large world[66]) and hence more consequences than a more simple decision tree offer

[65] For a more elaborate presentation of decision engineering see March (1994).
[66] For a more detailed description of this concept see page 19.

(see figure 9). An argument against the use of elaborate decisions trees has been that they quickly become complex[67]. However this argument could not be viewed as viable in the light of the information technology revolution.

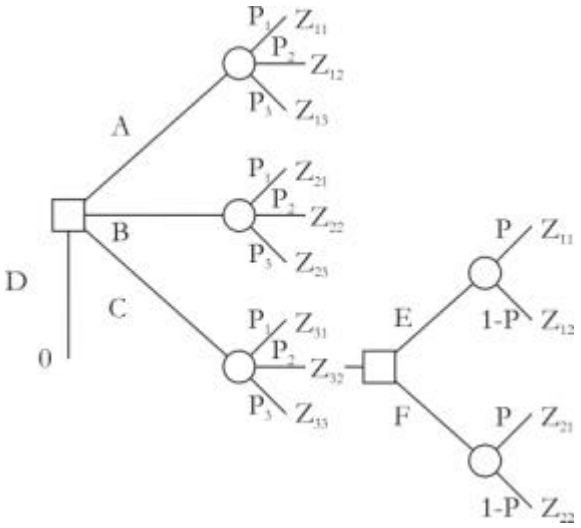

Figure 8 Elaborate decision tree.

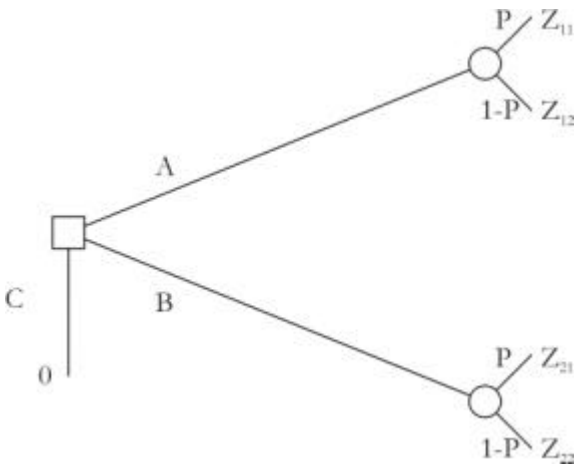

Figure 9 Simple decision tree.

By using the more elaborate decision tree a more strategic view could be incorporated in TDA trough a more thorough planning.

[67] Brealey & Myers (2003)

Using ROA to describe the process of investing in human resources will be efficient in the cases where the head of the department makes sequential decisions (i.e. uses managerial flexibility). If no sequential decisions are made ROA will not provide any net value over TDA. The cases where ROA describes the process well are the investments in teachers/senior lectures and administrative personnel due to several decisions made in the process.

In the case with the Ph. D student the head of the department do not use his managerial flexibility, i.e. he do not disinvest even when the option value has turned below the exercise cost for the option. By not doing so he is not using the option approach fully.

The above conclusions of how well and under what circumstances the two models can be used to describe an investment in a human resource can be summarized in the table 3 below.

		Management applied	
		Yes	No
Time limited	Yes	ROA	TDA
	No	ROA	TDA

Table 3 The two models relationship with management and time.

Finally, we would like to give an alternative explanation of why the investment decision made about the Ph. D student is made as it is. The Putty-Clay[68] approach states that a decision cannot be undone, as it was made, afterwards. The reason for this is that the consequences of the decision will be grown in to the organization. If the decision is to be undone by a new decision, it is hard to only neutralize the consequences from the first decision with out creating

[68] Johansen (1959)

new unwanted consequences. Thereby new decisions are not made to neutralize the prior decision made.

In the light of this, it is understandable why the head of the department will not disinvest a Ph. D student who has failed to meet the pre-agreed upon objectives. It could be hard to only undo that investment decision in question without creating new consequences.

GENERALIZATION

The results in this study can be generalized if the conditions for the decision making process, described by the decision maker, are the same. An iterative version of TDA or ROA is usable if managerial flexibility will be used. If no managerial flexibility is used a strict version of TDA can describe the investment. Managerial flexibility in this case refers to making sequential decisions based on new information. To be able apply this tactic the applicant must be test-hired before the non-time limited employment decision is made or the organization must be willing to disinvest if the value of the employment investment turns below exercise value. The organization must also have procedures for information gathering. Without new information the organization has no reason to make a new/different decision.

FUTURE RESEARCH

In writing this study we came across a great deal of books and papers. However, some areas were not discussed in the same magnitude as for example TDA. An area that we considered less studied is the area of disinvestments. The only paper[69] we found in this area is how ROA can increase to total net value of the investment when disinvestments are included (abandonment options). The paper did unfortunately not treat intangible investments, as investments in human resources can be categorized as. The only point made in the paper concerning intangible assets is that the residual value of an intangible asset is lower than the residual value of a tangible asset, where the residual value is the market value of an asset sold of prior to when utility value is zero.

We thus see that there is a need for a similar study aimed how residual value from intangible assets influences the total net value of intangible assets. We also think that there should be more studies done where human resources are viewed as investments and valued thereby. Now human investments are seen as HR-department issues only.

[69] Farrell (2002)

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APPENDIX

INTERVIEW QUESTIONS

1. What is the initializing factor that triggers the recruitment of new staff?
    a. A primary long term or short term need?
    b. An existing or future need?

2. Explain the hiring process of new staff.
    a. Is the process similar for all types staff (i.e. administrative, professors, lecturers and teaching assistants)?
    b. Do you actively pursue applicants or do the applicants come to you?
    c. How and when do you advertise vacancies?
    d. Is there a time of the year when the hiring process is more intense?
    e. What kinds of agreement types concerning employment time exist between the organization and the employee (i.e. a time limited test employment, a substitute employment or for the time being employment etc)

3. What kind of information do you receive from the applicants applying for a vacancy?
    a. What kind of information do you need to make a decision to hire or not?
    b. Is the amount and kind of information the same for all types of staff vacancies?
    c. What kind of priority do different types of information supplied by applicants have?
    d. Do you validate the information provided by the applicants?

4. Is the hiring of teaching assistants made with the purpose of filling a pressing need, existing need or could the hiring of teaching assistants be seen as an option for future employments?

5. Do you have persons applying for work even if no vacancies exist?

6. If you realize after a while that an employee is not the right man for the job, what do you do about it?
    a. Do you have regular evaluation meetings with your employees?
    b. Do you do a follow-up or these evaluation meetings?
        i. How is this follow-up conducted?
        ii. To what purpose are the follow-ups made?
    c. Do you have course evaluations on every course?
    d. Is the performance of the teacher measured by this evaluation?
        i. How do you use the information from the course evaluations?
        ii. Is the information from course evaluations used in evaluation meetings with teachers?

7. Have you ever fired someone?
    a. If yes, on what grounds?
    b. If yes, is it common?

VON NEUMANN & MORGENSTERN'S UTILITY FUNCTION

This part is based on Neumann & Morgenstern (1944).

A decisional analysis suggests that one begin with the determination of the utility (U) and thereafter determine the probability (P). The existence of U is recorded by the way a person ranks consequences driven by objective probabilities[70].

An individual must choose among a set of consequences, *Z*:

$$Z_k \, ? \, Z, \; k \, ? \, 1, , , ,N$$

Where the numbers of consequences range from Z_1 to Z_N

Subjective utility and probability estimation has raised a range of behavioral theories. These theories have been presented in axioms by a range of researcher's in order to describe human behavior. The most important are presented below.

AXIOM OF INDIFFERENCE

A person's ranking or ordering of strategies is driven by utility preference. A "weak preference", "$\underset{\sim}{\square}$" order is said to exist.

The following relationship exist: $Z_k \underset{\sim}{\square} Z_q \quad k,q \, ? \, 1, , , ,N$

And if also this relation exists: $Z_q \underset{\sim}{\square} Z_k$

Then $Z_k \sim Z_q$ is equal in utility, which mean that a person is indifferent between the both outcomes (consequences) from decisions made from a utility point o view.

[70] Also called a von Neumann & Morgenstern utility function.

AXIOM OF TRANSITIVITY

If we continue and say that apart from the relationships $Z_k \underset{\sim}{\square} Z_q$ and $Z_q \underset{\sim}{\square} Z_o$ another relationship can be established, namely $Z_k \underset{\sim}{\square} Z_o$, due to the property of transitivity.

AXIOM OF CONTINUITY

This axiom states that there exist a lottery (figure 10) with a probability u_k, $0 ? u_k ? 1$ of winning a prize Z_1 that will make an individual indifferent between a certain prize, Z_k (figure 11).

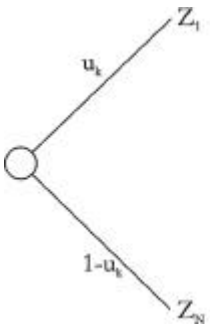


Figure 10 Binary lottery.

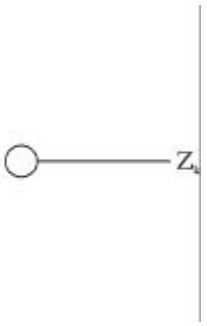


Figure 11 Certain payoff.

AXIOM OF MONOTONICITY

If two lotteries have the same prizes, an individual will choose the lottery with the highest probability.

AXIOM OF REDUCTION OF COMPOUND LOTTERIES

A lottery can be reduced from a complex lottery to a simple one through this axiom. A complex and a simple lottery can be treated as equal if their expected utility is the same.

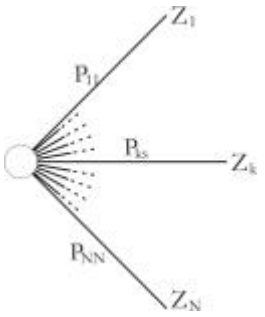
A simple lottery has the following properties:

The number of prizes: $Z_k ? Z,\ k ? 1,,,,N$

Objective probabilities $P_{ks} ? P,\ k,s ? 1,,,,N$

Objective probabilities $P_{ks}^{*} ? P,\ k,s ? 1,,,,N$

Complex probabilities $Q_k ? Q,\ k ? 1,,,,N$



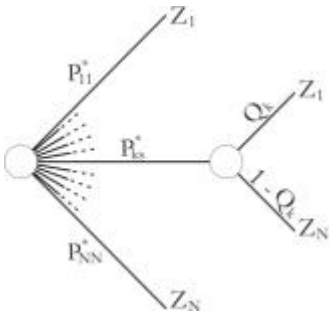


Figure 12 Simple lottery (L). **Figure 13 Complex lottery (L').**

This axiom implies that an individual will find theses two lotteries equivalent:

The simple lottery expected utility:

$$L_s ? \sum_{k,s?1}^{N} P_{ks} Z_k,\ k,s ? 1,,,,N$$

The complex lottery expected utility:

$$L' ? \sum_{k,s?1}^{N} Q_k L_s,\ k,s ? 1,,,,N$$

If the two lotteries is equal in expected utility, then:

$$L_s ? \sum_{k,s?1}^{N} P_{ks} Z_k \sim \sum_{k,s?1}^{N} Q_k L_s ? \mathrm{L}'$$

Where L' can be rewritten as:

$$L' ? \sum_{k,s?1}^{N} Q_k L_s \; ? \sum_{k,s?1}^{N} P_{ks}^{*} Q_k Z_k \; ? \quad P_{ks} \; ? P_{ks}^{*} Q_k$$

As the expressions above shows, a complex lottery can be substituted by a simple lottery and the compounded probability is calculated as the sum of the product of the probabilities in the complex lottery. An individual is only concerned with the marginal probability for the different outcomes.

BAYES THEOREM

This part is based upon the original paper by Rev. Bayes[71]. Consider a decision with a probability distribution (P_1 and P_2) for a decision under risk that is described by two states (A and B) of the world with payoffs Z_1 and Z_2.

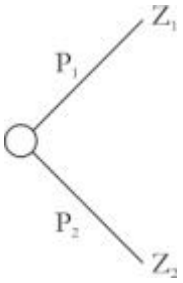


Figure 14 Decision tree with original probabilities and payoffs.

If new knowledge become available that affirm that the real state of the world will be either A or B with a probability distribution. The probability that the real state of nature is A, is given by the probability P_{11} similarly the probability that the real state of nature is B is given by P_{22}.

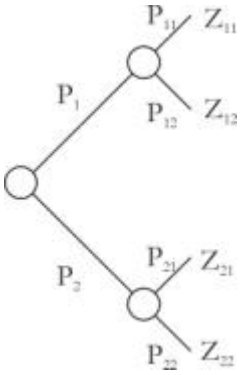


Figure 15 Original decision tree with affirming activities.

Bayes theorem conclude that the compounded conditional probability can be calculated through the following formulas (7) (8):

[71] Rev. Bayes, T., (1763)

$$P(P_1 \mid P_{11}) ? \frac{P_1 * P_{11}}{P_1 * P_{11} ? P_2 * P_{21}} \quad (7)$$

$$P(P_2 \mid P_{22}) ? \frac{P_2 * P_{21}}{P_1 * P_{11} ? P_2 * P_{21}} \quad (8)$$

The original probabilities have hence changed from P_1 and P_2 to $P(P_1 ? P_{11})$ and $P(P_2 ? P_{22})$.

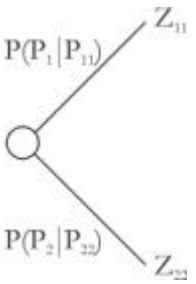


Figure 16 Conditional probabilities and payoffs.