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Bachelor's thesis

IT PROJECTS UNCERTAINTY REDUCTION BY MEANS OF REAL
OPTIONS AND CLOUDS

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Declaration

I confirm that the Bachelor thesis was disposed by myself and independently, under leading of my thesis supervisor. All sources of the documents and literature are stated.

In Prague

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Name and Surname

Acknowledgments

I dedicate this work to my parents, who always love me despite my flaws.

I would like to thank my supervisor Ing. Pavel Náplava, for his advices, interests, patience and great support in all my beginnings.

My parents for supporting and sharing love with me in times of weakness.

Tolkynay Kartabayeva

Abstract

The goal of this thesis is to define, research and compare approaches of the economical assessment of IT project investment in cloud environment. In the first part of the thesis, there is explanation of uncertainty events, known as Black/Grey/White swans. Their influence toward IT projects. The second part of thesis is possibilities of investment calculations, their description including quantitative criteria and formulas, but more focus on real options method approach. The next part of thesis elaborates with properties of cloud computing, where its advantages, disadvantages, components, services and infrastructures are mentioned and clarified. At the end, there is business and technology of cloud computing is penetrating to each other, while an example is evaluated with real options method.

Keywords

Investment assessment methods, Investment, Cloud computing, Real options method, Volatility, Flexibility, Black/Grey/White swan.

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Introduction

Evaluating the costs and benefits of information technology (IT) projects is currently a major issue for senior general managers. Many organizations report that they are uncertain how to measure the impact of their IT investments.

The general unease masks more specific issues such as whether an organization has achieved value for money for its IT expenditures and how corporate and IT strategies should be aligned. This bachelor thesis focuses on one particular issue that is a major practical concern: how can organizations appraise IT investments in taking the decision to go ahead with them or not? Also to research and compare approaches of the economical assessment of investment in cloud environment, and analyze the use of one of these approaches - methods of real options, for a decision on investment in this area.

Risk of failure, as the result of an incorrect planning, can be minimized by using a wide range of existing methods and using new technologies. I will focus on connection with cloud computing and methods of real options valuation in the area of IT companies (IT projects). Cloud computing helps to reduce a required initial investment, real options valuation methods shows how to evaluate the profit and at the same time reflect the uncertainty that exists in IT projects. The first chapter is devoted to a special form of uncertainty events, known as black/grey/white swans. Furthermore, there are several methods of investment evaluation that are compared with each other. The intention is mainly to highlight the differences between them. The fourth chapter is devoted to cloud computing. Explain its definition by Gartner group and by National Institute of Standards and Technology (NIST), characteristics, service and deployment models. As a conclusion, there is given an example to show calculation of real option valuation in practice and to analyze results.

1. Information technology areas

Therefore topic of this thesis is IT projects uncertainty reduction by means of real options and clouds, first of all I'll begin by taking a closer look at a market where clouds belong. This market is information technology. IT investments are made to achieve a broad range of managerial objectives. Managers expect IT investment to influence performance in a number of ways, which includes:

- Provide a competitive advantage by facilitating rapid response to changing needs in the market place.
- Provide timely and accurate information to facilitate better decision making.
- Reduce the cost of doing business by substituting capital for labor often automating the transactions of the firm.
- Allow the firm to compete in marketplaces requiring a specific technology (e.g. ATMs for banks, EDI for parts suppliers).
- Provide flexibility so that firms can handle a wider array of customers' needs without cost increases.
- Provide a technological platform to enable other business systems to be produced.

The type of IT is often referred to as an infrastructure. Despite of the uncertainty in large investments are made in IT infrastructure as the enabling foundation for other business systems. What distinguishes infrastructure is that it is IT shared throughout the firm. Infrastructure investment is long-term in nature, often takes advantage of economies of scale of centralized investment, and supports a shared firm-wide vision.

1.1 White/Grey/Black Swans

Today's fast changing world creates more uncertainty for organizations and makes it harder for them to understand where new risks are going to come from. Movements on the investment market are always fluctuating. We can perform Monte Carlo simulations to model the interactions to help to understand the potential outcomes, but these simulations are only as good as the inputs to the model. Value is rare, extreme and obvious in hindsight

which brings us nicely onto a rather special form of uncertainty. In fact, there are three types of swans. A special form of uncertainty is a black swan event. “These are a form of “unknown unknowns” that produce extreme results. The notion of black swan events was first set forth by Nassim Nicholas Taleb, a finance professor and former Wall Street trader. He defines three attributes that are common to all black swan events:

- The event is unpredictable (to the observer)
- The event has widespread branching
- After the event has occurred, people will assert that it was indeed explainable and predictable (hindsight bias)”. [1]

We can define the black swan as an event of low probability but high impact. They rarely fly and not even every year. The black swans do not appear out of nowhere and suddenly, before them there are grey swans fly. Organizations should construct the criteria of «grey swan» for its strategy. They are called grey because their timing is unpredictable but the vary fact that you have a system consisting of many interacting elements makes their eventual presence inevitable. What we may be able to impact is their frequency through changing systems characteristics. The grey swan event is a bridge that can only handle, let's say, certain size trucks, for example two-ton trucks and you know, trucks can be much bigger than that. So all it would take is a couple of those for the bridge to collapse. That would be a grey swan. And then there's the current crisis, which is actually a white swan event. The white swan is a bridge that can only handle these trucks, and you are certain because you have seen from a helicopter a few big six-ton trucks coming on the highway, and so you know the bridge is going to collapse, it's only a matter of time. The figure 1 below sums up the categorization of the three swan events.

Uncertainty to Certainty	Black Swan Event: Highly improbable <i>3 principal characteristics:</i> <ul style="list-style-type: none"> ➤ Unpredictable ➤ Massive impact ➤ After the fact, explained to appear less random and more predictable. 	Grey Swan Event: High probability <i>3 principal characteristics:</i> <ul style="list-style-type: none"> ➤ Predictable ➤ Impact can easily cascade ➤ After the fact, shifts focus to errors in judgment or some other human form of causation. 	White Swan Event: High certainty <i>3 principal characteristics:</i> <ul style="list-style-type: none"> ➤ Certainty ➤ Impact easily estimated ➤ After the fact explanation shifts the focus to errors in judgment or some other human form of causation.
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Figure 1 Categorization of the three swan events. [2]

According to what type of swan event, we can use and calculate investment evaluation methods. It's clear that if an event is about white swan, we will normally calculate and make a decision based on an investment costs and predicted profit. However, in case of black swan events, the thing is quite complicated. Common sense dictates that reliance on the record of the past (history) as a tool to forecast the future is not very useful. We will never be able to capture all the variables that affect decision making. Hence, there are various types of investment valuation methods use to predict profitability of IT project in case of uncertainty and these methods are described in the next chapter.

2. Investment evaluation methods

One of the key steps for an IT investment decision maker is to evaluate the investment to ensure that it is truly in the interest of the organization. Gauging the time frame for an investment makes IT investment evaluation a difficult task, as the cost of technology is high at the beginning (when the technology is introduced) and decreases over time. On the other hand, early investment in the technology can give a competitive advantage to the organization. IT investments are generally perceived as risky due to uncertainties in their implementation and their benefits. Managerial flexibilities such as postponing new applications, switching to another platform, and speeding up a project help managers to deal with uncertainties in investing in new projects. Real options are one of the techniques used in the economics of IT to capture managerial flexibilities and gauge the benefits of IT investments. But before explaining real option, there are various methods of investment evaluation, which I'd like to mention.

2.1 Investment decision criteria

When trying to figure out which valuation method to use to value investment, there is no one method that is best suited for every situation. Each business is different, and each industry sector has unique properties that may require varying valuation approaches. I will attempt to define the general cases of when to use most of the valuation methods. That's why it is better to specify some parameters (criteria) as these following questions:

- Does method take the time value of money into consideration?
- Does method adjust for risk?

- Does method tell us whether and by how much the project add value to the firm?

After each method, I will try to ask these questions and answer by summarizing method's pros and cons, so that at least we can specify the most suitable investment evaluation method.

2.1.1 Payback period

Payback period as a tool of analysis is often used because it is easy to apply and easy to understand for the most individuals. The payback period is considered a method of analysis with serious limitations and qualifications for its use, because it does not account for the time value of money, risk, financing, or other important considerations, such as opportunity cost. Calculated as:

$$\text{Payback Period} = \text{Initial Investment} / \text{Cash Inflow per Period}$$

Investment criteria of payback period:

$$\text{Payback period} \rightarrow \text{MIN}$$

The goal is to find a project that will have the lowest payback period.

Payback period is probably the easiest method of investment evaluation. It is clear for everyone that it is a period of time required to recover the cost of an investment. All other things being equal, the better investment is the one with the shortest payback period. For example, if a project costs 100,000 CZK and is expected to return 20,000 CZK annually, the payback period will be 100,000/20,000 CZK, or five years.

According to our criteria let's conclude payback period. It's advantage:

- Easy to understand and communicate.

But its disadvantages:

- Ignores the time value of money.
- Fail to consider the riskiness of the project.
- Ignores cash flows beyond the cutoff.
- Biased against long-term projects, such as R&Ds.

Payback period's disadvantages is more than its advantages, so that it leads to "low" predicative value, which is not good for IT projects investment valuation.

2.1.2 Discounted Payback Period

An extended version of payback period (see previous part. [2.1.1](#)) which is commonly called as discounted payback period. Only difference it makes is the cash flows used are discounted cash flows, but it also does not consider the cash flows after payback period. Calculated as:

$$\text{Discounted Payback Period} = \text{Actual cash Inflow} / (1 + r)^n$$

where,

- **r** is the discount rate;
- **n** is the period to which the cash inflow relates.

Here, the discount rate refers to the interest rate used in discounted cash flow (DCF) analysis to determine the present value of future cash flows. The discount rate takes into account not just the time value of money, but also the risk or uncertainty of future cash flows; the greater the uncertainty of future cash flows, the higher the discount rate.

Investment criteria of discounted payback period:

Discounted Payback Period → MIN

The goal is to find a project that will have the lowest discounted payback period. To conclude discounted payback period, it is better to show its good and the bad sides.

- Advantage:
 - Still fairly easy to understand and communicate.
 - Take time value of money into consideration.
- Disadvantages:
 - Requires an arbitrary cutoff point.
 - Ignores cash flows beyond the cutoff.
 - Biased against long-term projects, such as R&Ds.

Unlike to payback period, discounted payback period consider time value of money, which is one of the criteria that we highlight. This makes its predicative value as “medium”.

2.1.3 Return on investment - ROI

Return on investment (ROI) is one of the most preferred and mostly used methods of investment evaluation. ROI is usually expressed as a percentage and is typically used for

personal financial decisions, to compare a company's profitability or to compare the efficiency of different investments. Calculated as:

$$ROI = (Gain\ from\ Investment - Cost\ of\ Investment) / Cost\ of\ Investment$$

Investment criteria of ROI:

$$ROI \rightarrow MAX$$

The goal is to find a project that will have the highest ROI.

The advantage of ROI is simplicity and relatively easy interpretation of results. ROI is one of the most used profitability ratios because of its flexibility. When using ROI to compare investments, it's important to use the same inputs to get an accurate comparison. Also, it's important to note that the basic ROI calculation does not take time into consideration. ROI does not account for the time value of money. However, for the short-term projects, it is very convenient, so that makes its predicative value as “medium”.

2.1.4 Net present value (NPV)

The net present value (NPV) is a method that investors use to select the most profitable projects to invest in. Since it essentially determines the present value of the gain or loss of an investment, it is easy to understand and is a great decision making tool. Method is often used because it is relatively easy to use, easily comparable, and customizable. A project's NPV is based on its future cash flows and initial cost. Calculated as [3]:

$$NPV = \sum_{t=1}^T \frac{C_t}{(1+r)^t} - C_0$$

where:

- C_t = net cash inflow during the period
- C_0 = initial investment
- r = discount rate, and
- t = number of time periods

Investment criteria of NPV:

$$NPV \rightarrow MAX \wedge NPV \geq 0$$

In theory, an investor should undertake positive NPV investments, and never undertake negative NPV investments. Thus, NPV makes the decision making process relatively straight forward. It follows that in case of negative NPV, we will not invest in this project. But there are several types of projects where this rule does not apply.

Net present value is considered to be the best way to analyze, evaluate, and select big investment projects. At the same time, the estimation of cash flows requires carefulness because if the cash flow estimation is wrong, NPV is bound to be misleading. The disadvantages of NPV are that, it uses the same discounting rate for both cash inflow and outflows. We know that there are differences between borrowing and lending rates. As a conclusion let's specify shortly the advantages and disadvantages of NPV.

Net present value advantages include:

- uses cash flow not earnings;
- eliminates time component;
- results in investment decisions that add value.

Net present value disadvantages include:

- difficult to predict cash flows
- assumes a constant discount rate over life of investment

Despite its popularity, we match to NPV as a “medium” predicative value.

2.1.5 Internal rate of return

Internal rate of return (IRR) as NPV is concerned as one of the best investment evaluation methods in most articles. IRR is based on a similar principle as NPV, but with a little difference in a calculation formula. Calculated as:

$$\sum_{t=0}^T \frac{CF_t}{(1+IRR)^t} = 0$$

Where:

- IRR = internal rate of return
- CF_t = cash flow in t year
- t = year

The goal is to find out the required IRR at which the projects NPV will be equal to zero.

Investment criteria of IRR:

$$\text{IRR} \rightarrow \text{MAX} \wedge \text{IRR} \geq r$$

where:

- r = required rate of return

We calculate IRR for all variants of the investment, and then select the projects, where IRR will exceed a specified threshold (risk-free return, capital costs, and opportunity cost, etc.), and thus selected projects, which will be the highest IRR will be chosen. For most projects, NPV and IRR lead to the same conclusion. Investors really like to use IRR because this measure gives them a good idea about at what rate they are able to earn. IRR provides a measure about the value of a project to someone who doesn't know all the estimation details. That's why we can give it a "high" level of predicative value.

2.1.6 Total cost of ownership

Total cost of ownership (TCO) is a financial estimate intended to help managers determine the direct and indirect costs of a product or system. TCO includes a variety of cost of doing business items, for example ship, and opportunity costs, while it also considers incentives developed for an alternative approach.

Many different methodologies and software tools have been developed to analyze TCO. "TCO tries to quantify the financial impact of deploying an information technology product over its life cycle. These technologies include software and hardware, and training". [4] Technology deployment can include the following as part of TCO:

- Hardware
- Software
- Technical support, future upgrade
- Installation and integration of hardware and software
- Implementation
- Backup and recovery process, testing
- Technology training
- Development, modifications, replacement , scalability expenses
- License tracking - compliance
- Migration expenses
- Electricity (for related equipment, cooling, backup power)

- Human resources

Calculated as:
$$TCO = \sum_{i=1}^n Cost_i$$

Investment criteria of TCO:

$$TCO \rightarrow \text{MIN}$$

The goal is to find a project that will have the lowest TCO value. Applying TCO Model provides sourcing decision validation using full information to determine if a company should insource, outsource or offshore. Hence, its predicative value is “high”.

2.1.7 Total value of ownership

An improved alternative concept of TCO is total value of ownership (TVO), which differs from TCO in that it considers the benefits of alternative investments. It is a comparative measure that evaluates the TCO and any additional benefits, such as the mobility of laptops when compared to desktop computers. As the potential benefits in our case we have in a mean cloud technology, which currently does not always offer a significantly lower TCO and a quick return, but allow reaching as higher labor flexibility for employees while maintaining or even increasing work performance or level of information security.

Calculated as:

$$TVO = \sum_{i=1}^n Revenue_i - Cost_i$$

Investment criteria of TVO:

$$TVO \rightarrow \text{MAX}$$

The goal is to find a project that will have the highest TVO.

Given a limited research regarding TVO it is hard to find a clear definition of the concept. Nevertheless, it is clear from the discussion above that TVO expands the concept of TCO by including revenue aspects on top of the total cost. Therefore defining profit from investment is not easy to calculate and method of measurement is costly. Like the TCO, investment evaluation method’s results can be compared only with the investments of the same characteristic and range. Hence, its predicative value is “low”.

2.2 Summary of investment valuation methods

Different businesses will use different valuation methods to either accept or reject capital budgeting projects. Although the NPV method is considered the favorable one among analysts, the IRR, Payback period and others are often used as well under certain circumstances. So far, NPV is the best criterion, and IRR is another almost equally good and important one. But these analyses mainly address independent projects whose acceptance or rejection has no implications on the acceptance or rejection of other projects. When projects have (real) options, NPV and IRR may perform poorly. In real life, there are several more types of investment valuation, such as real options that will make capital budgeting even more complex task. So the next chapter will be about real options valuation.

3. Real options valuation method

Real options valuation (ROV) method is one of the main points of my thesis. That's why I will devote more space and clearly specify this method over other methods. Real options analysis, as a discipline, extends from its application in corporate finance, to decision making under uncertainty in general, adapting the techniques developed for financial options to "real-life" decisions. Let's review the principle of financial options on a simple example:

“You figured out on an Internet an advertisement of a new computer with an attractive offer that is costs 20.000 CZK. After you come to the store to buy it, the seller announced you that the computer has already sold out. However, the sales manager gave you a promise (call option), that if you come to the store during the next two months, he will sell computer for 20.000 CZK. After that there are two scenarios can occur: in a few weeks when you come back to the store to buy a computer and see that the price of the computer would increase to 22.000 CZK. Therefore you will exercise a given promise (call option), and your net profit is 2.000 CZK. Or you come to the store and the price of the computer would decrease to 18.000 CZK. In this case, you will not exercise an option, but still you will buy the computer for a lower price. It is obvious that such a promise has a certain value. The third option is therefore to sell this promise (call option) to your friend for

example for 100 CZK (option premium). The strike price remains 20.000 CZK and the expiration date is for 2 months. If the price of the computer will be higher than 20.100 CZK, e.g. 22.000 CZK, your friend will exercise the option and will gain 1.900 CZK. If the price will be between 20.000 – 20.100 CZK, your friend will exercise the option and will lose less or equal than 100 CZK. If the price drops even deeply, your friend will still loose only 100 CZK and of course will not exercise an option”.

Real options can be considered options for conducting a certain action for an agreed price in a certain period of time. The option is European if the execution of the option (to buy a computer) is only possible at the maturity date (2 months). If an execution prior to the maturity date is possible, the option is American.

Like the rights for the future decisions to the value in the financial markets, we can also use the rights and determine in real business decisions. The rights are not about finance, but real assets and here we use term «real options valuation», also often termed «real options analysis».

Real option is not concerned as a substitute toward other group of methods, but as a suitable complement for the valuation flexibility and counting risk of a project. “Real options modelling allows a cost benefit analysis to take into account managerial flexibilities when there is uncertainty in the investment, while system dynamics can build a predictive model, in which one can simulate different real-life and hypothetical scenarios in order to provide measurements that can be used in the real options model”. [5] The value of the project can then be quantified as net present value (NPV) increased the value of the option, which is a ranking of flexibility. We can calculate the value of the project as:

$$\text{The project value} = \text{NPV} + \text{Option value. [6]}$$

ROV takes into account uncertainty about the future evolution of the parameters that determine the value of the project, coupled with management's ability to respond to the evolution of these parameters. It is the combined effect of these that makes ROV technically more challenging than its alternatives. It is precisely the way in which real options deal with uncertainty and flexibility that generates their value. “Real options are not just about "getting a number", they also provide a useful framework for strategic decision making”. [7]

3.1 Flexibility

Changing circumstances often influence ongoing IT projects. As it was described in the chapter [1.1](#) swan events, almost every IT company faces with uncertainty, especially in case of black swan which badly influence to ongoing business. Therefore, companies must be able to flexibly react to new situations. That's why project flexibility is inherently valuable. Managers who are empowered to think about more adaptive and flexible strategies will adjust to black swan events more quickly and more successfully. Profitability increases with the ability to change the direction of a project as knowledge is accumulated during the design phase. However, traditional project valuation-modeling methods, such as net present value (NPV), or, as it is occasionally termed, discounted cash flows (DCF), do not appropriately value flexibility or quantify risk. “A major shortcoming of NPV analysis is that it fails to recognize that management has flexibility to alter the path of a project, and thus increase overall project value”. [8] Flexibility is clearly important in the evaluation of many investment opportunities under volatility (uncertainty). By delaying an investment decision, new information can be revealed that might affect the desirability of the investment, while management has the option to discontinue the project if market conditions turn out to be unfavorable.

3.2 Volatility

A key role in determining the value of option influencing segments are shares, option exercising time, historical, current and predicted situation in the market. These properties are summarized in the parameter "volatility". Volatility is a measure of uncertainty. “It is a bridge toward real options, where represents the variability of the market in which IT projects move. It brings to the strategy a neglected flexibility of the external environment. Higher value of volatility represents a higher dispersion of business success as possible towards higher losses and higher profits. Prediction probability of success (failure) is vice versa lower and risk is higher. The reason for this is instability of a segment and a low level of competition, which derives from the “novelty” (ignorance) of segment and new ideas that creates segment. Low volatility is more stable environment. It is based on a good knowledge of already existing market segment, existing competition and rigidity with regard to possible and meaningful innovation of that segment. This market is well predictable and possible variance of profit/loss is small”. [9]

Real option method is based on the evaluation of the product and works with its volatility. According to the table below (see figure 2) we can estimate the volatility of the project implemented in a specific market as following:

Industry name	Number of firms	Volatility 2013	Volatility 2012	Volatility 2011
Advertising	52	38,15%	75,44%	77,55%
Aerospace/Defense	93	43,84%	37,56%	51,49%
Air Transport	22	35,16%	46,40%	54,83%
Apparel	64	48,63%	67,70%	77,93%
Auto & Truck	22	26,76%	36,66%	39,72%
Bank(Money Center)	13	20,38%	29,39%	33,89%
Banks (Regional)	676	24,97%	27,02%	36,66%
Beverage	22	47,34%	40,40%	55,18%
Building Materials	39	35,23%	55,65%	50,00%
Cable TV	18	40,16%	28,13%	35,05%
Chemical (Basic)	46	39,08%	33,12%	40,97%
Coal & Related Energy	42	45,37%	38,99%	45,76%
Computer Services	119	49,34%	65,05%	77,48%
Computers/Peripherals	64	61,79%	76,08%	90,50%
Diversified	23	23,30%	40,23%	46,56%
Drugs (Biotechnology)	400	87,28%	72,45%	92,48%
Education	42	57,89%	61,91%	61,72%
Electrical Equipment	126	62,02%	63,52%	77,01%
Electronics (General)	189	48,58%	56,96%	83,88%
Engineering/Construction	56	50,88%	60,72%	70,39%
Entertainment	84	52,86%	56,96%	83,88%
Farming/Agriculture	37	45,29%	47,69%	68,43%
Healthcare IT	127	61,32%	40,74%	62,66%
Hotel/Gaming	80	36,06%	42,32%	58,18%
Information Services	67	38,74%	40,29%	39,37%
Insurance (Life)	25	23,54%	30,55%	37,38%
Investments	148	28,14%	22,76%	66,28%

Machinery	137	40,04%	39,80%	37,49%
Metals & Mining	124	55,13%	83,22%	38,49%
Office Equipment & Services	25	36,72%	35,33%	17,23%
Oil/Gas Distribution	85	32,36%	26,06%	53,22%
Packaging & Container	26	23,20%	26,41%	66,84%
Paper/Forest Products	22	33,21%	40,08%	34,04%
Power	82	19,96%	46,34%	85,40%
Publishing & Newspapers	43	37,87%	52,12%	39,63%
R.E.I.T.	213	20,35%	27,44%	36,17%
Restaurant/Dining	79	36,84%	46,24%	78,52%
Retail (Wholesale Food)	21	37,48%	23,89%	19,92%
Semiconductor	100	52,72%	49,76%	61,53%
Steel	40	36,76%	33,01%	79,79%
Telecom. Equipment	126	57,52%	58,83%	54,96%
Trucking	30	33,65%	37,16%	18,14%
Utility (Water)	19	28,35%	25,24%	12,46%
Total Market	7887	37,27%	45,36%	56,59%

Figure 2 Volatility report 2013. [10]

Regarding the market with a low volatility (e.g. automobile, food, banks), it is possible to predict future volatility based on the past development with a simple arithmetic average value or according to the value for the last period. In case with the market with high volatility (e.g. pharmacy, computer, power), it is necessary to monitor the development of volatility and predict it with help of extrapolation methods (linear regression etc.).

Volatility table gives us a fundamental knowledge of the value of volatility of the market where we can exactly want to run our project or make an investment for. But how calculate the volatility of a particular project more precisely? The procedure begins with the project pro-forma worksheet using expected values for project uncertainties, which is used to calculate the discounted net present value V of the project in time period 0. Next, key project uncertainties are entered as simulation input variables in the project cash flow pro-forma spreadsheet, so that each iteration in a simulation of the worksheet provides a new randomly sampled set of future cash flows from which the project value at the end of the first period V_1 is computed. Then a sample of the random variable γ can be calculated

as:

$$\tilde{\gamma} = \ln\left(\frac{V_1}{V_0}\right)$$

where γ is the project return between time zero and time 1. The estimate of the standard deviation of γ , denoted as s , can be obtained from the simulation results. The project volatility σ is then defined as the annualized percentage standard deviation of the returns, and is estimated by relationship $s \div \sqrt{\Delta t}$, where Δt is the length of the time period in years used in the cash flow pro forma worksheet. If the time period between V_1 and V_0 is one year, then $\sigma = s$.

This approach can be illustrated with the simple five-period example shown in Figure 3. Let's assume in this example that the project is subject to a single source of revenue uncertainty that is approximated by a GBM stochastic process with a growth rate $\alpha = 6\%$ and a volatility $\sigma_s = 25\%$, variable costs equal to 30% of revenues, and a fixed cost of \$3,000 in each of the five years of the project. We also assume that the firm will use a risk adjusted discount rate of $\mu = 10\%$. Given the initial estimate of the revenue in period 0 of \$10,000, the GBM process is approximated in discrete time in Excel by setting the revenue estimate in Period t+1 equal to the revenue estimate in Period t times $\exp(\nu\Delta t + \sigma_s \text{NORMINV}(\text{RAND}(0,1))\sqrt{\Delta t})$ where $\nu = \alpha - \sigma_s^2 / 2$ and $\Delta t = 1$ in this case since the time periods are one year. While this example project is very simple, it is representative of pro forma spreadsheet models used in practice.

	\$ 1000	0	1	2	3	4	5
Revenue		10,000	10,600	11,236	11,910	12,625	13,382
Variable Costs 30%			(3,180)	(3,371)	(3,573)	(3,787)	(4,015)
Fixed Costs			(3,000)	(3,000)	(3,000)	(3,000)	(3,000)
Investment		(20,000)					
Free Cash Flow		(20,000)	4,420	4,865	5,337	5,837	6,368
		V_0	V_1				
		19,990	21,989				
Invest. =		(20,000)					
NPV ₀ =		(10)		$\mu = 10\%$			
Revenue Parameters			Growth (α) =	6.0%			
			$\sigma =$	25%			

Figure 3 Example project with variable and fixed costs.

In figure 3, $V_0 = \$19,990$ is the present value of the expected cash flows from Period 1 to Period 5, discounted one year to Period 0, while $V_1 = \$21,989$ is the present value of the expected cash flows discounted to Period 1. The volatility of this project can be estimated by Monte Carlo simulation with this pro forma, where V_0 is a constant with the value shown above, but V_1 is a random variable which is recalculated in each iteration of the simulation, based on the realizations of the stochastic cash flows in Periods 1 through 5.

3.3 Determining the value of real options

The model that will be chosen for determining the value of a project using real options must accord the time aspect. If the option right usable at any time during expiration date, it is about an American option and its value can not be determined by traditional Black-Scholes model, but binomial model. Otherwise it may be exercised only at the expiration date of the option, the option is European and calculation can be used as the Black-Scholes and binomial model. In fact it is recommended to use the Black-Scholes because it has more simple application model and gives more accurate estimated value.

The Black-Scholes model calculates the value of a call option holds a value European (see prev. example with computer) option at the time T the maturity can be determined by Black-Scholes formula:

$$C = S \times N(d_1) - X \times e^{-rT} \times N(d_2)$$

where:

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r + \frac{\sigma^2}{2}\right) \times T}{\sigma \times \sqrt{T}}$$

$$d_2 = \frac{\ln\left(\frac{S}{X}\right) + \left(r - \frac{\sigma^2}{2}\right) \times T}{\sigma \times \sqrt{T}} = d_1 - \sigma \times \sqrt{T}$$

- S = is the spot price of the underlying asset,
- r = is the risk free rate (annual rate),
- T = is the time to maturity,
- σ = is the volatility of returns of the underlying asset

- X = is the strike price.
- e = natural logarithm
- $N(d_1), N(d_2)$ = is the cumulative distribution function of the standard normal distribution for d_1, d_2 .

The same for the value of European put option at the time of its maturity T can then be determined as follows:

$$C = S \times N(-d_1) - X \times e^{-rT} \times N(-d_2)$$

In order to better understand the principle of the calculation let's have a look to a simple example.

3.3.1 A simple example of the real options methods

To illustrate a real options valuation, let us first examine a project using a simple business case analyzed from an NPV approach. Imagine the company Boeing has the opportunity to design and build a small aircraft specialized for air cargo transport. A new specialized freighter might be competitive for transporting luxury goods. However, the specialty freighter remains a risky investment proposition because the air cargo market is difficult to forecast and therefore unit sales and price forecasts can vary greatly depending upon assumptions about the market. The engineers and marketing analysts are requesting authorization to spend 75 million CZK (Czech Koruna) in R&D expenses over the next three years. After three years, contingent on the success of the engineering efforts and a promising market forecast, Boeing would commit a one-time expenditure of 2.0 billion CZK to launch the air freighter. The strategic investment question facing senior management in this example is whether to authorize the 75 million CZK R&D expenditure. Over the last half-century or so, corporations have answered that question by applying NPV analysis to determine whether project net profits exceed the initial investment. NPV of the net profits is commonly based on the value estimates for the business case variables reflecting the most likely outcome of assumptions about the product strategy and market reception. NPV analysis typically discounts all cash flows at a common rate: the Project Risk rate, a rate established by management to meet a required rate of return for project investments. This rate is sometimes referred to as a hurdle rate. Applying the Excel NPV function with the Project Risk discount rate of $r_p = 15$ percent, the project net present value at Year 0, today, is estimated to be a negative 187 million CZK (see Figure 4).

Discount Rate Assumptions	
Project Risk Rate, r_p	15.0%
<i>NPV Calculations</i>	
PV_0 NPV Operating Profits	1,203
PV_0 NPV Launch Costs	1,315
R&D Expenses	75
Total Project NPV Value	187

Figure 4 NPV most likely results.

Under standard NPV decision-making, senior management would deny the request for initial funding of 75 million CZK because the freighter project is forecasted to lose money.

Let's have a look to the same project through real options valuation methods. Flexibility in projects implementation brings an effect similar to financial option, so it is called real option. To extend the NPV analysis beyond a single most-likely scenario, a common practice is to assess several scenarios.

To take into account the cost of real options at the moment, as a rule, there are three types of models which were originally developed for the assessment of financial options: compound-option approximation method; finite-difference methods; binomial model.

Compound-option approximation method assumes that the value of the asset has a log-normal distribution or that the proceeds are normally distributed. For relatively clear investment opportunities compound-option approximation method uses the Black-Scholes model.

Finite difference methods is a common method for the numerical approximation for the valuation of options. The method involves converting the corresponding differential equation with continuous time into a set of differential equations with discrete time and solution of these equations using a standard iterative reverse process. Although these models are easy for understanding than models of compound-option approximation, but it requires deep knowledge in the field of mathematics for use in practice.

The binomial pricing model traces the evolution of the option's key underlying variables in discrete-time. This is done by means of a binomial lattice (tree), for a number of time steps between the valuation and expiration dates. Each node in the lattice represents a possible price of the underlying at a given point in time.

Let's return to the previous example and use Datar–Mathews option pricing model attempts to provide a more transparent and intuitive approach to valuing project options.

The Datar–Mathew Method can be understood as an extension of the NPV multi-scenario Monte Carlo model with an adjustment for risk-aversion and economic decision-making. The D–M Method uses two discount rates:

1. $r_p = 15\%$, the hurdle rate, for the project operating profits, those cash flows that are at market risk.

2. $r_f = 5\%$, for investments that are relatively secure and over which the corporation has fairly extensive control, such as the launch cost.

The net profit is the difference between the two discounted cash flows(Operating Profits – Launch Cost). The result is the Year 0 net profit present value distribution (histogram) for the hundreds of cash flow scenario trials shown in Figure 5.

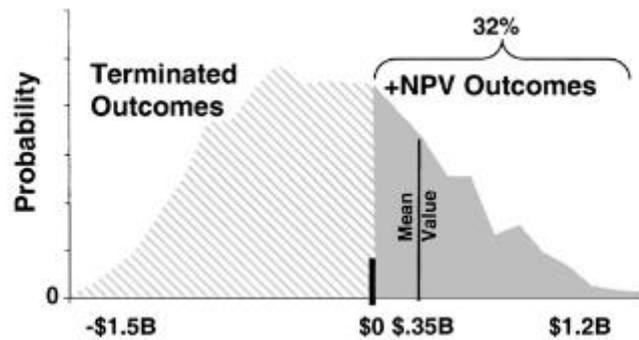


Figure 5 Year 0 net profit present value distribution.

The Terminated Outcomes section on the left tail of the present value distribution represents scenarios in which the discounted launch cost is anticipated to exceed the operating profits. In these instances of negative net profit, the rational choice is to avoid potential substantial losses by terminating the project. The right tail corresponds to the 32 percent of scenarios with a positive NPV outcome where the discounted operating profits exceed the launch cost. The real option value can be understood as the average of the appropriately discounted Year 0 net profit, contingent on terminating the project if a loss is forecast. The real option value, which is easily generated by the Monte Carlo software, is the average value of this payoff distribution, approximately 113 million CZK in this example. The 113 million CZK option value is the maximum amount the company would be willing to pay today for the opportunity to participate in the air freighter project. The company could choose to invest the total amount or a portion into its R&D effort. The engineers and marketing analysts are requesting authorization to spend 75 million CZK in R&D expenses over the next three years.

Based on the real option value of the business prospects, management has the justification to invest in the freighter project. The real options approach delays the “go forward” or “terminate” decision until Year 3, when there is more information and a better decision can be made. The formal calculation of the real option value is done using the Boeing Datar–Mathews Method as follows:

$$\text{Real option value} = \text{Mean} [\text{MAX} (\text{operating profits} - \text{launch cost}, 0)]$$

An intuitive understanding of real options is useful during strategy discussions. An estimator for the real option value can be expressed as a function of positive NPV project outcomes in the following formula:

$$\text{Real option value} = \text{NPV Risk Adjusted Probability} \times (\text{Operating Profits} - \text{Launch Costs})$$

For example, in Figure 4 the risk-adjusted probability of positive NPV forecast is 32%, and the appropriately discounted mean net profits value (operating profits – launch costs) of the successful outcomes is \$0.35B. Using these values in the above formula produces real options value of the project given its contingencies:

$$\text{Real option value} = 32\% \times (0.35\text{B CZK}) \approx 113 \text{ million CZK}$$

A real options approach gives management the justification to commit a contingent strategic investment in technology, engineering and marketing R&D prior to the launch.

3.4 Summary methods of investment evaluation

While comparing the various methods among others, in fact there are main three categories of criteria. The first category is simple criteria used for the initial orientation of the investment problem, but does not calculate the time value of money, which is quite wrong. These methods are called static methods. The second group of methods are based on the time value of money. These methods are now well known and use criteria of NPV, IRR and real options method. The last group of methods are more complex which is known as a multi-criteria evaluation methodology, which may include, as one of the criteria to use the methods mentioned above. The question is when exactly and which group of methods to use. The first group is more suitable for fast, indicative calculations. The real options approach is more dynamic than the traditional approaches since it is capable of incorporating not only the value of flexibility and growth opportunities but also of competitive strategies in an uncertain environment. If the result has to be obtained thorough rating of the investment, other two groups should be used. For a comprehensive summary of properties of the methods here is the table with all the evaluation criteria for

investment. See the following table (see figure 6).

3.4.1 Summary table of investment evaluation

Name	Abbreviation	Calculation	Investment criteria	Advantages	Disadvantages	Predicative value
Return On Investment	ROI	(Gain from Investment - Cost of Investment) / Cost of Investment	ROI→MAX	Simplicity Priority	Do not consider the time value of money.	Medium
Payback period	PP	Initial Investment / Cash Inflow per Period	PP → MIN	Simplicity Priority	Ignores cash flow. Do not consider the time value of money.	Low
Discounted payback period	DPP	Actual cash Inflow / $(1 + r)^n$	DPP → MIN	Priority Considering the time value of money.	Ignores cash flow. Do not consider the time value of money. Applied for short term period projects.	Medium
Net present value	NPV	$\sum_{t=1}^T \frac{C_t}{(1+r)^t} - C_0$	NPV→ MAX NPV ≥ 0	Widely use and preferred criteria.	Determination of discount. Difficult to	Medium

				Considering the time value of money	understand.	
Internal rate of return	IRR	$\sum_{t=0}^T \frac{CF_t}{(1+IRR)^t} = 0$	IRR → MAX IRR ≥ r	Well known and preferred criterion.	Difficult to understand.	High
Total costs of ownership	TCO	$\sum_{i=1}^n Cost_i$	TCO → MIN	Usability in any area.	Can't effort high flexibility, ability react to unexpected changes.	High
Total value of ownership	TVO	$\sum_{i=1}^n Revenue_i - Cost_i$	TVO → MAX	Consider both costs and profits.	Determination of monetary value and benefit of the firm.	Low
Real options	RO	$C = S \times N(-d_1) - X \times e^{-rT} \times N(-d_2)$	RO → MAX	Consider uncertainty.	Difficult to understand. Volatility determination	High

Figure 6 Summary table of investment methods. [11]

4. Cloud computing

Cloud Computing has recently emerged as an attractive model of providing Information Technology (IT) infrastructure (i.e., computing, storage, and network) to large as well as small enterprises both in private and public sectors. An enormous surge in the popularity of cloud computing is partly driven by its promise of on demand scalability and flexibility without making upfront investment in setting up and running large scale computing infrastructures and data centers.

4.1 Cloud computing definition

The Gartner Group was the first who defined Cloud Computing as “a style of computing in which massively scalable IT-related capabilities are provided "as a service" using Internet technologies to multiple external customers.”[12] However, there have been different perceptions of what is included in cloud computing and the word “massively scalable” was replaced with “scalable and elastic” by Gartner Group. Gartner saw an opportunity for cloud computing "to shape the relationship among consumers of IT services, those who use IT services and those who sell them”. [13] Therefore a broad definition of cloud computing gives NIST (National Institute of Standards and Technology), as a “model for enabling ubiquitous, convenient, on-demand network access to a shared pool of configurable computing resources (e.g., networks, servers, storage, applications, and services) that can be rapidly provisioned and released with minimal management effort or service provider interaction”. [14] According to the NIST, we can see that cloud consists of five essential characteristics, 3 service models and 4 deployment models (Figure 16).

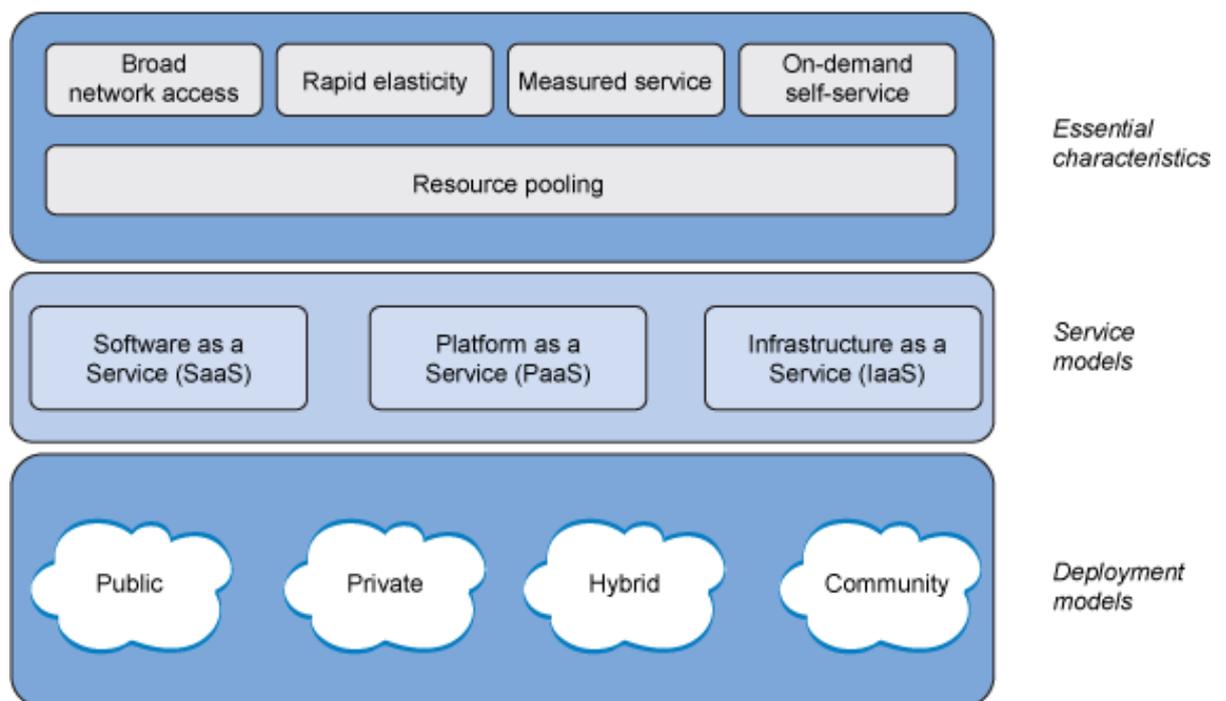


Figure 7 NIST cloud model. [15]

4.2 Five essential characteristics of cloud computing

As it was shown on a figure 16, there are five characteristics which should have each cloud.

These main five characteristics are:

1. **On-demand self-service:** A consumer can unilaterally provision computing capabilities, such as server time and network storage, as needed automatically without requiring human interaction with each service provider.
2. **Broad network access:** Capabilities are available over the network and accessed through standard mechanisms that promote use by heterogeneous thin or thick client platforms (e.g., mobile phones, tablets, laptops and workstations).
3. **Resource pooling:** The provider's computing resources are pooled to serve multiple consumers using a multi-tenant model, with different physical and virtual resources dynamically assigned and reassigned according to consumer demand. Examples of resources include storage, processing, memory and network bandwidth.
4. **Rapid elasticity:** Capabilities can be elastically provisioned and released, in some cases automatically, to scale rapidly outward and inward commensurate with demand. To the consumer, the capabilities available for provisioning often appear to be unlimited and can be appropriated in any quantity at any time.
5. **Measured service:** Cloud systems automatically control and optimize resource use by leveraging a metering capability at some level of abstraction appropriate to the type of service (e.g., storage, processing, bandwidth and active user accounts). Resource usage can be monitored, controlled and reported, providing transparency for the provider and consumer.

4.3 Deployment models of cloud

There are primarily four cloud deployment models, which have been recommended by NIST:

1. The private cloud. This model functions solely for one organization on a private network and is highly secure. The infrastructure required for hosting can be on-premises or at a third-party location.

2. The public cloud. This model represents true cloud hosting and is owned by the cloud service provider and offers the highest level of efficiency in shared resources. In this deployment model, services and infrastructure are provided to various clients. Example of a public cloud is Google.
3. The hybrid cloud. This is a combination of private and public deployment models. In a hybrid cloud, specific resources are run or used in a public cloud and others are run or used on premises in a private cloud. So that helps businesses to take advantage of secured applications and data hosting on a private cloud, while still enjoying cost benefits by keeping shared data and applications on the public cloud.
4. The community cloud. In this model, the cloud infrastructure is shared by several organizations with the same policy and compliance considerations. This helps to further reduce costs as compared to a private cloud, as it is shared by larger group.

4.4 Cloud computing models

Cloud computing consists of the following service models:

- Infrastructure as a service, IaaS
- Platform as a service, PaaS
- Software as a service, SaaS.

By using the IaaS model, organizations get infrastructure components such as computing power and storage capacity. Here, the organization has control over the entire IT infrastructure, including the hosting environment and their applications. However, the organization needs to allocate additional staff to maintain and manage the infrastructure and the application. Microsoft has proposed remote desktops and virtual machines to Microsoft Windows Azure as an IaaS offering.

The PaaS model provides organizations with a platform or a runtime environment to create and deploy applications. Here, the organization is only responsible for the development, maintenance, and management of the applications. Microsoft provides the Windows Azure platform as a PaaS offering.

The SaaS model provides organizations with ready-to-use applications that use a combination of cloud-based compute and storage services. Microsoft provides various

online services, such as Microsoft Business Productivity Online Suite, VPOS, and Microsoft Dynamic CRM Online as a SaaS offering.

To understand how cloud computing can help an organization extend its IT capabilities, consider Wide World Importers, a company that manufactures beauty products. Occasionally, the research department has to store and process a large amount of data. Consequently, the company is looking for a cost effective compute and storage solution. Additionally, Wide World Importers has a group of scientists situated at different geographical locations. The geographical barrier affects research requiring a better collaboration solution. In addition, the company is planning to develop a cost effective data mining application to collect visitor data during its week-long, worldwide annual beauty pageant.

Cloud computing provides Wide World Importers with an efficient and cost effective solution to their problems. Wide World Importers can subscribe for additional compute and storage services offered by Windows Azure on a pay-per-use basis to move all of its statistical data analysis and storage to Windows Azure. By doing so, they can invest more on research. Wide World Importers can use VPOS, Microsoft Live Meeting, and Microsoft SharePoint Online for efficient collaboration. For design, development, and testing of the data mining application, the company can use the Windows Azure platform to focus on software evaluation and reduce the time and cost required for preparation of the development and testing environment.

4.5 Advantages and disadvantages of cloud computing

Cloud computing offers numerous advantages both to businesses and end users. One of the most obvious advantage is that you no more have to support the infrastructure or develop environment or application. Hence, there are other advantages of cloud computing.

- *Cost efficient.* Cloud computing is probably one of the most cost efficient method to use, maintain and upgrade. The cloud, on the other hand, is available at cheaper rates, so that can significantly lower the company's IT expenses.
- *Almost unlimited storage.* Cloud gives us almost unlimited storage capacity for our data.

- *Easy access to information.* Once we register, we can access the information from anywhere, where there is an Internet connection.
- *Automatic software integration.* Software integration is something that occurs automatically. This means that we do not need to take efforts to customize our applications. This aspect usually takes care of itself.

In spite of its benefits, as mentioned above, cloud computing also has its disadvantages. Businesses, especially smaller ones, need to be aware of these disadvantages before going in for this technology.

- *Limited control.* Since the cloud infrastructure is entirely owned, managed and monitored by the service provider, it transfers minimal control over to the customer. The customer can only control and manage the applications, data and services operated on top of that, not the backend infrastructure itself.
- *Security in the Cloud.* Cloud potentially may put your company to great risk. Hence, we need to make absolutely sure that we choose the most reliable service provider, who will keep our information totally secure.

5. Connection between business and cloud computing

In terms of infrastructure, cloud computing is an attractive business opportunity of how incorporate in company's strategy planning flexibility of shared environment. First of all, take into account different scenarios of market development and build adequate infrastructure that will not neglect the business, but support on to it. There is one main question appears, how much should we invest so that we will be able to respond to any changes in the future. In other words, to be flexible. A tool that deals with flexibility is a real option, which can quantify the investment for future decisions.

Flexibility is called volatility in an option terminology, which introduces variability (volatility) of environment in which our business (project) moves. High volatility on the one hand poses high dispersion of business success, but on the other hand, the possibility of higher profits. Low volatility represents more stable environment, but also high level of competition and rigidity with respect to the existing representatives of the given market segment.

Real options help us with strategy planning and decisions about investment (business, project) in different environments by using volatility. We can say that real options provide with mechanism that calculates rates of investment (costs and revenues), which includes within a flexibility with regard to the future variability of the environment. The possibility to react according to their current situation can be modeled as a real option. Trigeorgis provides a good overview of possible types of flexibility as well as corresponding types of real options (Table 8).

Type of flexibility	Type of real option
A project can be abandoned at predefined milestones if it evolves unfavorably	Option to Abandon
The scope of a project can be scaled down if it evolves unfavorably	Option to Contract
The scope of a project can be scaled up if it evolves favorably	Option to Expand
The implementation of a project can be carried out in stages	Staging Option
The start of a project can be delayed	Option to Defer
The successful implementation of a project can lead to follow-up projects	Growth Option
Depending on the course of a project, the input resources can be replaced	Option to Switch

Figure 8 Types of flexibility/real options. [15]

This table shows a possible strategic considerations that can be executed by using real options mechanism. With clouds they provide first of all, the possibility of comparison with on-premise solution. So that for example, we compare investment on planning and development of our business (the company) in two cases. Thanks to mechanism of real options we are able to use clouds and quantify accurately costs of their use with regard to the company's future state. More detail will be on the following example below, where the company is running a new project to uncertain environment by using mechanism of real

options.

At the beginning of this chapter, I have defined the cloud, its characteristics and function, so now it is important to think about what cloud represents for companies and how it can support and what it brings to business. Qualified manager can easily respond to this question. A lot of IT companies, still argue about what kind of IT project to invest. Whether to buy your own equipment or rent it? How much does it cost to upgrade from old to new versions of software or hardware replacement? All of these questions are about costs and not only direct but also indirect costs. In order to get answers to all of these questions, managers should not take into account infrastructure as one a whole cost, but to calculate using TCO and check the result by using indicators as NPV, IRR or ROI.

To explain an assumption above, I chose one of the three types of real option.

- Option to defer: Here management has flexibility as to when to start a project. For example, in natural resource exploration a firm can delay mining a deposit until market conditions are favorable. However, in case if the company will not undertake an option, it loses its competitiveness on the market.
- Option to expand: Here the project is built with capacity in excess of the expected level of output so that it can produce at higher rate if needed. Management then has the option (but not the obligation) to expand – i.e. exercise the option – should conditions turn out to be favorable. A project with the option to expand will cost more to establish, the excess being the option premium, but is worth more than the same without the possibility of expansion.
- Option to contract: The project is engineered such that output can be contracted in future should conditions turn out to be unfavourable. Forgoing these future expenditures constitutes option exercise. This is the equivalent to a put option, and again, the excess upfront expenditure is the option premium.

5.1 Example of investment decision

Let's consider that there are students of FIT after graduating university decide to make an IT project. The project is about a location-based social discovery application that facilitates communication between mutually interested users. The idea of a project is to build a user profile with photos that have already been uploaded. Basic information is gathered and the users' social graph is analysed. Candidates who are most likely to be compatible based

on geographical location, number of mutual friends, and common interests are then streamed into a list of matches.

The life expectancy of the project is four years; the students (founders) hope that after this time they will sell this project. Each student is willing to invest twenty-five thousand Czech crowns (CZK) and a one year's work without any return. Discount rate in this case amounts to 3%.

5.1.1 Volatility estimation

One of the most common methods of determining volatility is according to the comparison of last year's experiences. Here we can easily use a figure 2 on chapter 3.2, so that we can estimate volatility of the project implemented in a specific market as following.

Industry name	Volatility	Volatility	Volatility
	2013	2012	2011
Entertainment	52,86%	56,96%	83,88%

Figure 9 Volatility of Entertainment industry for the last 3 years. [11]

This method in our case is quite inappropriate because of high volatility in a given industry. That's why it is recommended to use other methods, for which I decided to use logarithmic cash flow returns method. "This method provides a volatility factor that is based on the variability of the same cash flow estimates that are used in calculating the underlying assets value itself; therefore, it is most representative of the volatility of the asset value".[17]

First of all we calculate index of shifting I_k from the prediction from the future cash-flow, from which we define logarithmic value L_{I_k} , then standard deviation is found.

The following formulas are being used:

$$I_k = \frac{[CF_{k+1}]}{[CF_k]} \quad L_{I_k} = \ln(I_k)$$

The result of project volatility, which I will use in this example is 0.70. As an example for comparison I used the arithmetic average of the historical values. Approximately the result during 2 years is 0.50.

In the first year, there will run development and testing period. Because our FIT students have limited assets, they decided that first year will work on cloud and after decide whether to buy platform or not. According to the profit and demand at the end of this year, they will decide to expand or to sell the project. In fact, there is no point to consider to purchase own solution in the phase of testing. Because there are several reasons as uncertain demand for the service, high cost of training. This phase can be imagined as European options. Gives interested right defer the initiation of the project T years, in this case for a year, and during this period obtain additional information needed for a decision. If the situation will develop well, students can start the project, or exercise the option. Otherwise they will not exercise the project. This phase can be European option because it gives the right to exercise an option during T years, in this case for a one year. This given time (one year) will be enough to find out more information about future demand to this project and obtain additional information needed for a decision. If analyzed information will be good enough, students can start the project and exercise the option. Otherwise, they give up the project. In case of completion of the project, the students will get an option premium in an amount of 80.000 CZK. This amount is taken from Bitnami cloud hosting group, where students decided to rent a cloud. [18] As one of the main parameter for making decision, our students intent to reach at least 800.000 CZK as an income from service during testing period. This amount would cover the investments needed for their own solutions, and achieving more benefits for the future development of services. Here we can use the Black-Scholes option pricing model. The parameters for calculation are below:

- Current stock price $S = 600.000$ CZK.
- Cumulative standard normal probability dist. $S = 800.000$ CZK.
- Days until expiration $T = 1$ year.
- Risk free interest rate $r = 3.0\% = 0.03$.
- Volatility of future cash-flow $\sigma = 0.70$ (standard deviation)

First of all we should calculate parameters of d_1 and d_2 by using the formula:

$$d_1 = \frac{\ln\left(\frac{S}{X}\right) + \left(r + \frac{\sigma^2}{2}\right) \times T}{\sigma \times \sqrt{T}}$$

$$d_2 = d_1 - \sigma \times \sqrt{T}$$

After getting values of d_1 and d_2 , it is better to use NORMSDIST in Microsoft Excel, as it shown at a table below:

Option parameter	Calculated value
d_1	0,804
$N(d_1)$	0,789
d_2	0,104
$N(d_2)$	0,541

Figure 10 Calculation example

An obtained value we put on our Black-Scholes model, so that we get needed value of option.

$$C = S \times N(d_1) - X \times e^{-rT} \times N(d_2) = 316193$$

In our case, the value of the options, or rights to the future decisions is $C = 316.193$. If we take into account the maximum cost of running the cloud of 80.000 CZK, we get an approximate potential profit 235.000 CZK. It is clear to see that the project will be the most probably profitable. Otherwise, our loss will be in an amount of the option premium, maximum of the 80.000 CZK. We also should concern the situation, when service couldn't handle all requirements, but even though will make a profit, even it runs on a current cloud. Well in this case, our service providers can provide service during testing and developing period. Cloud computing brings a great range of possibilities how to deal with a given IT project, and allows us to respond to any changes that occurs on the market.

5.1.2 Option to expand example

We should review a case where this IT project succeeded during first year and here we chose the expensive cloud version. Cloud that we rent is configured for 150 users' scalability. As I explain about uncertainty swan events in chapter [1.1](#), there is uncertainty about number of users. The problem may occur when users rapidly and unexpectedly increase. In case of high stream of users we should reduce leased power, otherwise to increase it. So there is a possibility to apply option to expand or option to contract a project. Based on information that was obtained during the project, we can exercise the option to expand or contract the entire infrastructure without any negative impact to the project functionality, which at the end will lead to more profits and less costs.

Assume that the revenue from 150 users is about more than 150.000 CZK in a year. An investment to expansion of the cloud for the same period will cost approximately 30.000 CZK. Since our FIT students want to sell the project within four years, we set a project lifetime for this period. For simplicity, let's count one year as one period when we expect an increase. Project volatility is equal to 0,7 according to the table of volatility report 2013 (see figure 2) on entertainment industry. Total capital expenditure in four years for 150 users eventually will cost 120.000 CZK and expected profit is about 600.000 CZK. Here is about American call option, so that we can exercise at any time during the project, its value will be calculated by using the binomial model. Here are parameters that we use for our calculation:

- Cumulative standard normal probability dist. $S = 600.000$ CZK.
- Current stock price $X = 120.000$ CZK.
- Project lifetime period $T = 4$ year.
- Risk free interest rate $r = 3,0\% = 0,03$.
- Project standard deviation $\sigma = 0,70$.
- The number of counted period $n = 4$.

For the value calculation by using binomial option model, we have to identify growth rate u and decay rate d , which tells us how the stream of the project is likely to be, more precisely whether will rise or fall. Let's use given parameters to the following formulas:

$$u = e^{\sigma \cdot \sqrt{T/n}} \quad d = e^{-\sigma \cdot \sqrt{T/n}}$$

Growth rate is equal to $u = 2,014$ and decay rate is equal to $d = 0,497$. By using these values we calculate probability p and q in the following formula:

$$p = \frac{(1+r)^{T/n} - d}{u - d} \quad q = 1 - p$$

After calculation we get probability $p = 0,352$ $q = 0,648$. Other parameters are already known, figure 11, so we can start to calculate the option value.

Option parameters	Calculated value
u	2,014
d	0,497
p	0,352
q	0,648

Figure 11 Estimation parameters for calculation.

First of all, we have to find a possible development of the current revenue value with respect to the volatility of the market. In each period may occur growth u with probability p , or decay d with probability q , can be calculated by using method which is seen on figure 12. In our case, the development is shown on figure 13.

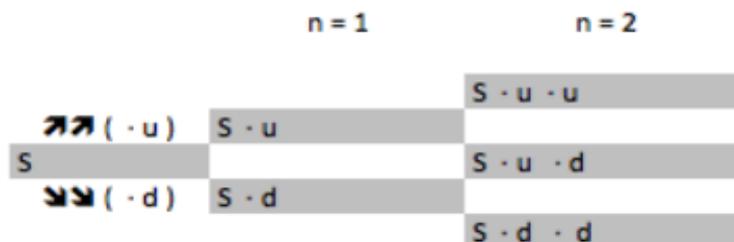


Figure 12 Development calculation of current value of additional revenue.

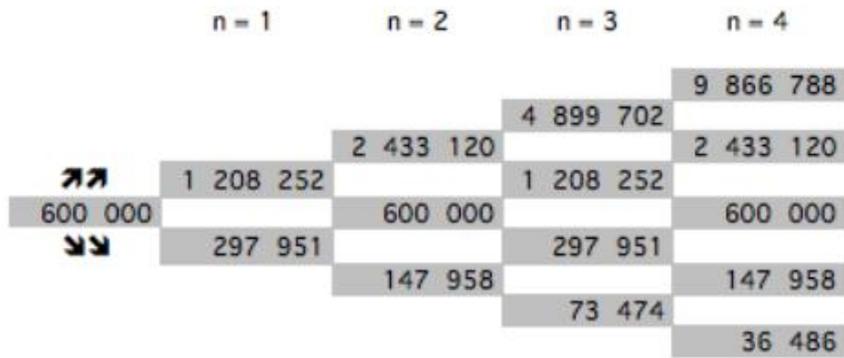


Figure 13 Possible developments present value of additional revenue.

For the final calculation of option value, we need to know project intrinsic value. We exercise an option only when its value is positive, in other words, when it generates a profit. We calculate the intrinsic value as shown in the figure 14. For our project's intrinsic value of an option is shown below in figure 15.

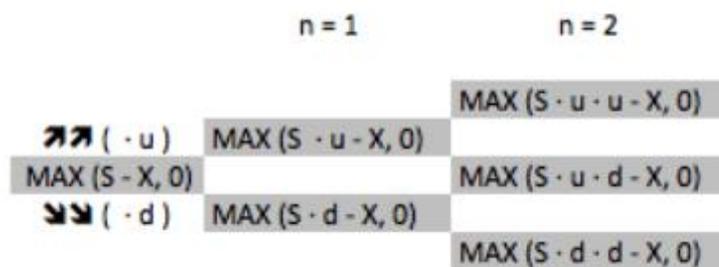


Figure 14 The intrinsic value of call option

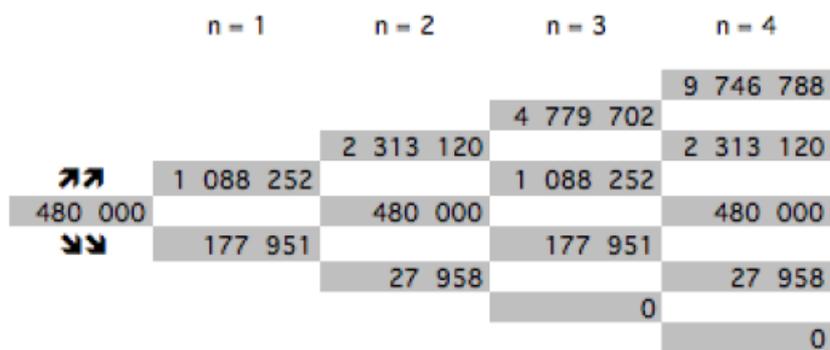


Figure 15 The intrinsic value of call option of our example.

At this stage, we already know all parameters required for the calculation of actual value of real options, and get results by using the following formula:

$$(C_i)_{n-q} = \max\left[\frac{1}{(1+r)} \cdot (p \cdot (C_i)_n + (1-p) \cdot (C_{i+1})_n), \max((S_i)_{n-1} - X, 0)\right]$$

At first glance, it seems quite complicated, but in fact it is not. First, we copy the last column of the intrinsic option value and then move from right to left. The first two values on the right, choose bigger one and multiply it to probability growth rate p , smaller one to the decay rate q . These two values are then summed. Subsequently, we look at the figure of the intrinsic value of the option to the left - between our two values, which we anticipated. If this value will be higher than our calculated value, we rewrite it into a new table. Otherwise we put our value to that position. This explanation is better shown on a figure below. (see figure 16)



Figure 16 Estimation of the value of option $(C_i)_{n-1}$.

1. $(0,352 * 9\,746\,788 + 0,648 * 2\,313\,120) / ((1 + 0,03)^{(4/4)}) = 4\,783\,197$
2. $\text{MAX}(4\,783\,197, 4\,779\,702) = 4\,783\,197$

All other values in this table calculate as the same way like the first method. The following from right to left, until it reaches the vertex. The value at the vertex represents the final value of the option to expand. In our case, this value of C is equal to 506,498, in other words, to expand for 150 additional users gives us the value of 506.498 CZK. This is shown on the figure 17.

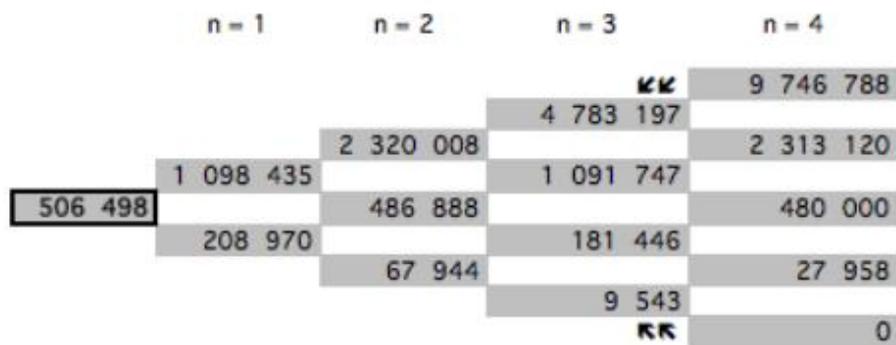


Figure 17 Recalculation of the final option value.

The aim of this example was to point out that cloud gives us right to future decisions, which in this case is option to expand a project and was shown with help of binomial model.

6. Discussion

In this thesis, I have explored the simplest form of a real option. The two pillars of IT project volatility (uncertainty) and managerial flexibility make real options especially pervasive on IT investment projects. After research study of this thesis, we are able to answer to questions such as “what exactly are real options, and why does uncertainty together with flexibility enhance their value?”. Real options are similar to financial-trading options such as calls and puts, and they can be valued similarly using options pricing models (OPMs), such as the Black-Scholes and the Binomial, that were shown by using simple example. Other categories of options are: option to alter operating scale (expand or contract), option to abandon, staged investment (looking at risks and return of any stages within an investment cycle), and multiple interactions option. Cloud adoption initiatives may be multistage, where management can decide, at any stage, whether to expand, to scale back or to abandon, depending on the profit, growth, uncertainty, and economic landscape at that point of time. This is an example of compound options where the decision made at one stage will affect the other stages, or may generate new stages. Staged investment (compound options) can be either sequential or simultaneous. Instead of considering the investment as a binary option, we may have to think of it as a binary tree,

where future option is dependent on previous decision. For example, Cloud procurement may need to be exercised first, before a company can move any services into Cloud, that is sequential option, whereas, a company may move their helpdesk services to Cloud independently (or simultaneously) with, say, customer relationship services to Cloud, this is simultaneous option. Or, it can be a combination of both. Another example is that as a company moves more services to the cloud their internal IT organization loses the ability to scale efficiently and the costs of those things they wish to keep in house increases. The key input for real option analysis, as we described in the main text is uncertainty (or volatility). Two important elements to consider here are:

1. If cloud migration is thought of a multiphase investment, then, we will expect uncertainty from multiple sources that need to be considered separately when evaluating the option value;
2. Uncertainty from multiple sources will change in time, due to technology advancement, the market landscape or the stewardship environment enforced by regulatory bodies.

We have described a real option model applied to a company's decision to move an IT service or platform into the cloud. The model can also be used by potential service providers trying to understand how those in their target segment may act. This will help them develop strategies for price, terms and conditions, assurance information and interoperability. The switching model could equally be applied to a software company looking to become a cloud service provider – the analysis of costs would change but the methods for dealing with uncertainty remain.

7. Conclusion

The aim of this thesis was to explore possible approaches of the investment evaluations, followed by a focus on valuation of investments in cloud environments using real options. This objective was achieved. Here also was shown a several approaches of the investment evaluation. The purpose was to explain each of these methods and compare with each other. But the focus was on the newest method such as real option valuation which was at the same time the theme of my thesis.

Real options concepts not only allow an organization to assess uncertain IT project investments, but can guide managers in how to create and extract value. It was intent to

provide a detailed managerial introduction to options thinking on IT project investment and reduce uncertainty through cloud computing.

Cloud services are just starting to emerge and as they do so companies are faced with the problem that the cost structures look attractive but they have uncertainties that they will get a good reliable service. Security and business continuity concerns are perhaps two of the biggest drivers for uncertainty. In this thesis I propose the use of real option theory as a way of enhancing decision making. The real options approach to decision making helps then understand the impact of this uncertainty allowing them to value their ability to move later as the picture becomes clearer.

Understanding the options space can provide a quantitative description of investment proposal, and a continuum of decision space along with a decision boundary matches the unique characteristics of the company described by their income patterns and risk appetite.

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Acronyms

NPV Net present value

DCF Discounted cash flow

ROI Return on investment

IRR Internal rate of return

CF Cash flow

TCO Total cost of ownership

TVO Total value of ownership

ROV Real option valuation

CZK Czech koruna

D-M Method Datar-Mathew Method

NIST National Institute of Standards and Technology

OPM Option price model

Contents of enclosed CD

```
readme.txt ..... the file with CD contents description
├── apk ..... the directory with executables
├── src ..... the directory of source codes
│   └── thesis ..... the directory of LATEX source codes of the thesis
├── text ..... the thesis text directory
│   └── BP_kartatol_2015.pdf ..... the thesis text in PDF format
```