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APPLICATION OF REAL OPTIONS ANALYSIS AS STRATEGIC DECISION MAKING TOOL IN IT DEVELOPMENT PROJECTS

Abstract

Decision making in IT development projects is fraught with risk because of high uncertainty that characterizes the firm's internal and external, environment-related, factors. It is not uncommon that often there is a significant gap between predicted and actual completion cost and time what influences on the project's risk profile. This article presents how the real option approach to strategy making can reduce the risk by improving the organization's ability to develop responsive and proactive strategies. Instead of planning based on expected values the Monte Carlo simulation will be applied. This technique allows better understanding of the range of possible outcomes and thus helps in modeling features in choice mechanisms and defining strategic options suitable for the strategic action space.

In the next section it will be demonstrated how real options model provides additional capabilities by allowing the project manager to measure the effect of uncertainty completion cost and time. An example will illustrate a framework for making decisions depending on changes of current cash flow and costs at any point of time during the project life cycle.

Introduction

Projects that involve creating a new IT asset, for example a software or a platform for realizing specific services, can be described as a process, which incurs costs from the moment of taking a decision to invest to the moment of reaching the final product, which can be sold, licensed or used for providing commercial services. The whole process can be divided into several succeeding phases that can be classified based on the following criteria:

- stated requirements for commencing the phase,
- known method of allocating resources and personnel,
- stated requirements that can be used to declare phase as finished.

Finishing one phase is a prerequisite for commencing the next phase. Based on the current estimation of the level of costs necessary for finishing the phase and the current value of assets, project manager can decide on initiating the next investment, suspending and restarting it, abandoning, or switching to other project. Choosing one of these strategies during the project's life has an effect on the investment risk profile and allows for postponing the decision of incurring additional costs until the uncertainty is reduced.

Estimating the profitability of such projects, by often used DCF methods, does not include added value of its flexible structure. In this approach it is assumed that all the future variables can be estimated ex ante and all the future financial benefits can be described in terms of expected values. In case of highly risky projects, such as IT development projects, estimates based on the future values of the initial variables will always be highly unreliable. The future value of assets is dependant on many unstable variables, such as changes in technology, short life cycles of products, changes in the customers' preferences, rapid increase in competition. The same trends affect the prices of resources and services, which in turn affect the final cost of conducting the project. Also, the time each phase lasts varies, which influences fixed costs and labor costs. The estimation of completion costs K, values of asset V and project duration can be obtain by using Monte Carlo simulation, replacing expected value with the ranges the initial variables can oscillate between.

The other approach is the real option analysis, which allows for presenting multi-optional strategies in form of real options and assessing their value. In case of IT development projects, call options of the European type are widely used (Mun J., 2002). This approach, however, requires establishing time frames for each phase of the project, which is not consistent with the management reality, where decisions concerning an investment can be made at any time of the project's life (American type option). Estimating the fixed cost of a project, which in IT sector can be very unstable, is yet another simplification.

In the following section the implementation of the ROA method, as a tool supporting decision making process, in which both variables, completion cost K and value of asset V are taken into consideration, will be presented.

Real Options Approach in terms of firm's strategic action space

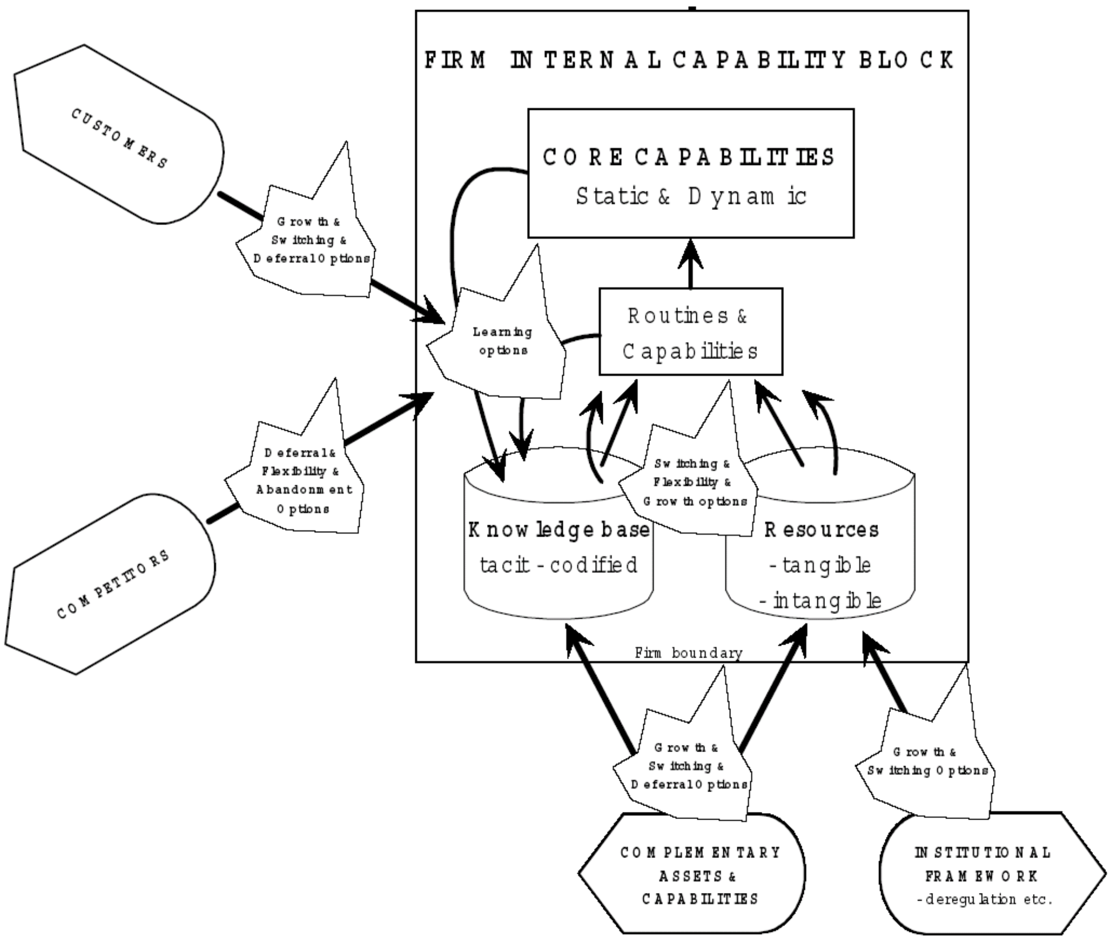
ROA method assumes that company's competitive advantage is linked to its dynamic capabilities. The most important factors are strategic management and adaptation capabilities through the modification within the disposable resources, and their allocation according to the changing conditions . Internal and environment related factors both determine strategic action space, where real options can be defined. Figure 1 describes the reciprocal influence of these factors and possible real options.

The main task of management is to create strategies corresponding with the growth options. In order to limit the risk, also the other strategies are implemented, such as deferral option, abandonment, expansion, contraction, or switching. For the IT development projects, the main options can be interpreted as follows:

- Option of incurring the initial investment's costs which open up the way to the next, main phase of investment e.g. commencing the tasks on the very limited scale, assigning the smaller number of specialists for the project (learning option, which gives a feedback both on the market and the technological barriers).
- Suspending option, suspending project up to the moment when more information emerge.
- Option of commencing a project with the full potential available, which could bring the potential advantages of being a market leader.

In case of employing real options analysis for this type of strategies, possibility of dividing into phases is often represented by the mean of European call type option, with the expiry point at the moment of commencing the subsequent phase. Its value is farther calculated using Black-Scholes formula. This approach, however, requires assuming significant simplification, including assumption that the time of a decision about commencing a future investment and the cost of finishing investment are known. In many cases it is the project manager who makes a decision as when to move to the next phase of the investment. Also, because of the decreasing costs of the equipment due to the technology development, costs of finishing a project will change with time. Therefore, optimal decision will have to take into account both the future cash benefits and changes in the investment expenditures. Strong tendencies towards lowering the equipment prices in the initial phases of given technology development suggests that the most effective solution could be postponing the time of commencing the investment (value increase in deferral option). Utilizing this option may, however, result in loosing the advantages coming from the position of a market leader (Dixit A., Pindyck R., 1998).

Figure 1. Strategic options as results of interplay between internal capabilities and external market and institutional environment



Source: Edelman, 2002.

Direct implementation of the B&S model for IT Development projects requires accepting the significant reality simplification:

- B&S formula applies only to European type options, assuming fixed maturity date.
- It does not take into consideration temporary suspension of the project (at any time).
- It assumes the fixed cost of finishing the project.

Fixed time of finishing the project is based on the assumption that the difference between the actual and projected time, so called expectation gap, is insignificant comparing to the whole project's life cycle. In the case of some type of projects e.g. creating software, it is impossible to define technical obstacles that will have to be solved. This type of uncertainty can only be reduced after the investment has started. Uncertainty also comes from the changing technological trends. For instance, it may turn out that during the process of creating a product, the standards or customers' preferences have changed. Changes in these factors may result in the necessity of making modifications, which in turn influences timeframe of product development. Since, it is a very common occurrence for IT Development, conducting simulations to get the possible duration range, is recommended.

Simulations using the Monte Carlo method

Monte Carlo method allows for evaluation of the impact of known risk factors and other variables on the possible outcomes. By creating a number of random, hypothetical development scenarios the range of the possible outcomes is presented. It allows estimating the probability of their occurrence. ROA uses this method to establish the expected NPV of the project. In this article it is illustrated how to use Monte Carlo in estimating the project's duration and completion cost.

Table 1. Task duration estimate window

Task	Best	Most likely	Worst
Cost rollup analysis	10	10	15
Exercise Systems test 1	8	12	14
Exercise Systems test 2	15	30	45
Test rework	4	4	9
Exercise planning	6	6	8

Source: Hallowel, 2006

For IT development projects, e.g. connected with creating software, the method for evaluating the duration of the project involves dividing it into the possibly smallest number of independent tasks, for which the duration time can be estimated (Hallowel, 2006). A person responsible for each task creates the worst, the most likely and the best scenario. The next step is the creation of the hierarchy of tasks based on the order of their implementations and the creation of routes that leads to finishing the project. The longest of all the routes based on the most likely scenario makes up so called "critical path." The critical path is used to establish the time needed for finishing the project. For each of the tasks the distribution type is established based on its properties.

Table 1 shows some of the tasks and corresponding assumptions in the simplified example. For each of the tasks triangular distribution has been defined. Running a simulation allows creating frequency chart, which can be used to estimate the probability of acquiring the results close to those predicted. Also, it allows analyzing the whole spectrum of possible durations.

Monte Carlo method helps realizing what kind of discrepancies between assumed and real completion time can be expected. If the range of possible durations is significant, replacing it with one value, while calculating option value, is too significant of the simplification. Development cost is the next crucial parameter. As some of the costs' components , like overhead expenses or labor expenses, depend strictly on the time their future value may also vary from the forecast. Additionally, some other components like cost of materials can drop significantly due to technological improvements.

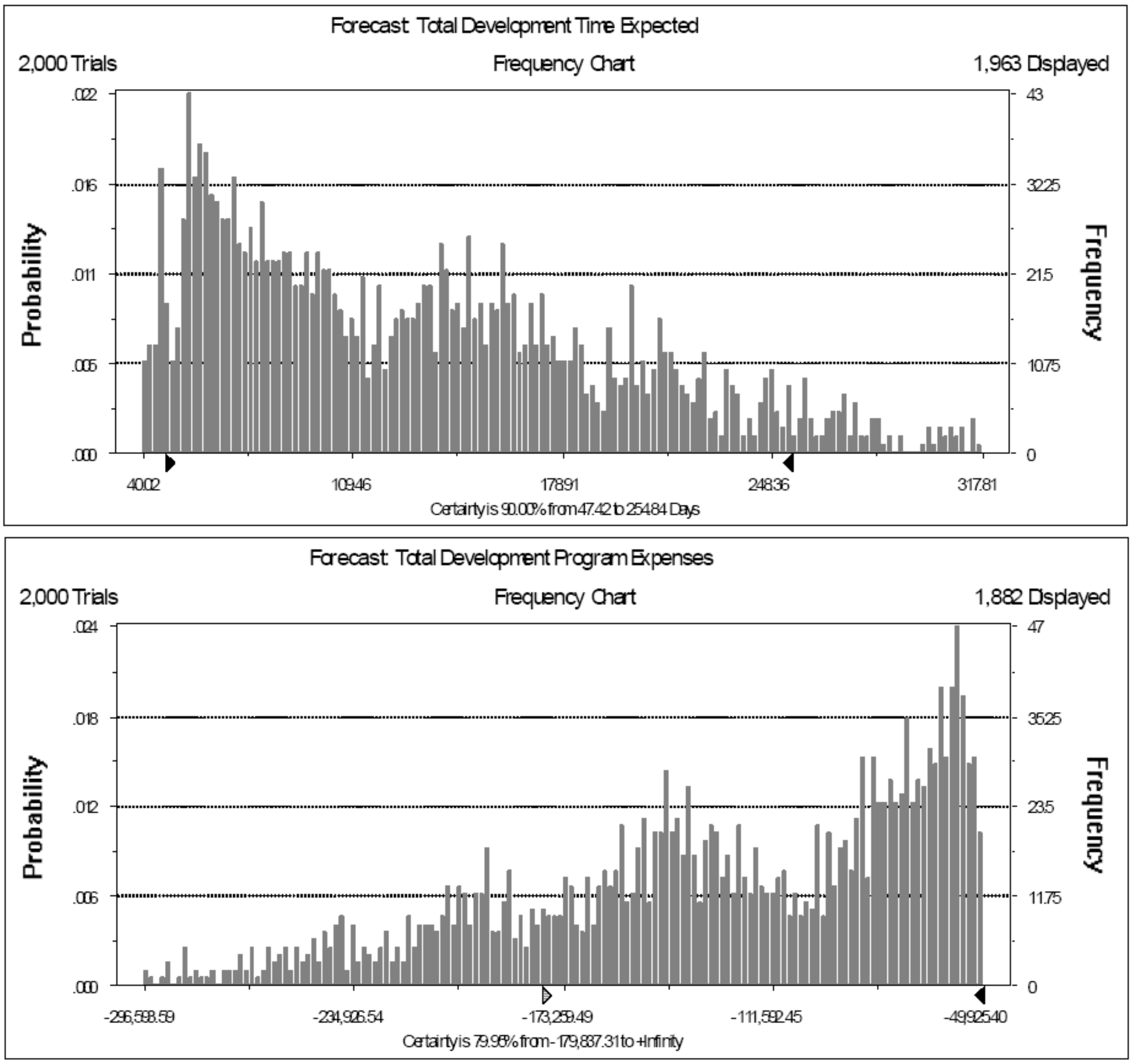
Knowing the boundaries costs and the finishing time allows for more effective choice of the decision supporting tools for these types of projects. Moreover, simulations offer information on the volatility of the input parameters, which is a crucial information in the valuation process.

Valuation model

Presented model takes into consideration uncertainty of the project's cash benefits and project's costs. Also, it extends the application of the ROA to the projects that assume changing of the cost with time, for example, as a consequence of changes in technology trends. Time of acquiring assets, in this model, is vague and is linked with investments I incurred from the beginning of the project, which cannot exceed the assumed maximal value

Im. Only after the project has been completed, the company acquires assets of V value and the time remaining to finish the projects comes to zero. As a consequence of learning, after initiating the project, the technological ambiguity will decrease. Also, waiting for the costs to lower can be an attractive strategy. A project that has been initiated can be suspended or halted. Optimal course of action is decided by the project manager based on the changes in the K and V variables.

Figure 2. Frequency Charts for the development time and development expenses



Source: Howell, 2002

It can be illustrated by the creation on a new software package. When it is completed it can be sold, but the income it generates is uncertain. Similarly uncertain are the length of the project and the costs related to conducting it. Management estimates that the total costs should not exceed 100 thousands PLN, with projected benefits not exceeding 300 thousands PLN. Maximum investment value Im is 50 thousands PLN.

The uncertainty linked to the expected costs of finishing the project K(t) can be described by the stochastic process:

Equation 1

$$dK = -Idt + \delta Kdt + \beta(IK)^{1/2}dz + \gamma Kdw$$

Where:

dz and dw – increments in Wiener Process,
Idt – parameter connected with the diffusion process,
δ – variation of cost (reached in the simulation, or based on the similar projects conducted in the past),
$\beta(IK)^{1/1}$ – values related to the physical difficulties that may occur (Pindyck),
γKdw – term related to the ambiguity coming from the changes in external factors.

Equation 2 presents the similar process of changing expected asset value V:

Equation 2

$$dV = i_v Vdt + \sigma Vdy$$

Where:

σ – standard deviation of changes in V,
μv – drift related to changes in values with time,
dy – increment in the Wiener process.

Stochastically, changes in V and K can be treated as mutually correlated. Estimating investment opportunity F(V,K), Ito's Lemma can be applied:

Equation 3

$$\mathrm{dF} = \frac{\partial \mathrm{F}}{\partial \mathrm{V}}dV + \frac{\partial F}{\partial K}dK + \frac{1}{2}\frac{\partial^2 F}{\partial V^2}dV^2 + \frac{1}{2}\frac{\partial^2 F}{\partial K^2}dK^2 + \frac{1}{2}\frac{\partial^2 F}{\partial V \partial K}dVdK$$

Then, using the Bellman equation of optimality, elliptic differential equation is created.

Equation 4

$$MaxI\begin{bmatrix} \frac{1}{2}\sigma^2 V^2 F_{VV} + \frac{1}{2}\beta^2 IKF_{KK} + \frac{1}{2}\tilde{a}^2 K^2 F_{KK} + \tilde{n}_{VK}\sigma\tilde{a}VKF_{VK} + (\mu_V - \varsigma_V)VF_V \\ -(I - \delta K - \varsigma_K)F_K - (r_f + \lambda)F - I = 0 \end{bmatrix}$$

If the value of asset V exceeds critical values V(K) from the equation 4, the optimal strategy is to conduct the investment with the maximum rate Im, otherwise to resign from the investment, where I=0.

This model takes into consideration the value of wait option defined by the company before it commences the investment, and the suspend option, if the factors have changed.
By postponing the investment a company can expect the future costs to decrease or the future assets to increase, which in turn may render the future investment rational.
The table below shows the exemplary data that will be used to solve the equation 4 using an iterative procedure.

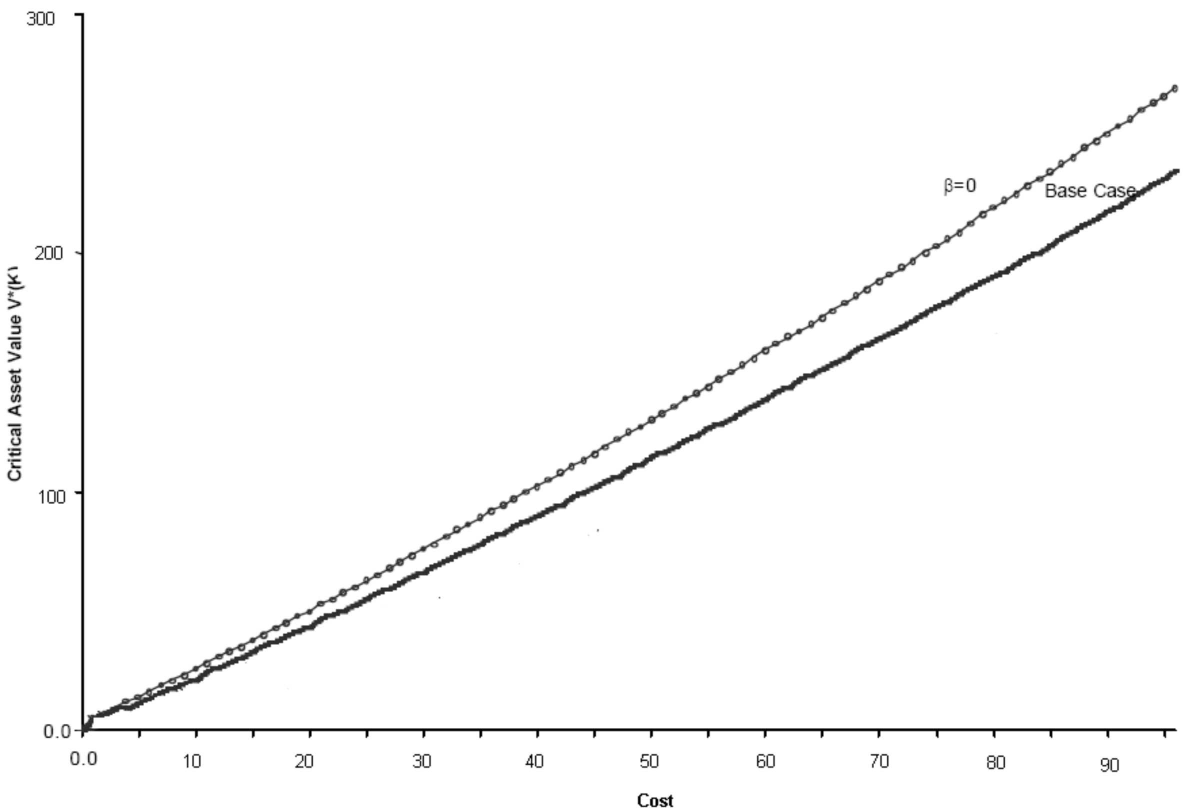
Table 2. Input parameters for the example IT development project

Cost parameters			*Asset value parameters*		
Range of cost	*K*	0 to100 000	Range of asset values	*V*	0 to 300 000
Technical uncertainty	β	0.5	Drift in asset value	μv	0.01
Input cost uncertainty	γ	0.05	Asset value uncertainty	σ	0.35
Rate of cost change	δ	-0.3	Risk premium	ηv	0.08
Adjustment for risk	ηK	0			
Other parameters					
Maximum Investment	*Im*	50 000			
Risk free rate	*rf*	0.06			

Source: own compilation.

Figure 3 presents the results acquired, and also presents the changes in the costs variability on the critical values V(K).

Figure 3. Critical values V(K) depending on the level of cost uncertainty



Source: own compilation.

As it is shown on the illustration, critical values with the absence of costs uncertainty are greater that those for the base case. It is a consequence of higher attractiveness of the project because the high level of costs variation results in high probability of lowering costs. In addition, manager has the option of abandoning the project at any given moment. Also, the technical uncertainty reduces the value of wait option, because commencing the investment and consequent learning will reveal the information on costs.

Summary

The article describes the framework of IT development projects. Highly characteristic for these types of projects is the discrepancy between the planned and actual time necessary to acquire assets, which influences the level of costs. In addition, some of the cost components that are easily influenced by unstable, short term technological trends, can change within the project's life cycle stochastically. Due to the same factors and the competition activity, also the future asset value is highly unpredictable. Possibility of controlling project's processes and opportunity of changing the strategy with the new information available renders the real option approach the most suitable.

Valuation model, which helps making decision about the best time of realizing an investment, has been presented based on the example. Its application also enables for conducting sensitive analysis taking into consideration variability of costs and investment project's benefits.

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