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PROCESS FOR APPLICATION OF THE REAL OPTIONS METHODOLOGY IN INVESTMENT PROJECT VALUATION[1]

[1] The article is based on the doctorate thesis of Rafał Ziarkowski entitled: "Application of the Real Options-based methodology to the valuation and optimal formulation of investment projects" („Wykorzystanie koncepcji opcji rzeczowych w formułowaniu projektów inwestycyjnych i kształtowaniu ich finansowej efektywności"), written in the Investment Department of the Karol Adamiecki University of Economics in Katowice in the year 2003. In the thesis one can also find an extensive Case Study presenting in detail a real world application of the process proposed in this article.

This article presents a comprehensive process for application of the real options methodology in the investment project analysis and valuation. In the first part of the article some processes proposed in the world literature will be briefly discussed than the authors will present their own proposition of such a process and characterise all its steps.

The process proposed should offer:

- relatively easy and systematic applicability of to a wide range of various investment projects,
- possibility of a quick verification of utility and feasibility of the quantitative real options application to the particular case of investment project,
- comprehensive results, both qualitative and quantitative, offering a complete view of the project's risk, flexibility and also calculation of its value, considering the flexibility available in the project.

1. What are the real options?[2]

The real options methodology allows to value investment projects taking into consideration the value of its operational flexibility and all kind of growth options available in the project.

The real options concept is based on the analogy between some real investment project and options on the financial market. A financial option gives the right, but not the obligation, to buy (or sell) an financial asset at some period within predetermined period of time for a predetermined price. Similarly, an owner of a real option has the right, but not the obligation, to modify an investment project (expand, postpone, abandon etc.) in predetermined time, paying predetermined price. The right to modify the project in a flexible way offers, on the one hand, protection in case of unfavourable changes in the project's context, on the other, allows to take advantage of some opportunities which could appear during its realisation.

To value the project taking into consideration all the flexibility available during its realisation (ignored by the traditional methods like NPV) the project can be seen not any more like a series of cash flows, but like an option or a combination of the various, combined options. Such a change of optic allows to apply the option pricing models from financial markets to real investments. The

[2] More about the real options concept in: Trigeorgis L.: Real Options: Managerial Flexibility and Strategy in Resource Allocation, The MIT Press, 1996.

real options methodology is particularly useful when evaluating the highly uncertain projects offering also some managerial flexibility.

The look at an investment project like a combination of the options opens two very interesting and important areas when formulating and evaluating investment project. On the one hand it offers a tool for numerical valuation of the flexibility available in investment projects. On the other hand, the real options give a new way of thinking about investment project, focused on its flexibility and optionality of some project's parts. Both these characteristics influence directly the investment decisions of enterprises.

2. Processes for application of the real options methodology

The real options, as a kind of philosophy of investment projects management, can be applied at very different levels. It can be, for example, used for the valuation of an investment project being prepared for realisation. Such an application requires a process which would allow a systematic and comprehensive analysis and valuation of a wide range of different investment projects.

2.1. Processes proposed in the literature

M. Amram and N. Kulatilaka present a four-step process for the real options application. Each step of the process is composed of several activities[3]:

1. Outline of the project.
   - identification of all the crucial decisions to be taken during the realisation of the investment project;
   - identification and primary analysis of project's sources of uncertainty;
   - formulation of the decisional criteria maximising the project value;
   - analysis of the problem interpretation, clarity and correctness of possible conclusions.
2. Application of a numerical model for the project valuation.
   - quantification of all the input data necessary to the valuation;
   - valuation of the project using the real options – based methodology;

[3] Amram M., Kulatilaka N.: Real Options – strategie d'investimento in un mondo dominato dall'incertezza, Etas Libri, Italia, 1999, pp. 95-112.

3. Results analysis.
   - presentation of the results in an appropriate form;
   - identification of all critical factors to take the decisions strategically correct;
   - verification of possible necessity of a new formulation of the problem.
4. New formulation of the problem.

T. Copland and V. Anticarov discuss another four-step process which is quite different from the one presented above[4]:

1. Standard Net Present Value analysis.
2. Building of an event tree, based on the set of combined uncertainties that drive the volatility of the project.
   - identification of all the uncertain variables,
   - application of the Monte Carlo simulation to estimate the standard deviation of the rates of return,
   - construction of the event tree.
3. Identification and incorporation of the managerial flexibility creating a decision tree.
   - identification of all the real options available in the project,
   - formulation of all decisional criteria and creation of a decision tree.
4. Real Options Analysis.
   - valuation of the project using the options-based methodology,
   - identification of the optimal exercise path for the real options,
   - comparison between NPV and ROA to find the combined value of all options.

Another author who propose an interesting process for valuing real options is A. Micalizzi[5]. His process is composed of three steps:

1. Project's uncertainty analysis.
   - identification of all the uncertain variables and individuation of a stochastic process which describes their volatility,
   - quantification of trend and standard deviation for all the uncertain variables.
2. Project's strategic profile analysis.
   - analysis of the areas of strategic flexibility,
   - identification of all the real options in the project and their parameters,

[4] Copland T, Anticarov V.: Real Options a practitioner's guide, Texere New York, 2001, pp. 220-222.

[5] Micalizzi A.: Opzioni reali. Logiche e casi di valutazione degli investimenti in contesti di incertezza, EGEA, Italia, 1997, pp. 131-136.

- definition of decisional criteria for all the options,
- analysis of a sequence and conditions of realisation of all the individual options.

3. Quantitative analysis.
   - project valuation using the options-based methodology,
   - analysis of all interactions between the options,
   - sensitivity analysis.

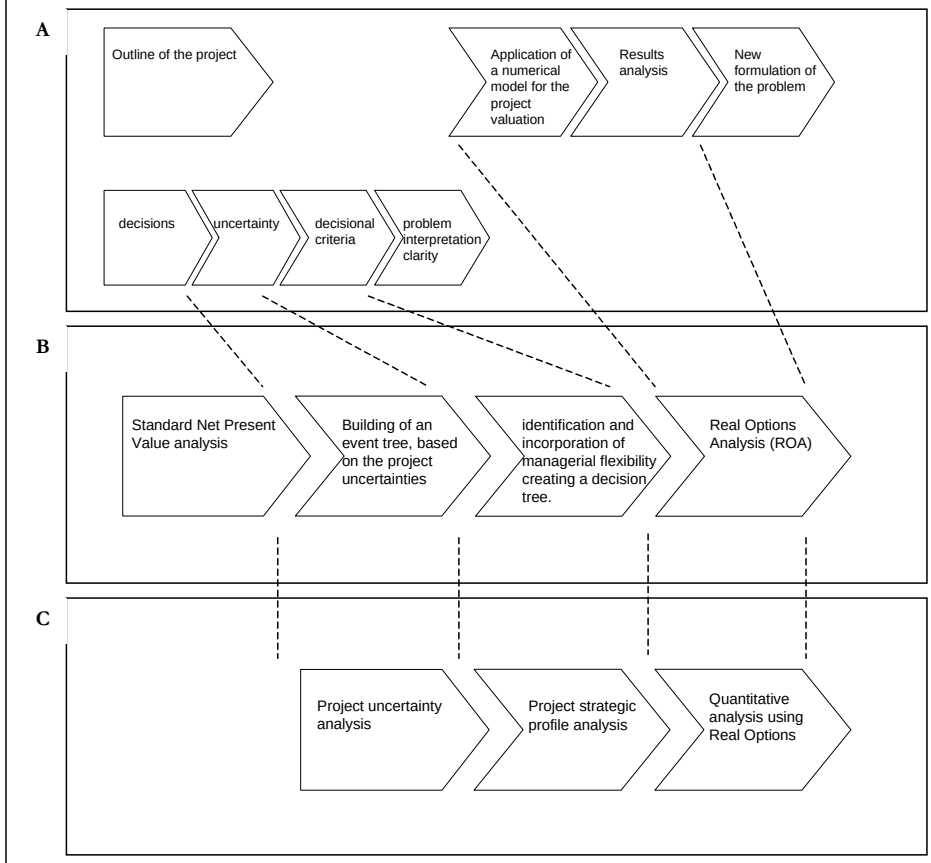
2. 2. Comparison of the processes presented in literature

Exhibit 1 presents a graphical comparison between the three processes described in the previous chapter (A – Amram, Kulatilaka, B – Copland, Anticarov, C – Micalizzi). Analysing the three different approaches to value the project using real options, we can identify three basic, common for all the approaches, steps:

- analysis of the project's uncertainty,
- analysis of options available in the project,
- quantitative valuation of the project using the real options methodology.

The sequence of the three steps mentioned above is the first important issue to be analysed. Undoubtedly, the third step must be realised at the end of the process. But the sequence of the other two ones is much more arguable. It seems that the identification of the options available in the project should be a kind of response to the uncertainty identified before. In consequence this step should follow the analysis of the project's uncertainty. Such a solution has been proposed both by T. Copland – V. Anticarov and A. Micalizzi. Nevertheless, M. Amram and N. Kulatilaka suggest that the initial analysis of the managerial flexibility should be realised at the beginning of the whole process. Availability of some strategic decisions, that could be taken during the realisation of the investment project, is usually known from the beginning and derives from characteristics of the project. It seems to be a reasonable approach because the early identification of the availability of some managerial flexibility (options) in the project can justify or not the future application of the real options to value the project. When flexibility does not exist it is sufficient to value the project using the standard NPV methodology.

Exhibit. 1: **Different variants of the real options process**



Another interesting issue that results from the comparative analysis of the three different approaches to the project valuation using the real options, is integration of the standard NPV approach with the process. T. Copland and V. Anticarov include the NPV valuation in the real options process, treating it as the first step of the process aimed on the project valuation without flexibility. The value obtained is used as an initial value of the underlying asset in the next step of the process. Such an integration seems to be a very good solution, above all, because of the fact that the NPV supplies a very important input to the following valuation. In fact, it is quite impossible to consider the complete omission of the NPV in an investment project valuation. NPV is not only an important input to the process but also gives the basis to compare the results obtained using real options.

M. Amram and N. Kulatilaka have additionally distinguished the analysis of the problem clarity and the potential new formulation of the project as a separate steps of the process. Both issues are very important but their individuation as separate steps of the process seems not to be necessary.

3. Proposition of the comprehensive process for the analysis and valuation of investment project

In the next part of the article a process which, in a systematic and comprehensive way, allows to analyse and value an investment project using the real options approach will be presented. The proposal will be created on the basis of the processes presented above and the authors' experience in the real world cases of real options application. The process presented in the below charts, step by step, a series of activities starting from identification of an investment possibility to the analysis of final results of valuation.

3.1. Qualitative and quantitative project analysis

It seems that one of the basic characteristics of the process analysed should be a very clear distinction between the qualitative and the quantitative part of the analysis. Such a division has not been proposed by any of the authors quoted above.

There are two basic reasons to consider such a distinction very useful. Above all, it offers a possibility to limit the analysis only to the quantitative one. In practice, there are a lot of the complex investment projects or situations in which the valuator (or the evaluating team) has no sufficient competencies or does not consider necessary to conduct a complex quantitative analysis using real options. In such cases, only the qualitative part of the process can be conducted and the NPV methodology applied to obtain a quantitative results of valuation. This "limited" application of the real options allows to analyse the sources of uncertainty of the project and gives an interesting view over its strategic flexibility and optionality of some project's parts. At the same time it does not require a specific knowledge of the options of the evaluation techniques.

When the quantitative real options evaluation would be applied too, the earlier conduction of the qualitative one offers a very useful verification of the utility and feasibility of using the real options on the qualitative level. In many cases there is no managerial flexibility available in the investment project. The

application of any real options – based methodology to such project does not bring any additional information in comparison to the traditional NPV analysis. The qualitative analysis allows to discover this fact at an early stage of the process and in consequence avoid dispensable work.

3.2. Characteristics of the individual steps of the process

Both the qualitative and the quantitative analysis should be composed of the several steps to be followed to the complete analysis and evaluation of an investment project. The Table 1 presents all the individual steps and results to be achieved at each step.

3.2.1. Qualitative analysis

Formulation of the investment project and identification of all significant decisions available during the project's realisation

The process proposed in this article is to apply from the moment when the first idea of an investment project is ready, it is also necessary to determine the expected value of the project and to find the optimal (the one which maximise value) frame of the project. The most important purpose of the first step of the process is to identify all the significant decisions to be taken during the realisation of the project. As far as the decisions are concerned, it is useful to identify all the factors which influence the decisions, people who would take them and time limits of all the decisions. It is very important to identify only these decisions which influence in a significant way the project's realisation. The concentration on too many, non significant decisional points, make the analysis too complex and, at the same time, does not improve the quality of the analysis' results. This is important especially in these cases when an investment project is large and has a complex structure[6].

The clear identification of all the important decisional points, which describes the course of the project, gives a common base to analyse the project for all the people involved in its planning and realisation.

Risk identification

Risk identification is usually omitted in the processes proposed in the world literature. Authors do not consider this phase as a part of the process of the

[6] Amram M., Kulatilaka N.: Real Options – strategie d'investimento in un mondo dominato dall'incertezza, Etas Libri, Italia, 1999, pp. 96-97.

investment evaluation using the real options. Nevertheless, it seems to be quite a natural initial step when planning an investment project, above all, using such an "uncertainty oriented" methodology like the real options.

Table 1

Steps of the process for valuing an investment project using the real options methodology

Steps	Results to achieve at each step
Qualitative analysis	
1. Formulation of an investment project and identification of all potential decisions available in the project	• Description of the project; • List of all relevant decisions to be taken during the realisation of the project; • Time frames and relations between all the decisions.
2. Identification of project's risk.	• Identification of all sources of the project uncertainty, both technical once and relative to the market.
3. Analysis of the flexibility available in the project	• Subdivision of the project into logical parts in which various sources of managerial flexibility are available; • Construction of a decision tree of the project.
Quantitative analysis	
4. Project valuation using NPV	• Quantification of all the variables determining the project value: investment layouts, expected incomes, costs etc. • Project valuation without flexibility.
5. Regrouping of the NPV data with reference to the flexibility areas of the project identified earlier.	• Quantification of the initial value of the underlying asset; • Analysis of the value loss for all the project's underlying assets. • Identification of all the variables characterising optional parts of the project.
6. Uncertainty quantification	• Identification of all the significant uncertain variables; • Quantification of the volatility of the underlying asset. • Quantification of the technical risk of the project; • Expression of the uncertainty in a form of lattice (for example binomial tree).
7. Giving the specific names to the options and definition of their decisional criteria	• Quantification of all the variables characterising project's options; • Definition of all the options in a form of decisional criteria.
8. Numerical options valuation (ROV)	• Calculation of the project value in the presents of all the options available; • Valuation of all the individual options treated separately.
9. Results analysis	• Confrontation between NPV and ROV; • Identification of the optimal path of options realisation; • Sensitivity analysis.

Risk identification can be generally defined as identification and documentation of all this risk sources, which probably will influence the project[7].

The comprehensive look at the project which allows to create a possibly complete list of all types of risk influencing the project's results, lies in the basis of the risk identification. As far as the risk identification for the real options application and its integration with the process proposed is consider, there is no significant difference in comparison to the risk identification applied separately. The purpose of the activity is always the same. In spite of this, from the beginning, it is useful to keep separately two different types of the project's uncertainties. On the one hand, a lot of the uncertainties relative to the investment projects like: expected sales, price level, costs etc. are resolved continuously over time. In the real options methodology this kind of uncertainties is reflected by the event tree. However, for many projects the major uncertainties are related to technology, changes of regulation, competitor's move and others. These kinds of risks are resolved in one particular point of time when the information is available. Moreover, it is possible to identify a few alternative variants of the results and their probability.

Because the two types of uncertainty have so different characteristics and are treated differently in the quantitative analysis it is reasonable to keep them separately from the beginning[8].

The analysis of the flexibility available in the project

The second (after the risk identification) area of the qualitative project analysis is its optionality. Realisation of this step require a subdivision of the project in logically dividable parts and analysis of the optionality of realisation of all the individual parts.

The real options methodology is very useful for the multi-steps project evaluation. In such a type of the investments there is a series of the investment layouts relative to realisation of each step of the project. It gives a natural possibility to verify the profitability of continuing the project and paying another investment outlay at some steps. Realisation of some of them can be obviously necessary, but there are often some steps which are optional or their realisation may seem to be necessary but in fact is not.

There are also some investment projects in which realisation of one step gives an opportunity to start in the future another project. This kind of opportunities is usually called Growth Options. Realisation of such a new project is

[7] A Guide to the Management Body of Knowledge, Project Management Institute, Upper Darby, 1996, p. 111.
[8] More in: Copland T, Anticarov V.: Real Options... op.cit., pp. 270-271.

usually optional too, therefore this kind of the future investment possibilities relative to the project should be analysed at this step of the process.

Once the optional parts of the project are individualized, it is very important to understand correctly a logical sequence and possible relations between the parts and identify all the factors which determine the realisation of the individual parts. The factors joint the uncertainty sources identified earlier and the realisation of the optional parts of the project identified at this step.

The method which could be very useful at this step of the process is the decision tree. The purpose of its application in this context is not the project evaluation but only a graphical illustration of the project, presenting relations between its uncertainty sources, realisation of all the optional parts of the project and their sequence.

3.2.2. Quantitative analysis

Project evaluation using NPV

This step does not require an extensive description because the traditional NPV methodology is well known and described in literature. Therefore, it is worth charting briefly this step, paying attention on its integration with the hole process proposed in this article. This step can be subdivided in the three following actions:

- Determination of the expected (the most probable) project's scenario, which will be evaluated using the NPV.

The taken scenario will constitute the reference point for the later valuing of all project's options. This "static" project's scenario (without considering any managerial flexibility) should be determine in such a way that all the options available in the project could be treated like its possible modifications: expansion, shrink, abandonment etc. Management can modify the project's path exercising some options and, in this way, influence the value of the project's cash flows calculated at the beginning.

- Quantification of all the parameters necessary to carry out the NPV valuation (inflows, outflows, investment outlays, discount rate).
- Discounting of the project's expected cash flows.

Regrouping of the NPV data with reference to the flexibility areas of the project identified earlier

The NPV evaluation realised in the previous step assumed that the project's realisation would follow the initial scenario with the assumed values of all

the cash flows. The real options methodology allows to move from this optic to the flexible project planning. This change, on the qualitative level, has been done while the optionality of the project was analysed and the decision tree built. In order to do some transformation, from the static to the flexible project's vision, at the quantitative level it is necessary to reorganise the numerical NPV data with reference to the flexibility (optional) areas of the project identified earlier.

The essence of this step lies in the logically correct attribution of the values of the financial inflows and outflows to the optional parts of the project and definition of how the possible investment outlays would influence these values. It means that all the numbers must be attributed to the decisions on the basis of their logical relations. This phase is composed of the following activities:

- Identification of the underlying asset (assets) and quantification of its initial value.

The action require the definition of these cash flows which will be included in the project's underlying asset. Sometimes it may also be necessary to identify more underlying assets in the some project.

- Analysis of the value loss for all the underlying assets[9].
- Identification of all the variables characterising the optional parts of the project.

Within this step it is necessary to identify and quantify all the outlays necessary to realise all the individual project's parts. Some of these values are already present in the NPV calculation, others must to be calculated separately. To the second type belong usually all the outlays relative to the various kinds of project's expansion which are usually not concerned in the static NPV scenario. However, these outlays which are present in the NPV calculation require sometimes additional regrouping. It happens because investment outlays together with some costs of realisation of the individual project's parts, grouped together, form exercising price of some options.

Quantification of the project's uncertainty

The measurement of projects' uncertainty is quite a complex and not easy task in general. When applying the real options, it is also the most problematic part of the analysis. Construction of the event tree (binomial tree) requires however quantification of the uncertainty. As far as the real options are concerned, there can be a lot of different variables, uncertainty of which must be quantified. Usually, it is the discounted value of all the cash flows generated by the project

[9] Copland T., Anticarov V.: Real Options..., op. cit., pp. 149-155.

during its realisation and exploitation. However, it can also be other uncertain parameters like: prices, costs, quantity etc[10].

Difficulties in determining of the volatility of underlying asset for real options is caused by the major difference between real and financial options. When evaluating an option on financial asset the volatility is observable and the historical data are usually available. This is, however, generally not the case when evaluating the options on real asset[11]. If the project in question is a start-up venture, R&D or market introduction of an innovative product it can be very difficult or even impossible to determine volatility based on projection on the project. It is necessary to look for other ways to determine the volatility.

T.A. Luehrman, for instance, suggest the three following approaches to deal with the problem[12]:

1. estimate the volatility based on historical data on similar project from related industries,
2. subjective estimation provided by experts,
3. simulate the volatility using simulation methods, like Monte Carlo.

In some cases it may be reasonable to assume that the future will be like the past therefore we can decide to use historical data to estimate the value of uncertainty in the discounted cash flows. This will be reasonable mostly when a project is a replacement investment, when we are studying abandon or shrink option on an existing project. The problem is much more serious when the historical data are not available.

In these cases the project's uncertainty can be quantified on the basis of a subjective expert's judgement[13]. In this method a group of managers, being experts in the area of the project analysed, gives their subjective opinions or estimations. On this basis, the project's uncertainty can be estimated. In practice this approach is quite difficult to apply. In the traditional project valuation methods, like NPV, the uncertainty quantification is not necessary. Therefore managers are not used to doing such estimations. It is much easier for them to express qualitative opinions about uncertainty: "high", "low" etc. Such an approach has

[10] R.L. Shockey presents the case where the product price (uncertain variable) is modelled with a binomial lattice. On the basis of this modelling the binomial tree of the project value (underlying asset) is built. Shockey R.L.: Two Real Options Case Studies, Papers from 5th Annual International Conference on Real Options, Los Angeles, July 2001.

[11] Bruun S., Bason P.: Real Options in Venture Capital Finance – Essay Series, 2001, available: www.realoptions.dk.

[12] Luehrman T.A.: Investment Opportunities as Real Options: Getting Started on the Numbers, Harvard Business Review, July-August 1998, pp. 51-67.

[13] Application of this method for real options is proposed by: Lint O., Pennings E.: R&D as an options on market introduction, R&D Management 28, 4, 1998, pp. 279-287.

unfortunately very little applicability[14]. Quantification of the uncertainty is necessary for the real options and, considering the difficulties mentioned, this process should be supported by some systematic approach and statistic tools. T.A. Luehrman defines this methods like a standard deviation "guessing", but at the some time confirms the necessity of using it in many real cases[15].

The third possible approach to the uncertainty quantification is using simulation methods, for example the most popular one – Monte Carlo simulation. Its application allows to build up a single estimate of project's volatility from many uncertainties that contribute to it (price, quantity etc.)[16].

As already mentioned, for many projects, the major uncertainties are related to technology, changes of regulation, competitor's move and similar. The kind of risks are resolved in one particular point of time when the information is available, raising or reducing project value in this unique moment. Moreover, it is possible to identify a few alternative variants of results and their probability. Considering the characteristics of these sources of risk, it seems to be reasonable to quantify its uncertainty using probabilities.

Giving the specific names to the options and definition of their decisional criteria

Till this phase, the optional project's parts, giving its flexibility, ware not called with the real options specific names. But to allow the quantitative evaluation it is necessary to formulate all the options in the specific real options way. At this step it is necessary to realise the following activities:

- Give to all the options available in the project the specific names which reflect their type and characteristics (expand option, abandonment option, shrink option etc).
- Formulate all the options in decisional criteria which reflect their logic of realisation to assure the maximisation of the project value. The decisional criteria should include all the variables necessary to obtain the options value. The variables are for example: investment outlays, cost of project's expansion, savings relative to project's reduction, residual value when abandoning the project, percentage of project's expansion or reduction etc.
- Quantify of all the variables included in the decisional criteria.

[14] Marcinek K.: Ryzyko Projektów inwestycyjnych. Akademia Ekonomiczna w Katowicach, Katowice 2001, p. 129.

[15] T.A. Luehram writes that estimating σ for a real investment project and not having any data to rely on, it is reasonable to look for a value between 30-60%. More in: Luehrman T.A.: Investment Opportunities…, op. cit.

[16] More in: Copland T, Anticarov V.: Real Options..., op. cit., pp. 245-256.

Majority of this values should be already available from the previous steps of this process.

Numerical options evaluation

After identifying all the options available in the project with their decisional criteria and quantifying all the options' parameters it becomes possible to evaluate the options and in consequence the whole project with flexibility. In order to evaluate the options, one can use one of the options pricing methods like: Replicating Portfolio or Risk Neutral Probabilities[17].

Results analysis

The analysis conducted in all the steps of the process proposed should give an answer to the question: how much is the project's flexibility worth? For this purpose it is necessary to compare the NPV result with the real options value (ROV). The difference between this two numbers is the value of the flexibility available in the project, which was ignored by the NPV valuation. Obviously the only one number as the result of the analysis gives a very little input to the decisional process. Therefore the results analysis should be much more detailed.

Firstly, it is worth to analyse in detail all the individual sources of flexibility to understand which ones give more value for investors. It is particularly important when formulating investment project, because the attention can be concentrated to create the options which gives the most value. The optimal path of options' exercising can be also analysed[18].

Considering the purpose of the optimal project's formulation also the sensibility analysis can give very interesting results. It allows to identify this parameters of the project which have the biggest influence on the value of options and in consequence find the levers to improve the project's profitability. Sometimes it may also be reasonable to formulate the problem again in an alternative way. It may be done by considering some additional options increasing, for example, the number of phases of the project[19].

[17] More in: Trigeorgis L.: Real Options: Managerial Flexibility and Strategy in Resource Allocation, The MIT Press, 1996.
[18] Various ways of ilustrating the real options analysis resalts present:: Amram M., Kulatilaka N.: Real Options – strategie d'investimento in un mondo dominato dall'incertezza, Etas Libri, Italia, 1999, pp. 109-110.
[19] Amram M., Kulatilaka N.: Real Options – strategie…, op. cit., p. 111.

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