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Investment Project Evaluation using the Component of Embedded Real Option

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Abstract

Analysis of the large-scaled investment projects plays a major role in the decision-making process of business corporations. Regardless the existence of various valuation models, the methods based on the idea of discounted cash flow (DCF) have gained the upmost popularity among the financial professionals. Two main problems arise in connection with this method: the problem of cash flow definition and the problem of determining the discount factor. Thus, under assumption that the incremental cash flows have been duly forecasted and the discount factor has been diligently determined, the management of the company may take the informed decisions based on calculated metrics such as *NPV*, *IRR*, *discounted payback period* etc. However, it is presumed that after the decision about the investment project has been taken, the management has little or no influence on the future execution of the project. Under such assumption the investment project possesses a static nature; consequently, all the known present, as well as *future* risks and uncertainties associated with the investment project are assumed to be incorporated into discount factor.

In the real world, however, the assumption of all future uncertainties being captured into discount factor, as well as the passive role of management seem to be a bit oversimplified. The method of *real option analysis* tries to address these problems. The basic idea of *real option* is that taking the final investment decision could and even should be postponed in the future, until some basic uncertainties associated with the investment project have been resolved. By analogy with the financial options, the real options have a certain value, which might be captured and added to the project NPV figure resulting in *strategic NPV*, which serves as a better gauge for the informed decision making.
The research paper considers the implication of the real option component into the DCF analysis of the real investment projects and addresses some of the criticisms of this method.

Keywords: investment project, discounted cash flow (DCF) method, WACC, cost of equity, unlevered beta, leveraged beta, cost of debt, NPV, IRR, discounted payback period, certainty equivalent method, risk-adjusted discount rate (RADR) method, real option, option to expand the operations, CRR model, real option premium, strategic NPV.

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1. Introduction

In the current research paper I am advocating the need of a holistic approach to the appraisal of the investment project and will consequently develop the Excel-based model, which might be used in the organization (the Company) I am currently working with as a practical tool in the investment project evaluation process. I expect that the results of the current research paper might be considered for use as an investment manual for the Company in the future.

The research paper consists of a theoretical part and part of research, the latter containing the practical implications of the reviewed theories. The theoretical part is split into two main blocks represented by the review of the conventional methods of the quantitative analysis and the strategic application of the real options theory to the investment project evaluation process. In the first block I will describe basic theories and managerial practices used in the process of analysis of the investment projects based on the method of discounted cash flows. The second block will be devoted to the review the theoretical background of real options methodology followed by examples of its application to the investment project evaluation process. For convenience of the reader I will also provide a short description of the typical investment project undertaken by the Company in connection to its business operations.

In the part of research I will elaborate an Excel-based investment *project evaluation model* using the theories and practices reviewed under the theoretical part. The explanation of the model and its results will be preceded by the detailed description of the particular investment project undertaken by the Company; this description will contribute to better understanding of the basic assumptions used in construction of the Excel model.

The result of the research paper is the working project evaluation model, which management of the Company might use as a part of the investment evaluation process including the reference to the aforementioned model into Company's investment manual. The model will also contain guidelines for inserting the real option evaluation into the broader process of the investment project appraisal.

1.1. Description of a Typical Investment Project

The Company I will review in the current research paper is involved into production and distribution of air gases both in gaseous and liquid substances. The main type of investment project, which affects the Company's strategy, demands huge investments and consequently requires a thorough analysis and control are the project of erection and subsequent operation of production facilities. The production facilities might be of different types; however, further in the text of research paper I will refer to one specific type of production facilities denoted by the term Air Separation Unit (or ASU). The typical ASU is designed in a way that it can produce air gases of high purity using the air rectification process in both gaseous and liquid substances.

Under the term “investment project” further I understand the newly erected ASU, which is delivering gaseous products to an *onsite customer* through the system of connected pipelines; whereas the additional liquid production volume is being sold by the Company on the retail market.

The project of erection of ASU might be characterized by the following:

1. It normally requires big investments (based on the size, the investment amounts might be from 10-15 Mio. EUR to hundreds millions of euros).
2. It has an extended erection time (normally 20-24 months with some variations).
3. It is erected and operated by the gas company based on the long-term (normally 15 years) gas supply contract with onsite customer. The gas company retains full control over the production facility and is responsible in front of the customer for gas deliveries.
4. There are two basic types of product produced by the ASU: a gaseous substance supplied to the onsite customer and a liquid substance sold by the gas company on the open market.
5. The contract with onsite customer normally includes the take or pay (TOP) condition, based on which the customer is obliged to consume the minimum designated percentage amount of the contractual gas volume. If the consumption falls below TOP volume, the customer is obliged to pay to the gas company for the TOP volume. This clause is necessary for securing the investment made by the gas company in terms of covering its fixed costs.
6. Normally ASU is purchased by the gas company from the external technology supplier (main contractor) based on erection-procurement-commissioning (EPC) contract (or turn-key basis). Thus, the existence of predefined time and payment schedules is supposed.
7. The main components of the plant (in form of the machinery and equipment or M&E) are produced, delivered to the site, installed and commissioned by the main contractor. After the gas supply contract with customer expires, the equipment might be dismantled and carried over to another location or sold on the market.

   The second component of the investment project are local civil works (mainly foundations for M&E, electrical installations, office building etc.), which cannot be dismantled and sold after the expiry of gas supply contract. I will draw the line between these two in my model.
8. The gas supply contract is mainly prolonged after the expiration of initial term. It might be also terminated with arising obligation for the gas company to dismantle the equipment. In analysis of the investment project for the reasons of achieving the conservative valuation, it is normally not counted on the possibility of the future contract prolongation.

1.2. Review of the Basic Conventional Methods

The first part of the theoretical background will be concerned with particular conventional quantitative methods used in the process of project evaluation. In this section I will discuss the basic valuation methods, which are broadly used in capital budgeting process. I will review the concepts of the *net present value* (NPV), *internal rate of return* (IRR) and *discounted payback period* (DPP). In relation to IRR and NPV I will explain the general underlying concepts; after that I will briefly touch specific case of multiple IRR and a case of conflict results of IRR and NPV.

I will present a review of two methods that might be used during the execution of the NPV analysis: the *certainty equivalent method* and the *risk adjusted discount rate (RADR)*. Further under the section of Literature Review I will describe both these methods. The main difference of the *certainty equivalent method* from the RADR is that the adjustment for risk is made in the forecasted future cash flows (which tends to be subjective from time to time) and not in the discount rate. The next difference is related to the treatment of the tax issues. I will shortly review the essence of tax issues in the cash flows forecast in NPV model based on *certainty equivalent method* using the discussion from Arnold & Nixon (2011).

Under the RADR the adjustment for risk is made in the required rate of return or *discount rate*. I will use in my research paper the idea of *weighted average cost of capital* (WACC) for definition of the discount rate. In my calculation of WACC I will differentiate between two sources of capital: *equity* and *debt*. For the calculation of the cost of equity I will use the results of the Capital Assets Pricing Model (CAPM). Regardless the fact that CAPM is normally used by analyst on a corporate level, I will demonstrate that based on certain assumptions it might be successfully applied to the analysis of a standalone project. It should be also mentioned that although CAPM definitely has some deficiencies (e.g. the issue of stability of beta ratios over the time and arising in this regard more general question about the applicability of historical betas for determining of the cost of equity in WACC) and sometimes is being criticized for its ambiguity, it still might be regarded as an efficient simplified method for capturing the complex real world ideas into the generalized model; consequently, its results might be used as an approximation in attempt to capture the associated with the investment project uncertainties into the discount rate factor.

1.3. Review of the Complementary Real Option Method

The second part of the theoretical section will be concerned with the discussion on the real options concept. This concept represents the extension of the analysis of an investment project based on the concept of a conventional (static) NPV. The idea of real options provides an extension to the evaluation framework based on conventional methods. Without consideration of real options the conventional methods of investment project evaluation might be imprecise and even flawed because, according to Mun (2006, chapter ‘A Paradigm Shift’, paragraph 3), they “assume a static, one-time decision-making process, while the real options approach takes into consideration the strategic managerial options certain projects create under uncertainty and management’s flexibility exercising or abandoning these options at different point in time, when the level of uncertainty has decreased or has become known over time”. Thus, the implementation of real options method allows the manager to create a more flexible framework for the investment project appraisal, as the improved model accounts for the managerial flexibility and management's ability to interfere and influence the project during its life-span.

I also will devote some time to discussion regarding the various types of real options based on L. Trigeorgis (2002) and conclude the theoretical part with the idea of reconciliation of two methods of the conventional NPV and the *strategic NPV* figure calculated based on results of the complementary real options analysis.

1.4. Application of the Theory

In the second part of the research paper I will turn attention to practical implications of the theories reviewed in the first part to the process of investment project appraisal. First, I will provide a short description of the potential investment project executed by the Company. After that, I will focus on the construction of the Excel-based project evaluation model based on the concepts of NPV, IRR and DPP using as a discount rate the number of WACC.

I will conclude the analysis with a practical implication of a real option to the model and calculation of the *strategic NPV*, which includes the conventional (or static) NPV adjusted for a value of a real option premium, and discuss the viability of this approach to the practical investment project analysis. The particular value of the inclusion of the real option valuation and associated with this number of *strategic NPV* into the investment project evaluation model lies in the fact that it allows for measuring of the managerial flexibility during the execution of the investment project under circumstances of existing uncertainty.

The inclusion of the real option valuation brings the dynamics associated with the complexity of the uncertain future circumstances into the static conventional model, thus giving to the manager a more profound insight into the real underlying value of the investment project. Under particular circumstances the value of a real option might be intuitively graspable (as in example of the investment project discussed in the current research paper). Under another circumstances it might be counterintuitive, as for example in a case of postponing the crucial decision until some of the uncertainties will be resolved (the value of no-immediate-action, which from the point of view of trivial logic might seem to have no value). However, even in the case of intuitively justifiable value of the embedded real option, the real value in the decision making process might be created only if some reliable method of quantification of the aforementioned value is proposed and used by the management in their decision making process. In my research paper I propose and develop the idea of using the figure of *strategic NPV* as a number, which captures the value of the embedded real option related to the existing managerial flexibility under circumstances of a persistent uncertainty.

2. Review of Methodology

2.1. General Considerations

The process of the investment project evaluation is closely linked to the idea of *capital budgeting* which is “concerned with the allocation of resources among investment project on a long-term basis” (Trigeorgis, 1996, p.23). The definition of capital budgeting process given above, however, does not define the exact criteria for the decision on the allocation of resources. Financial analyst often thinks of the capital budgeting in terms of quantitative analysis, thus ignoring the strategic aspect of the capital budgeting decisions expressed in the flexibility of the managerial decision making process.

One should keep in mind that the general idea of the company’s existence and thus the main goal for the management is the maximization of the shareholders’ value (at least in the capitalistic word). The shareholders’ value is being maximized not only by selecting the profitable investment projects with positive quantitative metrics (such as NPV, IRR etc.), but when the managerial potential to influence the flow of the investment project and its ability to change the course of the company in case if some initial assumptions do not hold is fully utilized and incorporated into the final result of the investment project appraisal.

A manager should also be aware of the fact that the quantitative methods used in process of investment project appraisal represent only one part of the complete capital budgeting process. The process by itself shall begin not with the calculation of the return and risk metrics, but from general strategic consideration of the company’s vision, mission and long-term goals. Speaking in a plain language, a new project shall first pass the filter of qualitative strategic analysis, in order to be accepted as contributing to the achievement of the long-term company’s goals.

Although qualitative methods of the investment project appraisal are not in the focus of the current research paper, I would like to stress once more the fact that without conducting the initial qualitative strategic review of the new investment opportunity and making a verdict of whether and how it suits into the general company’s strategy, the manager should not apply the quantitative evaluation routines irrespective of the fact whatever scientific or advanced methods he or she might be using. Dayananda et al. (2002, p.5) refer to capital budgeting as a multi-staged activity (see Figure 2.1.).

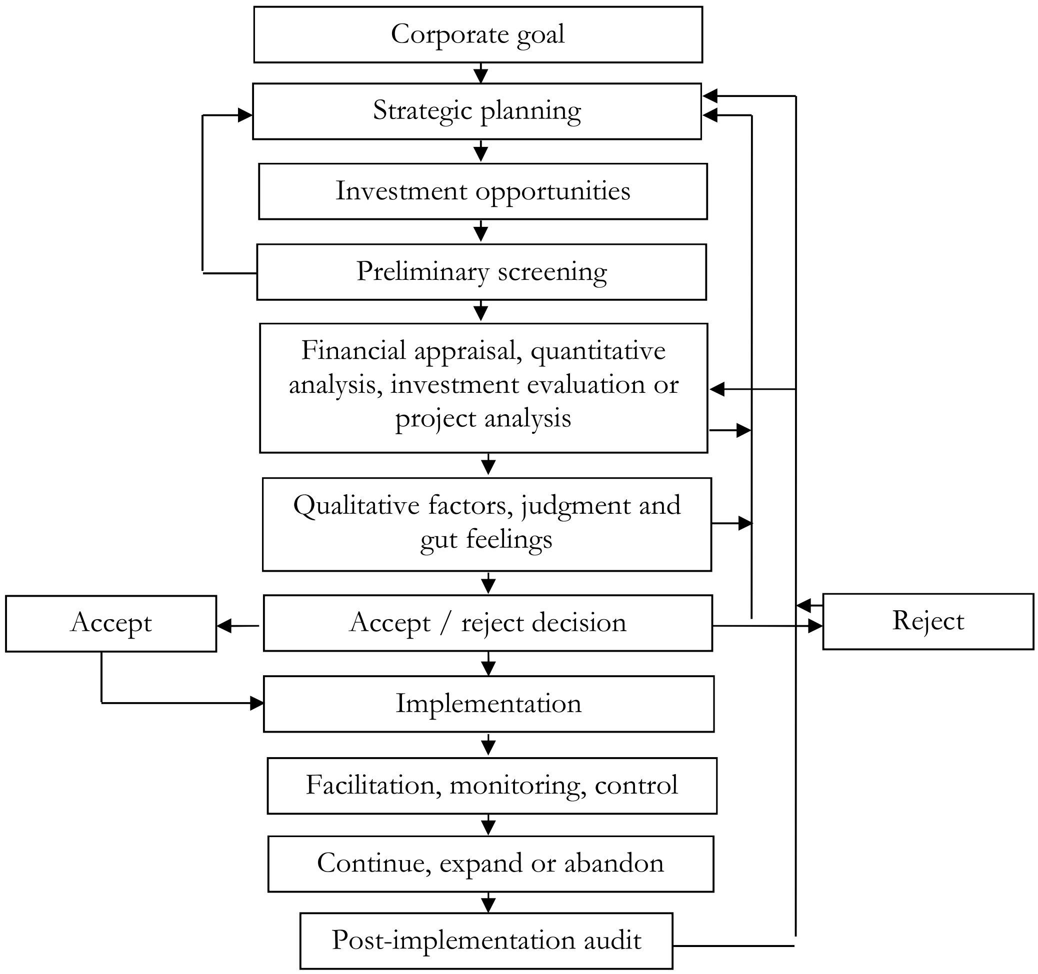

Figure 2.1. The stages of a capital budgeting process

As one might see on the Figure 2.1., the capital budgeting process starts with the strategic plan defined by Dayananda et al. (2002, p.5) as "the grand design of the firm and [that] clearly identifies the business the firm is in and where it intends to position itself in the future". The strategic plan is based on the company's goal. Moreover, the strategic plan transfers the corporate goal into the business language by specifying policies, defining the company's structure etc., which is required for the pursuing the corporate goals. It should be noted, however, that in most financial books the *capital budgeting* is understood more narrowly with the reference to the stages starting with the quantitative analysis and ending with the post-implementation audit (with some modifications in between).

There is a need to admit that in real life situations management might get caught into the quantitative mentality without paying duly attention to the fact of how the particular project does fit into the general strategy of the company. Migliore & McCracken (2001) demonstrate the necessity of linking the quantitative capital budgeting methods to the general strategic plan of the company. According to them, "since capital expenditures are long-term commitments, you should consider only strategically defined, thoroughly thought-out, *qualitative* and *quantitative* capital budgeting proposals. The classical concept of capital budgeting decisions says a company will accept the investment proposals up to that point where marginal costs equal revenues. But since you can't accept all capital investment proposals, you need to rank them based on some mathematical standard and keep going until you reach the point where funds aren't available or the project's return falls below the company's hurdle rate. You'll make these choices after you accept the mandatory and nonfinancial operating necessity proposals, such as pollution devices, safety programs, or employee benefits" (Migliore & McCracken, 2001, p.43; *cursive* mine).

Trigeorgis (1996) further notes that the inherent deficiencies of traditional quantitative methods of investment project appraisal (more precisely, the discounted cash flow-based methods) have become the major obstacle for use of these methods in the strategic planning, which was therefore dominated by the concepts of competitive advantage, market leadership etc. As the advocate of a real options concept, he claims that the gap between strategic analysis and quantitative methods might be narrowed by embedding the strategic real options into the project evaluation process. Consequently, one part of my research paper is specifically devoted to the idea and concept of real options applicability to the evaluation of the investment project.

2.2. Review of the Conventional Methods of Analysis

2.2.1. Investment Decision Criteria

There are multiple investment decision criteria that might be used in the process of the investment project evaluation. In current research paper I will focus mainly on two of them: net present value (NPV) and internal rate of return (IRR). According to results of two surveys of Graham and Harvey (2001) and Brounen, De Jong & Koedijk (2004) cited by Stowe and Gagne (2010), these two techniques are of the most importance in the US and play a major role among the valuation techniques in U.K., Netherlands, Germany and France (countries covered by the survey). After this, I will shortly explain the idea of a *discounted payback period* (DPP).

According to the definition given by Stowe and Gagne (2010), the project NPV is the 'present value of the future after-tax cash flows minus the investment outlay'. The conventional formula for calculation of the NPV is as follows:

$$NPV = \sum_{t=1}^{n} \frac{CF_t}{(1+r)^t} - \textit{Initial Investment}, \qquad \text{(F 2.1.)}$$

where CF_t – after-tax cash flow at time point t;
r – required rate of return on the investment;
Initial Investment – initial outlay at time point zero.

Thus, the concept of NPV is based on the discounted cash flow (DCF) method which, in turn, takes its roots in the theory of time value of money. Hence, the NPV represents nothing more than just a comparison of the future economic benefits from realisation of the investment project using their present values with the present value of the investment required (including the initial investment and all future investments attributable to the particular project). The rule of thumb is: invest, if NPV is equal or greater than zero; reject the project, if NPV is below zero.

Although the concept by itself is quite simple, there are couple of complications related to the NPV formula. The first complication is related to the question of how the cash flows are defined and forecasted. The second complication is related to the discount rate (designated here as the *required rate of return*); the main question here is how the manager defines this rate and which rate he or she shall select from the range of alternative rates. I will discuss these complications in more details later on.

The third complication is related to how to define the term ‘initial investment’. The general consensus is that the so called sunk costs (or costs associated e.g. with necessary research, that should be absorbed before even conducting the analysis of the investment project, and that cannot be recovered afterwards) are excluded from the amount of initial investment. In my research paper I will rely on the general consensus and exclude the sunk costs from the calculation.

A fourth complication is connected to the ideas of *terminal value* and *salvage value*. The idea of *terminal value* is based on the *going concern* assumption and might be defined as the present value of all cash flows occurred beyond the sequence of all forecasted cash flows (efficiently we might refer to it as a perpetuity if the zero-growth assumption holds place). It should be mentioned here that although the going concern assumption might be justified in case of the business entity (a company) as a whole, it is rather difficult to assume that the investment project will generate cash flows during the unidentified period of time. Thus, the component of terminal value is excluded from the formula (F 2.1.) and will be not used in the investment model afterwards.

The idea of a *salvage value* relates to the expected realisable (or selling) value of the asset after the end of its *useful life*. In the frame of my investment project valuation model I will refer to the *useful life* in terms of a lifespan of the gas supply contract (normally period of 15 years). It is clear that after the gas supply contract expires, there is a certain value of the equipment existing[1] regardless the fact that the equipment is being normally depreciated to zero value during the 15-years period. The problem with the definition of the salvage value is related to the technical specifications of the ASU-s, which often possess quite specific tailor-made characteristics and there is no certainty over the fact whether that specific equipment might be used by another customer without significant modifications. The practical model constructed and presented in the current research paper allows a provision for the flexible managerial assumption over the salvage value percentage after the expiration of the gas supply contract.

The concept of IRR is closely associated with the concept of NPV, whereas IRR represents the discount rate that turns the NPV value to zero by discounting the project cash

[1] Although, a zero-value for the civil works is assumed, see my comments and considerations above in the section 1.2 of the current research paper.

flows. By default, if the IRR is greater than the required rate of return, the NPV value should be above or equal to zero, and vice versa. However, it should be taken into consideration that the IRR by itself has no clear criterion regarding accepting or rejecting the investment project, as it should be compared to the so-called *cut-off* or *hurdle rate*, that as a rule represents the return necessary for raising funds in order to execute the investment project. The IRR is preferable under condition, when the management has difficulties with determining the discount rate (required rate of return) necessary for conducting the NPV analysis.

Of special interest might be some cases, when there is a problem of multiple IRR existing in the project. As the IRR equation represents a polynomial equation of n^{th} degree, it may have up to *n* solutions; moreover, it will have only as many *real* solutions, as many sign changes occurs in the sequence of the cash flows. There also might be some special cases, when the IRR equation associated with the investment project has no *real* solution. It should be mentioned, however, that the cases of a multiple IRR or "no-IRR" do not mean that the project should be rejected; in such cases the NPV criterion should be used. Such cases do not occur frequently in a real-life investment practice and are not of the high importance outside the academic circles.

The interesting case might represent the situation of the conflict between the NPV and IRR rankings (this case is also considered Stowe and Gagne, 2010). In this special case, the NPV and IRR generate different results for mutually exclusive investment projects. In such situations the strong suggestion is to use the NPV criterion due to the consideration that the NPV represents the amount of wealth increase in currency units. Thus, comparing of the NPV-s of mutually exclusive projects should indicate, which of them does generate the maximum value in cash flows for the company. The maximization of cash flow from the project leads to the maximisation of the value of the firm, thus aiming the maximization of the shareholders' value.

Another measure used for the description of the investment project is the *payback period*. The payback period indicates the number of years necessary for the investment amount to be earned based on the projected cash flows. This approach has two main deficiencies. First, it does not take into consideration the cost of capital, as it calculates the value of incoming nominal cash flows and compares them with the initially invested amount. Second, it ignores all the cash flows behind the payback period. If the project has a total length of ten years for example, and the payback period equals to seven years, then the payback calculation provides us with no information on the cash flows after the seventh year of the project execution.

To battle the first deficiency of the *payback period* method one might use the method of *discounted payback period*, where instead of nominal cash flows the discounted values of the projected cash flows are in use. This method is more advanced than the simple *payback period* method; however, it also does not provide us with the information on the cash flow series behind the payback period. The *discounted payback period* is quite comfortable measure, as it allows to quickly asses, whether the project will earn the invested money back during the time of validity of supply contact for instance. However, to battle the deficiency of not taking into consideration the residual cash flows, this method should be used as a complementary to the NPV and IRR criteria.

2.2.2. Breaking Apart the NPV Analysis

Two-Periodic Model under Certainty Condition

In this section I will closer investigate the idea underlying the concept of the NPV using the simplified two-periodic model with no-risk assumption based on Trigeorgis (1996).

Assuming that the main reason for company's existence is maximization of shareholders value, one can further define it in terms of maximizing the utility function of the individual shareholder, which represents the individual preferences between current and future consumption. It should be made clear in the very beginning that the management of the particular company bears responsibility for the maximization of the particular part of the shareholder's utility function, which is related to the investment into this company. Thus, under condition that the shareholders define their utility in monetary terms, the main objective of the management is the maximization of the company's market capitalization, which represents by itself the expected discounted dividend flow and final liquidation value (as it might be assumed that any changes in market value of the share are related to changes in expectation of the future dividend flow and liquidation value, as we assume no-risk and, thus, no changes in discount rate).

The utility-indifference U_1 curve reproduced below on the Figure 2.2 indicates the relationship between individual's preferences of current vs. future consumption. On the Figure 2.2 the U_1 and U_2 represent the indifference-utility curves for the particular individual; C_0 is the level of income (consumption) in current period; C_1 is the level of income (consumption) in the future period.

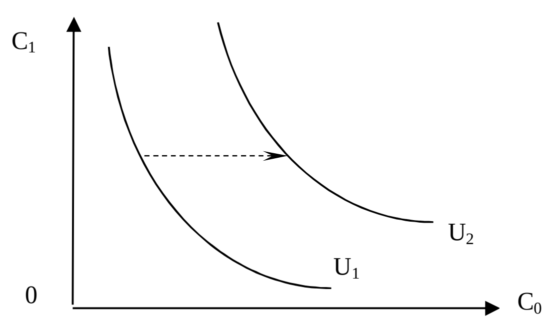

Figure 2.2. Individual Utility Indifference (UI) Curves

Under assumption of reasonable behavior one might conclude that any individual will try to push his (her) utility-indifference curve to the right ($U_1 \rightarrow U_2$). Whereas Trigeorgis (1996) notes that there are only two basic constraints existing on how far the utility-indifference curve might be shifted to the right. The first constraint represents the productive investment opportunities (i.e. investment into real assets or a company); the second constraint is defined by the market opportunities (represented by the individual's ability to borrow or to invest money on financial markets).

The productive investment opportunity might be graphically represented by the productive opportunity curve, as shown in Figure 2.3. below.

Acording to the PP’ curve on the Figure 2.3., an individual investor can achieve a higher income for the future consumption by investing his current wealth starting at point P into productive opportunities (just another definition for the investment project). The slope of the curve PP’ represents the marginal rate of return on a productive opportunity.

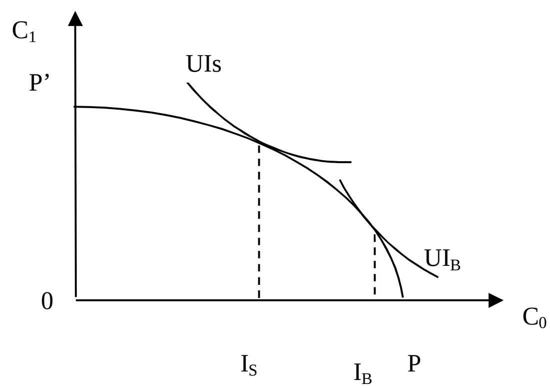

Figure 2.3. Productive Opportunity and UI Curves

It might be assumed that the reasonable individual will invest into productive opportunities based on his (her) specific utility function (preferences). The optimal investment level will be defined by a tangent of the highest possible utility-indifference line to the productive opportunity curve. Additional element in the Figure 2.3. are the utility-indifference (UI) curves for typical saver (UI_S) and borrower (UI_B). As one can see from the Figure 2.3., the UI curves for typical saver and typical borrower differ from one another (that is logical based on the utility concept), thus defining the different desired investment level into productive opportunities (I_S, P for the saver and I_B, P for the borrower). Such a conflict of interests should put the management of the firm into controversial position when different group of shareholders are expecting different levels of investment; however, the existence of financial market, which offer opportunity to borrow or to lend funds, create the opportunity for the shareholders to maximize their utility function apart from investment into productive opportunities.

The effect of existence of financial markets might be graphically repesented by the market opportunity line with the slope (1+r), where r represents the market interest rate (or risk-free rate under the risk-free assumption) as represented by the Figure 2.4.

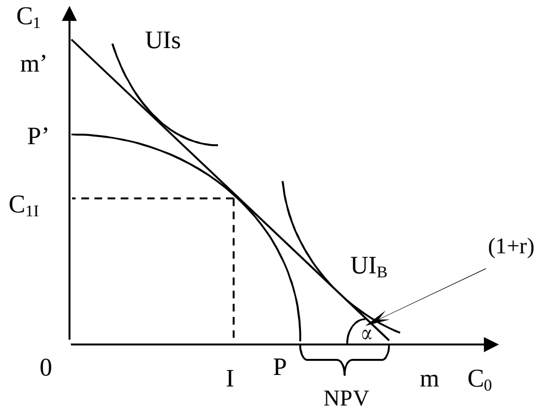

Figure 2.4. The effect of the market opportunity

Here again the curve PP' represents the productive opportunity with slope representing the marginal rate of return. C_0 and C_1 are the current and future income (consumption) level respectively. Line mm' represents the market opportunity line with a slope (1+r), where *r* is representing the market rate of return (or risk-free rate in our no-risk two-period model); note that for optimal case the mm' is tangent to PP'. IP represents the amount invested into productive opportunity in period 0 in order to achieve the level of income equal to $0C_{1I}$ in period 1. $UI_{(SB)}$ represent the utlility indifference curves respectively for a saver and a borrower; note that both are now higher that on Figure 2.3. due to existence of the market opportunity for borrowing and lending funds; this ability to maximize the individual utility function due to existence of financial market opportunities creates the possibility for the shareholders to delegate the decision making process regarding the productive investments to the management of the firm, which is the basis for an agency theory of the firm (the separation of ownership from the daily management).

Knowing $tg(\alpha) = (1+r)$ and $0C_{1I}$ one can find the Im equal to $0C_{1I}/tg(\alpha)$. Note that $0C_{1I}/tg(\alpha) = 0C_{1I}/(1+r)$ represents nothing else than discounting of the future income $0C_{1I}$ by the risk-free rate. Further, note that 0I represents the current level of income (consumption) and as I have just demonstrated that Im represents eventually the discounted future level of income (consumption), it is clear that $0I + Im = 0m$ represent the aggregate amount of dscounted cash flows from investment into production opportunity PP'. Consequently, Pm defined as 0m – 0I (where 0I is the amount invested in the period 0 into production opportunity PP') represents the positive Net Present Value (NPV) in risk-free two-period model (refer to Figure 2.4., see also Trigeorgis (1996)).

Extension of NPV Analysis to the Risky World

The previous section of the research paper considered NPV concept in the two-period world under certainty condition. It is clear that the latter is mostly not applicable to the real world situations (except maybe investments into US T-bills considered as a risk-free equivalent). Further I will extend the concept of NPV and include the risk factors into the analysis.

I would like to start with a consideration of two alternative methods that allow us to incorporate the risk factors into the NPV analysis. The first method is called the *certainty equivalent method*; the second one is the *risk-adjusted discount rate method*. Further I will briefly consider both concepts, but with greater focus on the *risk-adjusted discount rate method*.

Certainty Equivalent Method

The *certainty equivalent method* takes its roots in the utility concept. Its basic idea is that any risky cash flow might be substituted by its *certain* or *zero-risk* equivalent. The substitution should be made in such a way that both the risky cash flow and its *certainty equivalent* cash flow are treated as indifferent for the particular economic agent. Formally speaking, the present value of the *certainty equivalent* must be equal to present value of its risky prototype.

After defining the *certainty equivalent*, the NPV is calculated as the aggregate present value of all *certainty equivalent* cash flows discounted using the risk-free rate in denominator less the amount of initial investment. The complication of the certainty equivalent criterion is related to the fact that there is no rule of thumb how to define the certainty equivalent for the particular cash flow. It should be also noted that for different periods there will be different certainty equivalents (even if the cash flow series consist of the equal amounts) due to the fact that the uncertainty increases for remote periods.

The second complication is related to the fact that the certainty equivalents by definition are discounted using the risk-free rate; thus, the discount factor does not include any reference to the tax effect from interest payment for instance (the problem resolved when risk-adjusted discount rate, e.g. weighted average cost of capital is in use). Due to this complication, one must additionally consider the cash flow projection under conditions of *certainty equivalent* method.

Considerations Regarding the Cash Flow Definition

It has been already mentioned that the problem with the cash flow definition in the evaluation of the investment project arises due to the treatment of a tax issue. According to Arnold et al (2011), for the project evaluation reasons the cash flow may be defined in two ways.

The first way of cash flow definition is based on using the value of net income adjusted for the tax effects of depreciation and interest expense. The formula for adjusted net income is:

(Revenue – Operating expenses) (1 – Tax Rate) + Depreciation (Tax Rate) + Interest Expense (Tax Rate) (F 2.2)

It should be mentioned that the idea of a tax shield from interest expense might be justified only under condition that the related to the investment project amount of a loan (or a part of it) might be identified. The formula (F 2.2.) is borrowed directly from Arnold & Nixon (2011). The idea to adjust the net income for the effect of tax savings from depreciation and interest expense follows the logic that the proper management of these two components allows company to spend less cash on tax payments, which should be incorporated into the value of incremental cash flow.

As a next step, in order to receive the value of the cash flow necessary for the project evaluation, the result of formula (F 2.2) is further adjusted by a change in net working capital and change in fixed assets (from the balance sheet of a company). The received value is a cash flow from assets (CFA) and according to Arnold et al (2011) should be calculated as follows:

CFA = (Revenue – Operating expenses) (1 – Tax Rate) + Depreciation (Tax Rate) + Interest Expense (Tax Rate) – Change in Net WC – Change in Fixed Assets (F 2.3)

The alternative way to define the cash flow needed for the project evaluation is to calculate the so called free cash flow (FCF). The way to define the value of FCF is similar to CFA, except of the fact that the tax saving effect from the interest expense is excluded from the calculation (Arnold & Nixon):

FCF = (Revenue – Operating expenses) (1 – Tax Rate) + Depreciation (Tax Rate) – Change in Net WC – Change in Fixed Assets (F 2.4)

Arnold et al (2011) note that there are certain inconsistences among researchers' approach to the problem of the cash flow definition. However, taking into consideration the fact that the FCF might be considered as an "all-equity equivalent" of the CFA (i.e. cash flow to the shareholders from the project that is financed without use of the borrowed capital), they argue that the discount rate for CFA should be greater than one for the FCF due to the additional component for borrowed financing (taking into consideration the fact that CFA = FCF + Interest Expense (Tax Rate)).

Risk-Adjusted Discount Rate Method

The second method used in NPV concept is the *risk-adjusted discount rate* (RADR) method. Under this method, the projected cash flows are not adjusted; the risk factors are incorporated into the discount rate (*required rate of return*).

In my project evaluation model I will rely on this method. Consequently, I will use for the cash-flow projection the analogue of modified FCF method discussed above, as it is explicitly excluding the interest expense from the calculation of the cash flow (which is consistent with the idea of the *risk-adjusted discount rate* method, where the interest expense is effectively incorporated into the *cost of debt*, see below). The modification of the FCF method consists of the exclusion of a tax shield from the calculation due to the fact that the tax shield is also a part of the *cost of debt* and is included into the *risk-adjusted discount rate*.

Although there are several possible ways of how the required rate of return might be determined, the most common way to calculate it is to split this rate into parts according to the interests of providers of different types of capital (equity, debt, preferred shares etc.). This concept is referred to as a *weighted average cost of capital* (*WACC*).

The conventional formula for WACC calculation borrowed from Pagano and Stout (2004) is:

$$WACC = \sum_{i=0}^{n} Wi * Ki \quad \text{(F 2.5.)}$$

where w_i is the weight of the i^{th} unit of the source of capital based on market (or book) value in relation to the project total value;
k_i is the cost of the i^{th} unit of the source of capital.

Apparently, the portion of debt financing should be adjusted for the tax effect by multiplying it with (1-T), where T stands for the effective corporate tax rate. Thus, the cost of debt in WACC makes a provision for tax effect. As a result, there is no need for a cash flow adjustment for the tax effect from interest payments in a way it is done under *certainty equivalent* method. Moreover, any adjustment of the cash flow for tax effects might create the situation, when the tax effect is double counted (both under the cash flow and in discount factor). The cash flow sequence also has no need for inclusion of amounts of interest payments on the borrowed capital due to the fact that the *cost of debt* is already incorporated into the WACC.

Despite the seemingly simple underlying idea of WACC, three basic problems arise in connection to the process of its calculation. The first problem is related to the determining the *cost of equity*. For the privately held not listed companies the cost of equity is difficult to assess, as there is no market information available for calculation of beta ratios necessary for using CAPM. However, estimation for this component might be made based on the publicly available information for the listed peer companies, which are active in the same industry and on the same markets, or based on the sector beta.

Evaluating the Cost of Equity

The conventional way of defining the cost of equity is to use the Capital Asset Pricing Model (CAPM). According to CAPM, the cost of equity is defined by the expected return of the risk-free rate (k_{rf}), expected market return (k_m) and company's beta coefficient (ß) using the following formula:

$$k_e = k_{rf} + ß\,(k_m - k_{rf}) \quad \text{(F 2.6.),}$$

where k_e stands for cost of equity,
k_{rf} for expected return of the risk-free asset (usually represented by governmental bond yield),
ß for the beta ratio of the company (defined as the rate of change of regression line to the X-line, where regression line is built based on regression analysis between market and individual security historic returns);
k_m stands for expected market return;
($k_m - k_{rf}$) stands for equity risk premium.

As I have mentioned before, for not listed companies the estimation of historical betas could be made only based on the betas of the listed peer companies or sector beta.

The two main questions remain in relation to the use of CAPM in defining the cost of equity under the project financing exercise. The first question is related to the use of the project-based or company-based cost of equity under evaluation of an individual investment project. The second question is related to the use of leveraged vs. unlevered beta.

Project-Based vs. Company-Based Cost of Equity

The first question is whether one has to calculate the cost of equity for the particular investment project or for the company as a whole. The first proposition suggests that one should use the estimated company's beta and data for the risk-free rate and the expected market return for the particular market, in which the new project would be executed. The problem here arises with beta assessment in case if there is no sufficient time-series of sector vs. market returns (or these time-series are absent at all) for the particular market.

The second proposition suggests that we shall use the cost of equity calculated based on the aggregate company's business activities. The underlying idea is that if there is no SPV created for the execution of the new project, the new project will be apparently financed by the shareholders taking into consideration the whole specter of business activities of the company. In this case we do not have any problem with beta estimation, however, the next question might arise regarding which risk-free rate and expected market return numbers should be used. If we will use these numbers derived from the single market, we might face the situation when the cost of equity will substantially differ from the cost of equity of the aggregate company due to the fact that the risk metrics of the particular market might be not similar to the risk metrics of the main markets in which the company conducts its operational activities. In other case, we have to raise the question, if the new investment project does increase substantially the underlying risk of company's business operations. In the latter case we have to find a way to adjust somehow the risk metrics. Finally, the question remains, whether it is justifiable to use the beta estimation for the diversified company operating on different markets for assessing the cost of equity for the individual investment project, which risk apparently might be higher than that of the diversified company.

In the particular company's case reviewed under the part of research of the current research paper this problem has been resolved by the management by adding the clause into Investment Policy manual stipulating that every investment project is being evaluated and assessed on a stand-alone basis. It means that different investment projects are 'competing' with each other for shareholders' money and should be treated by the analyst as separate companies raising equity for undertaking the project. In this case the use of risk metrics of the particular market where the prospective project will be executed is justified. From the point of view of shareholders it also makes sense, as in this way the cost of equity will be different for the markets with different risk metrics. In this way, the investment projects cash flows with different risk levels will be discounted using different required rates of return, thus delivering comparable data on NPV, IRR and DPP.

The only question left on the table is related to the beta ratio by itself. As it has been mentioned above, for the privately held not listed companies the beta estimation might be derived by averaging betas of their close listed peers or using the sector beta. However, in case when the business activities of the peers are not restricted by the particular market (on which the prospective investment project is being evaluated) and the particular market offers no reliable data (which is not a rare case on emerging markets), the question remains of how the 'aggregated' beta is applicable for the evaluation of this particular project. In my research paper I propose to use the extrapolation of beta ratios, it means I assume that the sector betas are similar on the developed and developing markets. Thus, I will apply the 'aggregate' betas to the analysis of individual investment project.

Unlevered vs. Leveraged Beta

The second main issue in assessing the cost of equity is related to the use of different types of beta ratios. It is supposed that the manager has to acquire the information on the unlevered (or *pure-equity*) beta and afterwards to adjust the number for the financing structure of the company. The adjustment is being made based on the following formula:

ß(leveraged) = ß(unlevered) + ß(unlevered) x Market Value of Debt(1-Tax)/ Market Value of Equity (F 2.7)

The problem with the leveraging of beta for the not listed companies is again related to the absence of the information on market values of debt and equity (under realistic assumption that not all debt obligations of the company are represented by the listed debt). In my research paper I propose to use the values of unlevered betas for the reason of simplicity and avoiding making the complicated and simultaneously unsubstantiated assumptions.

Reasons for Using CAPM and a Short Review of Alternative Methods

The CAPM has gained its popularity among the analysts and managers mainly due to its ease of use and intuitive underlying logic. There are, however, serious academic doubts concerning the validity of the use of this model for calculation of the cost of equity. Main critiques and concerns of the CAPM are associated with the implicit assumptions of this model: efficiency of markets, stability of betas, applicability for the multi-period project, ease of deleveraging beta and perfect character of capital markets (Hall and Westerman, 2011). Although most of these assumptions seem to be unrealistic in the real world, CAPM nevertheless remains one of the most frequently used models for the evaluation of the cost of equity.

In addition to CAPM, several other methods of calculation of the cost of equity exist. Two of them worth mentioning here are the Arbitrage Pricing Model (APM), which allows to include into estimation of cost of equity additional systematic risk factors based on the idea of financial arbitrage (although, according to Pagano and Stout (2004), without any theoretic guidance for the specific risk factors, thus relying in identification of these factors solely on the empirical data) and the so called Bond Yield Plus Risk Premium method (BY+P), which represents the attempt to estimate the return on the equity by adding to the company's bond yield the certain percentage of additional return (calculated solely based on empirical data). In my research paper I will further focus on CAPM, as it is not as complicated as APM and also allows estimating the cost of equity for the companies without marketable debt securities.

Estimation of the Cost of Debt

The second problem arising in connection to the WACC calculation is related to the definition of the cost of debt. The first remark is that in calculation of WACC, which will be used for the evaluation of the new long-term project, the marginal cost of new debt should be taken into consideration (not the existing debt of the company). The idea is that the new project will be financed by raising the new debt.

The second remark is related to the broader definition of the cost of debt. I propose to consider the cost of debt for the Company being equal to sum of the yield on the 10Y governmental USD denominated debt and the default premium for the company under assumption of execution of the investment project. Thus, for the evaluation of the actual cost of debt applicable to the use in calculation of WACC the following equation should be solved:

Actual cost of debt = Government bond yield + Default risk premium (F 2.8.)

The idea I would like to use for the determining of the default risk premium is based on the fact that there is an established relation between the Altman's Z-score (and its modification Z''-score) and the corporate ratings. The Altman's Z-score and its variations Z' and Z'' are used by finance practitioners for quick definition of the probability of default for the company. The idea I will use in the part of research is following: if I can define the Z''-score (the Altman's Z-score is not applicable to the privately held unlisted companies), and then find the corresponding credit rating (e.g. based on Hartzell et al., 1995), then knowing the cumulative historical rate of default for the period of the length of the project available from Moody's research, the annual default risk premium for the debt might be calculated. Then, knowing the governmental yields (this information should be normally available on the market) and adding to this number the default risk premium, I can determine the cost of debt, which will be used in WACC calculation.

Definition of the Weights of Debt and Equity in WACC

The next problematic issue arising in connection to the concept of WACC is related to the question of how to define the weights of debt and equity in WACC formula. There are several approaches that might be used. One approach is to use the market values of debt and equity. If for the listed public company mainly it is not difficult to find out the market value of equity, the market value of debt might be much more difficult to determine. For calculation of market value of debt the manager has to know the information on the yields to maturity of all company's debentures, which is mostly not available in the case, if company has no listed debt. As an approximation, the weight of debt might be determined using the formula:

w_d *= Book Value of Debt / [Market Value of Equity + Book Value of Debt]* (F 2.9.)

For the private not listed company the weight of debt cannot be determined using the formula (2.9.), as there is no indication of market value of equity due to the fact, the company is not listed. In this case the so called target weights of debt and equity might be used. The definition of target weights is mainly subjective and is the task of shareholders. If there are few shareholders, the definition of target weights is not as complicated, as it may be in case there are numerous shareholders in the company with different and sometimes conflicting interests. In my case I will rely in the project evaluation model on the target weights defined by the corporate policy of the shareholder company through the Debt / EBITDA ratio.

Single Discount Rate vs. Multiple Discount Rate Approach

One more problem associated with the use of WACC as discount factor under the NPV concept is that usually the cash flows are being discounted using one single discount rate. The discount rate should, however, account for the risk associated with cash flows. Taken into consideration the fact that the cash flow forecast by itself represents the risky activity (as it eventually represents the attempt to catch up with unknown future), it is intuitively clear that cash flows for the earlier periods may be forecasted with greater certainty than those for the later periods. As this is the case, the discount rate, that incorporates the element of riskiness of the particular cash flow, should differ for different time periods. This is particularly the same idea as under the *certainty equivalent* method. Although intuitively the problem is quite clear and understandable, in the real life it is not easy to overcome, as we do not possess the information today regarding the future cost of different types of capital; due to this fact our projections into the future will be heavily influenced by the information available today and, thus, biased.

To overcome the problem of the difference between periodic cash flows it might be noted that one can use the single discount rate for the whole sequence of the cash flows associated with the particular investment project. This single discount rate might be calculated by replacing the different discounts rates in the NPV formula with one rate that will generate the same result. As in such case mathematically it is indifferent, whether one single discount rate or the sequence of discount rates for cash flows associated with different time periods is in use, one might use the single rate based on the WACC calculated today under basic assumption that the beta ratios and thus the cost of equity calculated today incorporate all available information. By determining in this way the required rate of return from the side of shareholders and based on the assumption of repeating history, there should be no reason to believe that the future betas will be significantly different from today's in the long run.

The additional reason for the use of the different WACC for individual years lies in the fact that the D/E ratio usually changes for the companies over period of time. However, under assumption of the target D /E ratio, the use of the single number of WACC for the complete time series of the projected cash flows might be justified.

2.2.3. *Incorporating the Real Options Method*

The advantage of the so-called conventional methods of investment project evaluation discussed above is in their easiness to be understood (often on an intuitive level). These methods provide management with a comprehensive framework for the informed and fast decision-making.

The opponents of conventional methods are arguing that the problem of the NPV analysis is related to its static characteristics of the risk. The only factor capturing the risk associated with the investment project is the discount rate or management's perception of the certainty equivalent of the future cash flows. Although both described methods try to incorporate more or less all types and measures of risks that are known at the time of the decision making, they do not take into account a changing character of risks over the time of project execution.

Further, Mun (2006) argues that the static models of investment project evaluation deprive the management of any flexibility to influence the project or change the investment decision after it has been taken once in the past. In such a case, the static model does not correspond to the complexity of the real world, where the management has much more flexibility to be actively involved into the execution of the investment project on all stages beyond the initial project analysis and evaluation.

The method of real options might serve as a remedy for the static character of the conventional models. Depending on its specific type (I will refer to these specific types of real options later in this research paper), the real option might grant the management the right (but, similarly to the financial option definition, not an obligation) to wait and see, to expand or contract the operations based on the new information that becomes available during the course of project execution or when some of the uncertainties associated with the specific investment project will become resolved.

According to Ford et al. (2002), the main underlying concept for the real options theory is that under circumstances of a high implied uncertainty in the situations, when subsequent changes in the strategy during the process of implementation of the investment project might be very costly for the company, implementing the flexible strategy and postponing the final decision making into the future when some of the uncertainties might be resolved, generates the particular value on the stage of project planning and pre-executional analysis. According to this definition, the real option identification shall start on the stage of strategic planning with the subsequent analysis of the real options on the stage of the preliminary project screening and financial appraisal (according to Dayananda et al., 2002).

Moreover, as one will see during the discussion of the real options valuation techniques, the value of a real option depends on the time to maturity and the underlying volatility (the latter is directly connected to the level of uncertainty). Further, Benjaafar et al. (1995) prove that:

1. The flexibility has no value under circumstances of zero-uncertainty.
2. The flexibility has no value under circumstances of the absence of expeceted future information.

Hence, as it might be observed, the value of a real option (the option premium) is related to the value of flexibility. Moreover, if uncertainty rises, the value of flexibility and thus, the value of related real option, also rises. The same is true regarding the time of the project: with an increase in time of the project implementation, the value of flexibility and connected to it value of real option increases (*ceteris paribus*).

Speaking of the inclusion of the real option analysis into a broader framework of investment project analysis and evaluation, Trigeorgis (2002) defines the *strategic* (or expanded) *NPV* as the sum of the passive (or static) NPV and real option premium:

Strategic NPV = passive NPV + Real Option Premium (F 2.10.)

Taking into consideration the definition of the *strategic NPV* as the sum of static NPV and real option premium as in F 2.10., it can be concluded that for the projects with extended duration and high underlying uncertainty the strategic value of a real option calculated on the stage of planning might be high enough to significantly alter the result of the investment project evaluation activities. The fact that similar to financial options, real options have underlying value, means that incorporating real options into the NPV analysis of the investment project shall produce more accurate valuation results, which are more consistent with the real world conditions. Relying solely on static NVP and other DCF methods in the process of investment project evaluation might incorporate the risk of underestimating real economic benefits associated with the project, as will be demonstrated in the research section of research paper.

Further discussion on the idea of real options needs some clarification regarding the value of option premium. Namely, the option premium is increasing along with the increasing of the standard deviation of the sample, that means the real option value in (F 2.10.) should increase along with the riskeness of the investment project measured as a standard deviation of its possible outcomes (represents uncertainty according to Benjaafar et al., 1995). This statement is in line with results of conventional financial option valuation models (e.g. the Black-Sholes model for European options), but it is also intuitively clear. The statement simply means that the value of a real option embedded into the investment project will increase along with an increase in project’s level of risk; this means that the managerial flexibility in e.g. postponing the decision making will become more valuable and add to the project value according to (F 2.10.) in case when initial uncertainties related to the project are high enough. In such cases waiting for resolving of the underlying uncertainties in the future is worth undertaking.

Trigeorgis (2002) differentiate between following types of the real options:

1. The option to defer investment connected to the management's flexibility to take the investment decision in the future, after some of the uncertainties associated with the investment project have been resolved.
2. The option to abandon staged investment connected to the management's right to stop the project on some stage of its execution, if some of the investment conditions turn to be unfavourable.
3. The option to expand connected to management's right to increase the scope of the project and future production volume under favourable conditions.
4. The option to contract (contrarian to the section (3)).
5. The option to temporary shut down (and re-start) operation based on the changing conditions in the future.
6. The option to abandon for salvage value; again, if the future conditions turn to be unfavourable for the investment project.
7. The option to switch use (if there are several possibilities to use the assets, associated with the investment project, in the future).
8. Corporate growth options connected to the fact that some investments might be considered as initial pre-requisites for the future strategic developments.

Although there are numerious types of real options existing (see above) in the current research paper I will limit my analysis to the *option to expand the operations*. It should be mentioned that the option valuation model will work for any type of real options listed above; however, the identification of the additional specific real options imbedded into the project needs careful and rigorous analysis on the planning stage. It should be stated, however, that the *option to expand the operations* in its form as discribed and discussed in the current research paper represents the crucial element of the typical investment project described below, and the model might be used by the management of the concidered company without significant modifications.

According to Trigeorgis (1996), the analysis of real options may indicate the need of inclusion into the model of several options from the list, sometimes even the structures of option on option. It should be kept in mind, however, that any model will represent a sort of simplified approximation of the real world processes. Hence, any complications of the model might and should be considered only if they are really necessary for the appropriate reflection of the real world situation and add value to the analysis. Any unnecessary complication might lead to mistakes while adding no substantial value to the process of project evaluation.

Mun (2006) considers eight following steps in performing the real option's analysis:

1. Qualitative management screening;
2. Time-series and regression forecasting;
3. Base case NPV analysis;
4. Monte Carlo simulation;
5. Real option problem framing;
6. Real option modelling and analysis;

7. Portfolio and resource optimization;
8. Reporting and update analysis.

As it might be observed, the step of the real option modelling and analysis is included into a broader context of the project analysis and is performed after identifying the sources and magnitude of volatility (uncertainties associated with the project). Morover, Mun (2006) mentiones again that the presence of risk (uncertainty) and the fact of its influence on the decision making process is a necessary condition for the real option analysis.

In the next section of the research paper I will discuss the option valuation model proposed by Cox et al. (1979) named after its authors the Cox, Ross and Rubinstein (or the CRR) model. This model creates a framework for the quantification of the effect of a real option. However, here I would like to mention the fact that the quantitative valuation of the real option, as complicated as it might seem, is more technical process and might be easily done using the prefabricated Excel models. The most complicated step in the analysis is the part of *real option problem farming*, as sometimes it might be difficult even for the management to figure out what types of real options are imbedded into particular investment project.

Mun (2006) provides us with some considerations on the criticisms of the real option model:

1. Real option analysis is merely an academic excersize and has no practical value.
   As a counterargument Mun mentiones that although in the past it might be a true statement, nowadays more and more corporations start to include the real option valuation technics into the investment project analysis process.
2. Real option analysis just allows the management to artificially inflate the value of the investment project, in order to justify the unprofitable projects.
   Mun mentiones that in case if the project has a significant embedded option, not counting on this option is eventually leading to the undervaluing the value of the project. He also concludes that the real option valuation should be started only after there is an evidence and understanding that uncertainties do exist and that these uncertainties provide management with the flexibility. Thus, as it might be observed from the flow of real option analysis process reproduced on the previous page, identification of uncertainties (step 4) and analysis of their effect on flexibility in decision-making (step 5) are preceding the actual process of real option valuation and analysis (step 6).
3. Real option analysis end up in selecting the most risky process, as according to option valuation technics higher volatility (uncertainty) leads to higher value of real option.
   Again, Mun (2006) mentiones that in case if real option does not exist, its value is effectively zero (pointing to the need of a prudent analysis preceding the real option valuation process – refer to the previous section). Risky projects should be necessary viewed and considered in terms of embedded option, which allows to limit the potential loss, while keeps the opportunity open for capturing with potential upside. In this sense I would add that if the management sees the considerable uncertainty surrounding the project, it should conduct the thorough analysis of which options do

they have in the future for the flexible reaction to the changing circumstances. Capturing the value of these strategic options is just a technical issue, while understanding of the strategic options by the management might be of vital importance.

Moreover, Mun (2006) mentiones that regardless the fact that the value of an option at any point of time could be either zero or positive, the cost for obtaining the option might sometimes exceed the benefits associated with the option, that might make the value of a real option negative.

Some Considerations on the Real Options Valuation

The valuation of a real option refers to the step 6 of option analysis and follows identification of uncertainties associated with the investment project and the analysis of real options framework. Although there are several ways how to value the option (the valuation of the real option in its essence does not significantly differ from the valuation of financial options), the mostly known method was proposed in 1973 by Fisher Black and Myron Sholes (now referred to as the Black-Sholes model). I will not discuss this model in details in my research paper, as it might be found in various books on financial management or financial engineering. It should be mentioned, however, that the Black-Sholes model works perfectly for the European types of options (those with exercise only at the end of the option period), but for the American types of options more complicated structures of option on option need to be created. Additionally, according to Cox et al (1979), the complicated mathematical methods used by Black and Sholes are quite advanced and that they "have tended to obscure the underlying economics" (Cox et al., 1979, p.230).

Cox, Ross and Rubinstein developed the so-called binomial option pricing model (now referred to as CRR model in academic circles). The CRR model is based on assumptions of no-arbitrage, constant risk-free rate and efficient markets. The model assumes that the price of an asset is moving in descrete steps and every next movement (either up or down) is defined by the certain probability, and, according to Cox et al. (1979), it is of no importance to know, what is the probability for the asset price to move up or down, as it does not affect the value of an option (definitely, the sum of two probabilities must still be equal to one).

$$S \begin{array}{l} \nearrow uS \\ \searrow dS \end{array} \qquad \text{(F 2.11.)}$$

where S is initial value, uS and dS are expected values after first step defined by probabilities *p* and (*1*-*p*) (it does indifferent, whether the probability *p* defines the up-movement or down-movement).

Assuming that over short periods of time the binomial model may replicate the change in asset's value in a risk-neutral world and supposing the relation between u and d to be equal:

$u = 1 / d$ (F 2.12.)

CRR model proposes the following equations for determining p, u and d:

$$p = \frac{e^{r\Delta t} d}{u - d} \quad \text{(F 2.13.)}$$

$$u = e^{\sigma\sqrt{\Delta t}} \quad \text{(F 2.14.)}$$

$$\mathrm{d} = e^{-\sigma\sqrt{\Delta t}} \quad \text{(F 2.15.)}$$

where *p* is the probability of moving of the asset price one step up or down,
σ is the standard deviation calculated as a square root of the variance of a risk-free asset (the model assumes that the variances of the risk-free asset and the variance in a risk-neutral system match),
Δt is time span between two statuses of the system (e.g. S and uS or dS according to (F 2.11.)).

The value of an option according to multistep binomial model is defined as follows:

For the put option: $V_n = max\ (K - S_n, 0)$ (F 2.16.)
For the call option: $V_n = max\ (S_n - K, 0)$ (F 2.17.)

where V_N stands for the option price at the end of the node n (expiry date),
K stands for the strike price of an option,
S_N stands for the price of an asset the end of the node n.

Discounting the option value into todays value terms needs moving back through the lattice (similar to the represented in (F 2.11.), but usually with more nodes) and calculating the option price at every single step.

Although it should be mentioned that the binomial approach to option valuation generates the approximate results to the more sophisticated models (e.g. Black-Sholes model), it provides a quite good approximation if sufficient number of itirations (nodes) are used. Its strengths is that due to its relative simplicity it may be used with some modifications by the management not acquainted with the sophisticated mathimatical models.

Closing the part of discussion regarding real options analysis and valuation, I would like to briefly touch one more idea. Although, the real option that allows the management to postpone the decision-making until some uncertainties will be resolved might be seen as beneficial for the management, sometimes it might be contrary to the human nature itself. Postponment of the decision might create the uncomfortable situation of realising the uncertainties associated with the investment project. It may also demand the coordination of additional resources in the future necessary for controlling the course of actions and mobilisation of these resources for the multiple decision-makings in the future. Due to the fact that the decision-making process is time- and energy-consuming, it might be considered to be tempting and easier for the management to make the final decision regarding the investment project on an early stage of project evaluation.

3. Research Design

In the part of research I will complement the theoretical ideas and considerations discussed under the section of literature review with development of the Excel-based investment project evaluation model. I will describe the basic ideas underlying the concept of this model further in the text. Here I only would like to mention the fact that in my model I will use three gauges for the analysis of the results: NPV, IRR and DPP (I have already reviewed these ideas in the theoretical part of the current research paper).

Next, I will include into my investment project evaluation model the idea of real option valuation and demonstrate how the value of the embedded real option can positively affect the results of the model by adding the value of the real option premium to a static NPV figure resulting in the number of the *strategic NPV*.

I will conclude the research part of the research paper with recommendations to the management regarding the implementation of different investment project evaluation methods.

3.1. Stages of Research Design

The research design of the research paper is split into following steps:

- ✓ Design and forecast of the *time series* of cash flows;
- ✓ Calculation of the *cost of equity*;
- ✓ Adjustment of *cost of debt* for *default risk premium*;
- ✓ Calculation of WACC;
- ✓ Calculation of NPV;
- ✓ Calculation of IRR;
- ✓ Calculation of DPP;
- ✓ Real option valuation;
- ✓ Calculation of the *strategic NPV*.

I will introduce the consideration of the research topics listed above by a short description of the investment case, in order to make the reader acquainted with the background of the subsequent analysis.

The first block of the research will be devoted to the elaboration of the quantitative model of the investment project evaluation. In this model I will rely on the idea of the *risk-adjusted discount rate method*, as the method of *certainty equivalent* include the great amount of subjectivity and, thus, it would be more difficult to apply it to the generalized model. Further, I will conduct the analysis of the investment project based on NPV, IRR and DPP criteria.

For the calculation of NPV criterion I will use the required rate of return represented by the *WACC*.

Next, I will complement the model with the additional sheet for calculation of the value of real option (*option to expand the operations*) and demonstrate how the component of real option might be included into the investment project evaluation. As the value of real option is capturing the management ability to react flexibly to the changing conditions and to change the course of the project once the investment decision has been taken, I will demonstrate how the inclusion of the real option component into the model might add particular value to the investment project evaluation process and influence the ultimate result of the analysis. For the real option analysis I will construct the separate sheet for calculation of the results of additional investment (for explanation see further in the text of the section 3.3.). I will calculate the *present value* of the future operating cash flows (representing the market value of the security in the option analysis) and the present value of the delayed future investment (representing the strike price of the security under the option analysis). For the discounting of the operating cash flows I will use the value of WACC calculated on the earlier stages of the project evaluation model. The amount of delayed future investment will be discounted using the risk-free rate. The underlying idea is that the company does not need to invest or borrow this amount immediately; however, if the company would have this amount on its bank account, it could invest it into risk-free securities, in order to receive the necessary amount in time necessary for the investment.

In order to determine the present value of a real option I will use the predefined Excel model constructed based on the CRR available on http://investexcel.net, as the underlying idea is quite formal and there is no need to construct the real option valuation sheet by myself.

The research design is corresponding to the steps 2 – 6 of the proposed by Mun (2006) eight-step analysis of the real option analysis process (refer to the page 26 of the current research paper). Although, as I have mentioned in the introductory part of the research paper, step 1 of the Mun’s (2006) proposed real option analysis, which correlates with steps 1 – 4 of the Dayananda et al. (2002) of capital budgeting process (refer to the page 10 of the current research paper) is extremely important in the holistic process of the investment project appraisal, these steps lie outside the scope of the current quantitative research. Step 7 of the real option analysis process has reference to the optimization of the investment portfolio on the corporate level and does not possess any relevance to the study of individual investment project. Step 8 relates to the post-executional reporting and audit of results and thus, it is also outside of the scope of current research, which deals with the stages of the planning, analysis and quantitative evaluation of the prospective investment project.

3.2. Brief Description of the Investment Case

For the purpose of construction and explaining the project evaluation model I will use the example close to the real business situation. I will consider the possibility of the new investment on the Ukrainian market of air gases. For the sake of clarity I would like to add that although the investment case is very close to the real situation, there is no connection right now between the business case and actual plans of the particular company regarding the future development of its Ukrainian business; thus, any information presented in the current research paper might not be regarded as the basis for taking financial or other decisions by the third parties.

The company has its presence on Ukrainian market since the year 2005 when it has acquired the control stake in a former state-owned company from the Ukrainian government. Since then the Company has been actively involved in Ukrainian business of production and distribution of technical gases. In December 2007 the Company has signed the contract with Ukrainian steel producer (the customer). According to the Contract, the Company accepted the obligation to erect the ASU in order to supply with air gases the new electric arc furnace (EAF) premises erected by the customer. According to the initial plan, start of the new production facility was planned for the year 2009; however, due to the delay caused by the worldwide financial crisis of 2008 – 2009, the new ASU was finally completed in 2012.

For the explanation of the Excel-based model I will use the example of the analysis of the theoretical investment project in Ukraine similar to the project executed in 2007-2012. Let us assume that the company is considering an investment into the new ASU with a capacity of 7,910 Nm^3 per hour of gaseous oxygen (GOX). The ASU will also produce the gaseous nitrogen (GAN) for the onsite customer. In addition to the gaseous products, the ASU will produce the air gases in liquid substance: liquid oxygen (LOX), liquid nitrogen (LIN) and liquid argon (LAR), which company will be able to sell on the open market.

The onsite customer is a steel mill[2], which is currently undergoing the process of renovation of its production facilities. The old furnaces are being replaced by the new electric arc furnaces. The onsite customer estimates the quantity of oxygen necessary for the new production process equal exactly to 7,910 Nm^3 per hour with 7,500 hours per year of operation; however, as the technology is new, the customer cannot give any guarantee for the ordered volume. The parties can agree for the take or pay (TOP) quantity of gas in amount of 85% of the maximum volume.

The maximum turn down ratio of the new ASU is 85% (which means, the production of GOX may be reduced to 6,723.5 Nm^3 per hour without any loss in efficiency of the ASU; any further decrease in production will cause the excessive electricity consumption). Hence, the Company is on the safe side with its investment, as the TOP payment will cover the minimum volume of production independently on the actual consumption profile of the customer.

Further, the onsite customer is interested in purchasing the air gases, thus letting the Company proprietary rights to the equipment. The onsite customer is willing to sign the gas supply contract for the term of 15 years of deliveries. The company estimates that the erection of the ASU will take up to 26 month, but this is satisfactory for the customer, as it is

[2] It could be any other customer from any other industry; also the type of gas produced might be e.g. gaseous nitrogen.

expected the renovation works to take up to 30 months (thus, leaving the parties about four months of time for closing the tender and signing the gas supply contract). The Company is welcome to present its technical solution and to make a price proposal to the customer. There is available information that four other gas companies are competing for this project and considering making their proposals to the customer.

In order to make an offer to the customer, the management of the company has to assess the quantitative part of the project, in order to be able to work out the price proposal for the customer. For this purpose, the management has to know the cost of the constructed ASU, its technological characteristics (absorbed energy consumption etc.) and possible proposal ideas from the competitors; the management should as well collect the information from the sales and marketing department regarding the volumes and market prices for the liquid gases (which will be the complementary product to the gaseous production into customer's pipeline). Then, the management has to clearly articulate the investment decision criteria (either NPV, IRR, payback period or something else). After gathering all the necessary information and defining the investment criteria, the management can use the results of the investment project evaluation model as a decision making guideline.

During the forecasting of the project based cash flows, the gaseous sales volumes normally represent the TOP volumes according to the terms agreed with onsite customer (the so-called worst case scenario). Such a conservative approach to the project evaluation might be justified; however, taking into consideration the high uncertainty around the project (the main factor of uncertainty is the new technology implemented by an onsite customer and, as a result, the inability to forecast with certainty the required volume of oxygen and other air gases), the real sales can be understated if customer's consumption profile will match the initial engineering calculation of 7,910 Nm^3 per hour.

Here I would like to go further in the analysis and consider the spectre of management's choices under circumstances of realization of the worst case scenario, when it becomes clear that the onsite customer needs the gaseous product not exceeding the TOP quantity. Eventually, in such a case the management might consider the possibility of acquiring the additional liquefier, which will create the possibility to a company to liquefy the excessive amount of gaseous oxygen (let us say, 1,100 Nm^3 per hour) and to sell the additional liquid gas on the open market. The decision to acquire or not to acquire the liquefier depends on the estimation of the price of liquid oxygen (LOX) on the market in the future.

Not accounting on the management option to install the liquefier and for the company to generate the additional revenue through the sales of additional volume of liquid gas on an open market (I will refer to it as the *real option to expand the operations*), might create the situation of possible understatement of the real NPV of the investment project leading to a situation when management of the company might reject potentially profitable project if the real option analysis will not be included into the project evaluation. Thus, the additional value generated by the real option might be of critical importance in the decision making process of whether to accept or to reject the investment project.

3.3. The Description of the Project Valuation Model

3.3.1. Basic Assumptions and Structure of the Research Model

The second block of the research part is devoted to the construction of the Excel-based model for the evaluation of the investment project. The method is based on the forecast of the cash flows and then discounting them to present value using the required rate of return. Further I will shortly review the main components and results of the project evaluation model.

The basic assumptions of the model are as follows:

1. The investment project is being analysed on a stand-alone basis.
2. The cash flows are projected in real terms.
3. The construction interest is automatically capitalized due to the fact that it influences the basis for depreciation.
4. The interest expense on project financing is excluded from the cash flow calculations due to the fact that it is incorporated into WACC.
5. IRR and NVP are linked to the end of project commercial operations.
6. The evaluation of the project is conducted based on four metrics: NPV, IRR, DPP and Strategic NPV (in case of a real option).
7. The annual cash flow is constructed at the end of the fiscal year.
8. Interest revenues are excluded from the cash flow calculation.
9. 15-years straight line method of depreciation is in use.
10. Tax shield from depreciation amount is excluded from the calculation of the cash flows due to the fact that the WACC is already including the element of the tax shield.
11. For the means of simplification, the model is calculating all the incoming and outgoing cash flows in euro equivalent without adjustment for inflation.

I acknowledge that the last assumption is oversimplified, as the model in its current form does not account for the risk of local inflation and connected to it risk of devaluation of the local currency against euro. Also the element of inflation and the risk of devaluation are excluded from the calculation of the WACC. I assume the inclusion of inflation and accounting for risk of devaluation are the next step in developing the model and will be the ideas for the next research.

The model is based on the stages 2 – 6 of the eight-step real option analysis process proposed by Mun (2006). The five steps out of eight used in the construction of the model are:

1. Time-series and regression forecasting;
2. Base case NPV analysis;
3. Monte Carlo simulation;
4. Real option problem framing;
5. Real option modeling and analysis.

Next I will go through this list step by step.

3.3.2. Time-series and regression forecasting

On the step of 'Time-series and regression forecasting' the model requires following information:

1. Available information on prices and quantities, duration of the gas supply contract with the onsite customer and information on the local tax rate. The quantity of gaseous product for the onsite customer corresponds to the TOP condition resulted from negotiation between Company's and customer's management. The gaseous prices are the result of the tender process.

   The quantity and prices of liquid products are delivered by the commercial department of the company; both inputs should be forecasted taking into consideration the three types of scenarios (neutral, worst-case and best-case scenarios). In the static model the neutral scenario is in use.

   The data on product prices are inserted manually in the worksheet 'Highlights' (see Appendix A). The data on the product volumes are manually inserted into 'Finance Plan' worksheet (see Appendix B). The number signifying the duration of the gas supply contract in years is also inserted manually in the 'Finance Plan' worksheet; according to this number, the model is automatically detecting the lengths of incoming cash flows under 'Sales' worksheet. The data on the local tax rate is inserted manually 'Finance Plan' worksheet and is used in calculation of the after-tax cash flows.
2. Average payment terms of customers and to suppliers (in months). The data is inserted manually in the 'Finance Plan' worksheet and is being used by the model in the calculation of the necessary amount of investment into working capital under evaluation of project cash flows.
3. Payment schedule to the main contractor, i.e. when and in which instalments the Company is supposed to pay to its main contractor for the delivery of the ASU. The data is inserted manually in the 'Finance Plan' worksheet and is based on the terms of the contract with the main contractor. The payment schedule should differentiate between payment for the equipment and payment for civil construction activities. This is important, as the model will use the value of equipment for calculation of the residual value after the end or termination of the gas supply contract.
4. Terms of financing are inserted manually into the worksheet 'Cost of Debt' (see appendix D) according to the data from the contract with financing institution. These data is necessary for calculation of the *construction interest*, which will be capitalized and consequently increase the depreciable value of the ASU.
5. Management's estimation for the residual value of the equipment after the end or termination of the gas supply contract with pipeline customer (in percentage). This number is inserted in the 'Finance Plan' worksheet; based on this figure the model will calculate automatically the residual value of the equipment and use it in the calculation of static NPV.
6. Cost data for electricity, water supply, maintenance and repair (M&R), insurance etc. is inserted manually into the 'Cost' sheet (see Appendix C) and is based on the data

available from the contracts with suppliers of the cost articles (e.g. for prices from electricity supplier in Ukraine see www.nerc.gov.ua). Based on these data, the model will calculate automatically the amount of yearly variable costs taking into consideration the yearly volumes of sales (production) from the worksheet 'Sales'.

Based on the data and underlying assumptions described above, the model calculates the time series of the cash flows adjusted for the residual value of the equipment at the end of the contractual period. The time series are calculated automatically and recorded in the worksheet 'Profitability-Statement' of the project evaluation model (refer to Appendix E).

3.3.3. Base Case NPV Analysis

On this stage of the analysis the model requires the calculation of the applicable discount rate for the determining of the present value of cash flows time series calculated by the model on the first stage of *Time-series and regression forecasting*. The model is using WACC as the applicable discount rate. Further I will take a closer look to the calculation of WACC, as it is not as obvious as any other input in the proposed model and require additional assumptions and considerations.

Based on definition of WACC, the model requires some additional data necessary for the calculation of the cost of equity and cost of debt. For description of the process of calculation the cost of equity and cost of debt see explanations below.

Cost of Equity

The main element of the cost of equity, the beta ratio, is not available in our case, as the Company itself and both of its shareholders are privately held entities, not listed on any of the stock exchanges. On the worksheet 'Beta Estimation' (data available upon request) I have derived from the Bloomberg Terminal service two types of beta ratios. The first number of 0.72 corresponds to the 5Y historical beta of the industrial gases and chemistry sector vs. the broad MSCI World index. The second number of 0.37 represents the 4Y historical beta (starting since 2009 IPO) of the Chinese air gas producer Yndge Gases vs. the MSCI Emerging Markets index. As the comparative figures I considered the beta ratios for the closest listed peer companies German Linde Aktiengesellschaft (present on all markets, where the Company is active), French Air Liquid (currently entering the Ukrainian market, very active on a Russian market, in Baltics represented through some resellers) and the US-based company Praxair, Inc. with presence in Russia and Ukraine. The data on the betas of the peer companies are available e.g. on the website of Thomson Reuters (www.reuters.com). The historical betas for the aforementioned three peers are equal to 0.90; 0.55 and 0.83 respectively. One can observe that the average beta of three peer companies is close to the 5Y historical sector beta calculated using data from Bloomberg and is quite far away from the emerging market beta represented by the Chinese Yngde Gases. It might be reasonably assumed that the actual beta ratio of the company is close to 0.7-0.8. For the purpose of further calculations, I propose to use the sector beta of 0.72 as the approximation of the company's beta ratio.

As an approximation for a risk-free (RF) rate one would normally use the yield to maturity of government bonds with a maturity equal to the length of the cash flow time series. In the case of absence of information on such bond yields, the general advice is to use the 10 years governmental bond yield as a proxy for the risk-free rate. Unfortunately, no data is publicly available on the daily yields of the government bonds with 10Y maturities in Ukraine. As a reference source in this case I propose to use as a proxy the USD denominated 5Y Ukrainian government bond yield available on the website of the National Bank of Ukraine. The respected yield comprised 7.5% as of February 1, 2013. Further, the Reuters report from 5th of February 2013 (Thomson Reuters, 2013) indicates that the new placement of the USD denominated government bonds with 10Y maturity was successfully finalized on 4th of February 2013 with the annualized yield to maturity of 7.625%. Thus, we might see that there is only a minor difference today existing on the yield curve between the 5Y and 10Y yields. Based on this observation I propose to use the 5Y UAH denominated[3] government bond yield (14.30% as of February 1, 2013) as a basis for the calculation of the risk-free yield. However, we should take into consideration the fact that in the case of Ukrainian government the nominal yield encompasses the premium for risk of default. Thus, the value of government bond yield should be further adjusted for the percentage of CDS (*credit default swap*) *default spread* for finding a proxy of the risk-free yield. According to Damodaran (2013), as of January 2013 the CDS default spread in case of Ukrainian government accounted for 6.51%. Thus, the adjusted proxy figure of the risk-free rate represents the difference between the government bond yield and CDS default spread and equals to 7.79%.

Further, the E(RM) figure of *expected market return* represent the sum of the risk-free rate and the *equity risk premium* (the excess equity return over the risk-free rate). Taking into consideration the fact that the equity risk premium calculated based on country rating equals to 14.80% (see Damodaran, 2013), one can find the E(RM) figure equal to 22.59%.

The aggregate value of cost of equity thus equals to 18.41% according to F 2.6. and will be used further in the process of WACC calculation. For details of ‘Cost of Equity’ calculation please refer to the Appendix F.

Cost of Debt

For the calculation of cost of debt I propose to use the risk-free rate (as explained and calculated under the previous section of *Cost of Equity*) adjusted for the corporate default risk premium of the company and main (onsite) customer as explained below. The model also accounts for the additional information on the cost of financing (such as cost of guarantee, if any; commitment fee; upfront fee). The cost of financing impacts the depreciable aggregate value of the machinery and equipment (as during the construction phase the construction interest is being capitalized).

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[3] The reason I propose to use as an approximation for the risk-free rate the government debt denominated in the local currency is that only this type of governmental oblgations can be considered as quasy-riskfree by investors.

For the determining the default risk premium in order to adjust the value of cost of debt, I propose to calculate the probability of default for the given project. For evaluating the default probability I calculate the Z' and Z''-Score for the company based on data from company's annual report and its strategic plan; afterwards, I link the results of the Z''-Score to the table of correspondence between Z''-Score of the companies and their rating produced by Hartzel et al. (1995). The result indicates that the company's rating should be approximately between Ba2 and Ba1 (by Moody's), but closer to Ba1. However, as the Hartzel's et al. (1995) research was constructed for the US companies, some adjustment for the country risk should be made. Let us suppose that according to the management assessment, the risk of country of operation will bring the corporate rating two notches down to Ba3. The reference to the Moody's 'Annual Default Study' (2013) indicates that the 15-years cumulative default probability (the period of the validity of the gas supply contract) for the company based on the implied credit rating and average cumulative issuer-weighted global default rates for the period 1983-2012 is estimated to be 41.941%. It produces the average annual number of probability of default of 2.36%.

The next complication is related to the onsite customer of the company. Taking into consideration the fact that the total annual sales to this customer might constitute a considerably high proportion of the company's total sales in the particular market, it is reasonable to assume that the creditors will include the default risk premium of a customer into the company's cost of debt. Let us suppose that the key customer is ascribed a Moody's equivalent credit rating of B3. It means that according to Moody's 'Annual Default Study' (2013), it corresponds to the 15 years average cumulative issuer-weighted global default probability of 58.70%, or has the annualized value of 3.13%.

One can estimate the company's default risk premium by weighing the annualized probabilities of default for the company's regular business operations and for the key customer by the weights of key customer sales in the total amount of sales. The result will be 2.74% and, as it might be observed, it is expectedly higher that the average annual default probability for the company under condition of not undertaking the new project (2.74% vs. 2.36%).

The calculated average probability of the company's default is then added to the approximated value of the risk-free rate equal to 7.79% generating the adjusted number for the cost of debt equal to 10.58%; thus, in WACC calculation the value of cost of debt adjusted for the default risk premium will be in use. For details of default risk premium calculation refer to the Appendix G.

WACC Calculation

The value of WACC is calculated as the weighted average of the cost of equity and cost of debt (as in this particular case no other financing sources are in use). For the details of WACC calculation refer to the Appendix H.

The most controversial element of the WACC calculation however is the calculation of the weights of debt and equity. As I have already mentioned before, there are certain difficulties arising for the private company with determining of the weights of debt and equity in financing structure. The source of difficulty lies in the fact that the traditional method of using the market values of both debt and equity does not work in the case of a privately held (not listed) company with no traded debt, as in this case there is no indication of market value of neither debt nor equity. The idea for similar cases is to use the target weights of debt and equity, which might be subjective if the management is actively involved into definition of these 'target' weights or in case there are numerous shareholders with conflicting interests. In my valuation model I propose to find the target weights based on the *book value* of Debt / EBITDA ratio predefined by the shareholders on the corporate level and enforced by the corporate risk management policy. Let us suppose, the corporate risk management policy prescribes the maximum Debt / EBITDA level of 2.5 times.

As the next step, one should link the required Debt / EBITDA ratio with the company's strategic financial planning figures. The model recognizes the end period of the financing activities and is searching for the maximum amount of debt in this year, using this value as the acceptable weight of debt for WACC calculation (in the particular case 33.14%, see details of calculation in Appendix D for cost of debt calculation). The weight of equity is calculated by subtracting the weight of debt from 100% (as the company does not use any other sources of financing, except these two).

The 'WACC Calculation' worksheet of the model uses the input data calculated on the 'Cost of Equity data' and 'Cost of Debt' for calculating the number of WACC equal to 15.22%, which will be used for discounting of the projected cash flows time series.

Using the calculated WACC figure (see the above description and details of WACC calculation) as the discount factor, the model automatically defines the IRR, static NPV and DPP numbers (refer to the Appendix A). These numbers should serve as the guidelines for taking the investment decision by the management of the company: invest if NPV is equal to or greater than zero, IRR is greater than the required rate of return (in this case represented by WACC) and DPP is equal to or less than the contractual period of the gas supply contract.

3.3.4. Monte-Carlo Simulation

This is the pure mathematical stage of the modelling. The Monte-Carlo method presents the opportunity to define the variance and standard deviation of the future price dispersion for the liquid oxygen (the additional product used in real option analysis) on the open market based on predefined criteria. For conducting the Monte-Carlo analysis I use the assumption of prices being distributed on the basis of triangular distribution function. The main parameters of triangular distribution correspond to the LOX prices according to three scenarios provided by the commercial department of the company as follows:

Worst-case scenario	0.1785 EUR / Nm^3;
Neutral scenario	0.21 EUR / Nm^3;
Best-Case scenario	0.2247 EUR / Nm^3.

According to price forecast it may be concluded that the commercial department of the company expects the prices deviate from -15% to +7% to their magnitude under the neutral scenario.

Based on the price information and assumption of the triangular form of price distribution I conducted the Monte-Carlo simulation based on 1,000 iterations and defined that the variance of the prices for the quasi-random process equals to 9%. The value of variance will be further used in the calculation of the real option value based on the CRR model.

3.3.5. Real option problem framing

Although the different types of the real options embedded into the investment project might and should be identified and analysed, I will restrict the current analysis to one particular type of the real options, which corresponds to the *option to expand the operations* based on the classifications of real options proposed by Trigeorgis (2002). Let us assume that the management of the company might theoretically consider the possibility of installing an additional liquefier for the liquefaction of the gas volume above the TOP obligation of the customer. Now knowing the expected value of the future investment into additional equipment and expected cash flows from the sales of additional product based on the price information corresponding to neutral scenario one can calculate the present value of the future project cash flows and required investment.

3.3.6. Real option modelling and analysis

Assuming the value of postponed investment is equal to 2,300 thousands euros and discounting it using the risk-free rate of 7.79% (see substantiation for the use of risk-free rate in this case under the section 3.1.), one can calculate the present value of the postponed investment equal to 1,980 thousands euros. Knowing the capacity of additional liquefier of 1,100 Nm^3 per hour, one can calculate the present value of future project cash flows using the WACC number equal to 15.22% as a discount factor. This value is equal to 2,765 thousands euros. The results of the calculation of discounted cash flows from the additional business and discounted value of postponed investment might be observed in the Appendix J.

Please note that essentially the present value of operating cash inflows from the new liquid volume represents the analogue of the stock price under the framework of the option analysis. The discounted value of the postponed investment represents the strike (or exercise price) in the same framework. The additional required element of price volatility equal to 9% was calculated on the stage of Monte-Carlo simulation. Hence, we can effectively conduct the valuation of the real option to expand future operation based on the CRR model. According the calculation, the value of real option to expand the operation shall be 1,424 thousands euros (see Appendix J).

Combining the value of a real option with the results of a static DCF model one can determine the *strategic NPV* value equal to 632 thousands euros (refer to the Appendix A), which suggests the management should accept the investment under the current conditions.

4. Discussion of Results and Main Findings

4.1. Results

In the current research paper I have reviewed the basic theories underlying the implementation of conventional methods for the process of investment project appraisal and the complementary theory of the real option application to the investment project evaluation process. Based on the theoretical background discussed under the section of literature review I have constructed the Excel-based investment project evaluation model, which is intended to become the part of the investment appraisal process utilized by the management of the particular company.

According to the model, the results of the static DCF-based model indicate that under certain assumptions regarding the prices of the gaseous products (GOX 0.102 EUR / Nm^3, GAN 0.0075 EUR / Nm^3, LAR 0.55 EUR / Nm^3) the model generates the following results for the major profitability metrics:

DPP – more than 20 years;
IRR after 15 years – 14.22%, which is less than the value of WACC of 15.22%;
NPV after 15 years – minus 1.282 thousand euros.

The results of the static model indicate that the management should reject the investment project and look for next opportunities somewhere else.

Inclusion into the model of an additional element of real option (particularly, *the option to expand the business operations*) allows determining the *strategic NPV* figure consisting of the sum of static NPV and the calculated real option premium equal to 1,425 thousand euros. The value of the *strategic NPV* equals to rounded 143 thousands euros. The result of the inclusion of the real option into the investment project evaluation clearly indicates that the management should accept the investment regardless of the fact that the static DCF-based model generated the negative NPV value.

The following table summarizes the findings based on simulation of different outcomes. For the simulation I have used the different lengths of the gas supply contract (10 years and 15 years[4]) and different scenarios. Under scenarios I differentiate between the so called *base scenario* (under assumption that the onsite customer will utilize the 100% of the gaseous volume of oxygen and nitrogen) and the so called *extended scenario* (under assumption that only the take or pay volume of the gaseous products should be constantly available for the onsite customer and the rest might be liquefied and sold on the open market). Consequently, there are four outcomes available: base scenario with 10 years contract term; extended scenario with 10 years contract term; base scenario with 15 years contract term; and extended scenario with 15 years contract term. For every individual scenario the following profitability metrics are calculated and presented in the table: IRR, DPP, static NPV (under assumption of no real option available) and *strategic NPV* (static

[4] Please note that the estimated salvage value of the equipment differs in connection to the length of the gas supply contract; the percentages of the salvage value used in simulation are 30% for the 10 year contract and 20% for the 15 year contract.

NPV adjusted for the value of a real option premium). The additional row indicates the value of the real option under different scenarios.

As one can easily see from the table below, the management should reject the investment project under any scenario in the case if the contractual term is equal to 10 years. If the contractual term is equal to 15 years, the table demonstrates that the *strategic NPV* value falls between the best-case base scenario (under assumption that the onsite customer will demand the designed volume of gaseous products) and the worst-case scenario (under assumption that the onsite customer will demand only the take or pay amount).

	10Y Base Scenario	**10Y Extended Scenario**	**15Y Base Scenario**	**15Y Extended Scenario**
IRR	15.64%	11.68%	17.99%	14.22%
DPP	10 years	More than 20Y	11 years	More than 20Y
Static NPV	47 TEUR	-4,093 TEUR	3,729 TEUR	-1,282 TEUR
Real Option value	NA	961 TEUR	NA	1,425 TEUR
Strategic NPV	NA	-3,132 TEUR	NA	143 TEUR

Table 4.1. Profitability metrics under different scenarios

If the management is evaluating this type of investment projects, it might be puzzled by the question of which size of demand for gaseous product from the onsite customer should be accounted for in the profitability calculation. Taking into account the maximum designed volume produces the positive result demonstrated in the table under both base scenarios. However, the shareholders' requirement is to take into consideration the conservative scenario that might lead to quite opposite result of a static conventional model as demonstrated in the table under the extended scenarios. The inclusion of the real option premium value into the calculation allows the management to find the number of the *strategic NPV* for extended scenarios and use it as a guideline in the decision making process. As one might see from the table, the inclusion of the real option premium into the extended scenarios generates positive result for the contractual period of 15 years (while 10 years contractual length generates negative *strategic NVP* value). Thus, one might see that the inclusion of the real option premium into the profitability calculation allows the management to find the number of *strategic NPV* and provides it with an opportunity, while being conservative in its estimations, to rely on the *strategic NPV* value as the basis for the decision making. If the *strategic NPV* generates the positive result, I suggest the management should accept the investment project regardless of the possible negative static NPV number and negative result of the other investment criteria (in our case, the IRR and DPP).

4.2. *Limitations of the Model*

The model presented and discussed under the section of research of current research paper has definite limitations and shortcomings, which should be taken into consideration by the manager who implements the presented model for taking investment decisions. The main limitations are as follows:

1. Due to the fact that I have used the example of the private not listed company, there is no historical information on the company's beta, as well as market value of debt and equity. This leads to some basic assumption in the WACC definition, such as:
    a. Using the estimation of beta based on the sector beta and betas of close peer listed companies.
    b. Using the unlevered beta in the calculation of WACC.
    c. Using the Debt / EBITDA ratio (as substitute of the criterion of target debt to equity ratio) instead of market values of debt and equity.
    d. Use of the synthetic rating based on the Z''-Score calculation for determining the default premium due to absence of the assigned corporate rating.
2. For the discounting of the cash flows, the single number of WACC is in use, which can be very restrictive and lead to improper results in the countries with high rates of inflation.
3. The inflationary effect and risk of the devaluation of the local currency are explicitly excluded from the cash flow projection, as well as from the WACC calculation. This oversimplification might lead to the understatement of WACC and overstatement of the value of discounted cash flows[5].
4. Under the section of real option analysis it has been implicitly assumed that the real options are identical to the financial options and thus might be evaluated using the same valuation techniques as in the case of financial options. This statement, however, has some limitations, which were not discussed in the current research paper.
5. The stage of qualitative management screening corresponding to the analysis of project contribution to the strategic plans of the company was explicitly omitted in this research paper. It does not mean that I am neglecting or reducing the value of the strategic analysis of the investment project. The importance of such approach was explicitly underscored in the section 2.1. of General Considerations under Literature review.

5. Conclusions and Recommendations for Further Research

The results of the research indicate the fact that the managerial flexibility to take decisions during the course of the investment project execution has a real value, which can be captured and measured based on the real options analysis. The managerial option to take decisions or undertake actions in the future, after some of the basic uncertainties associated

[5] In this paper I am using the Ukrainian government bond yields denominated in local currency as a basis for the calculation of a proxy for the risk-free rate. Strictly, I should use the yield of the government bonds denominated in the same currency as the projected cash flows. However, in a simplified model it does not make difference, as I suppose the stability of the UAH / EUR exchange rate over time.

with the execution of the investment projects have been resolved, cannot be ignored on the stage of project evaluation. The option to postpone the decision is not just a waste of time, but has a certain underlying value that can be captured and *monetized* in the calculated real option premium. Ignoring the strategic value of a real option embedded into the investment project and conducting the project evaluation based on results generated solely by the static DCF-based models might lead to the rejection of potentially profitable investment opportunities and, thus, foregoing the opportunity to generate additional value to the shareholders.

Due to some limitations of the model proposed in the research paper, I suggest to complement it with the further research on the effects of inflation and connected to it risk of the devaluation of local currency against the euro. The macroeconomic relations between the figures of local vs. Eurozone inflation are creating the risk of devaluation of a local currency against the single currency and thus posing additional risks for the projected cash flows. Thus, the proposed investment project evaluation model should be amended by the inclusion of the inflationary effect and underlying risk of devaluation, which might affect the final result of profitability calculation.

In the section of real options analysis of the research paper I have focused solely on the *option to expand the future operations*. Such a narrow focus might be limiting the strategic importance of the real options analysis in the eyes of the reader. However, it should be clearly stated that multiple real options can simultaneously coexist in relation to the particular investment project. The identification and capturing of a value of different real options (including *option on option*) require additional rigorous research, but it is worth of effort because of the opportunity of mapping the full potential related to the strategic value of the managerial flexibility.

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Appendices

Appendix A. Main Highlights of the Model

Highlights

04/15/13

Project: **PLEASE INSERT THE NAME OF THE PROJECT**

Please Select the Currency: EUR

Unit / Volume: Nm³

Start of Finance/First Payment:

Quarter - Year	1 - 2013

Start up of Plant/Production:

Quarter - Year	4 - 2015
Project-Periods:	**15** years

Investments	2013	2014	2015	2016	2017	2018
ASU incl. GOX & GAN Compr. & Liquefier	6,700	7,920	3,880	0	0	0
Civil works (foundations, buildings, electrical instalaltions)	2,840	3,300	1,660	0	0	0
Storages for LOX, LIN, LAR; other costs	0	0	0	0	0	0
Construction Interests	1,133	2,341	0	0	0	0
Total Investments incl. Construction Interest:	10,673	13,561	5,540	0	0	0

Interest, Taxes, Funding

Tax Rate :	17 %	
Funding:	66.86 % Equity	33.14 % Borrowed capital
Required Rate of Return (WACC):	15.22 %	
Cost of Equity / Debt (%)	18.41 % Own funds	10.57 % Borrowed capital

Profitability Statement (10 years)

	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024
Sales	2,695	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780
Cost	1,183	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673
Depreciation	1,060	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985
Interest	1	6	6	6	6	6	6	6	6	6
EBIT	**450**	**4,117**	**4,117**	**4,117**	**4,117**	**4,117**	**4,117**	**4,117**	**4,117**	**4,117**
Loss carry forward	0	0	0	0	0	0	0	0	0	0
Tax	77	700	700	700	700	700	700	700	700	700
Income after Tax	**374**	**3,417**	**3,417**	**3,417**	**3,417**	**3,417**	**3,417**	**3,417**	**3,417**	**3,417**
Depreciation	1,060	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985
Interest	0	0	0	0	0	0	0	0	0	0
delta WC	-141	-423	0	0	0	0	0	0	0	0
Cash-Flow	**1,575**	**5,824**	**5,402**	**5,402**	**5,402**	**5,402**	**5,402**	**5,402**	**5,402**	**5,402**
Discounted Operating CF	1,030	3,305	2,660	2,309	2,004	1,739	1,510	1,310	1,137	987
Accumulated DCF	-22,071	-18,766	-16,106	-13,797	-11,793	-10,053	-8,544	-7,233	-6,096	-5,109

GOX to Onsite Customer	0.1020	EUR/Nm³
GAN to Onsite Customer	0.0075	EUR/Nm³
LAR to Onsite Customer	0.550	EUR/Nm³
LOX for Retail Market	0.210	EUR/Nm³
LIN for Retail Market	0.150	EUR/Nm³
LAR for Retail Market	0.650	EUR/Nm³
Basic Facility Charge (if any)	20	EUR / month

Dscounted Payback Period: **More than 20 years**

Internal Rate of Return: **14.22%**

after Year: 15

Net Present Value: **- 1,282 TEUR**

Strategic Net Present Value: **143 TEUR**

after Year: 15

The maximum capacity is not exceeded. O.K.

Appendix B. Financial Plan in the Model

Input fields are marked in blue

Financing Plan

Date and time 04/15/13 11:04 AM

Project: PLEASE INSERT THE NAME OF THE PROJECT

Start of Finance/First Payment:					
At the beginning of quarter	1		Please Select the Currency:	EUR	
Year	2013		Unit / Volume:	Nm³	
			Exchange Rate for 1 EURO	1	
			Enter the ours per year consumption:	7,500	
Start up of Plant/Production:					
At the beginning of quarter	4	1	Capacity of Main Air Compressor:	50,000 Nm³/h	of air
Year	2015				
			Please enter the contractual volumes for onsite customer:		
Project-Periods:	**15** years		(in Nm3 per hour) GOX	7,910 Nm³/h	
			GAN	1,100 Nm³/h	
END of CONTRACT			LAR	200 Nm³/h	
At the beginning of quarter	4		Enter the Take-or-Pay Volume (in %)		
Year	2030		GOX	85%	
			GAN	85%	
Please indicate the managerial assumption for a terminal value after the year 15 (in %)	**20%**		LAR	100%	
			Nominal LOX	2,090 Nm³/h	
			Nominal LIN	2,100 Nm³/h	
			Nominal LAR	320 Nm³/h	
			Please enter the contractual Electricity Cost	73.8 €/MWh	

ASU incl. GOX & GAN Compr. & Liquefie	18,500
Civil works (foundations, buildings, elec	7,800
Storages for LOX, LIN, LAR; other costs	-
Total	26,300
Constr. Inter.	3,474
TOTAL WITH INTEREST:	**29,774**

Payments - Cash out for project at the beginning of the period

Year/Quarter	2013				2014				2015				2016			
Description of Project	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
ASU incl. GOX & GAN Compr. & Liquefier	4,060			2,640	2,640	2,640		2,640	3,880							
Civil works (foundations, buildings, electrical instalaltions)	1,740			1,100	1,100	1,100		1,100	1,660							
Storages for LOX, LIN, LAR; other costs																
Total Payments	**5,800**	**0**	**0**	**3,740**	**3,740**	**3,740**	**0**	**3,740**	**5,540**	**0**	**0**	**0**	**0**	**0**	**0**	**0**
Construction Interests	277	248	248	360	473	585	585	698	0	0	0	0				
Total Investments incl. Construction Interest:	**6,077**	**248**	**248**	**4,100**	**4,213**	**4,325**	**585**	**4,438**	**5,540**	**0**	**0**	**0**	**0**	**0**	**0**	**0**

Interest, Taxes, Funding

Tax Rate :	17 %		
DSO:	1 months	DPO:	1 months
Funding:	**66.86** % Equity	**33.14** % Borrowed capital	
	Go to Cost of Equity Sheet	Go to Cost of Debt Sheet	
Required Rate of Return (WACC):	**15.22 %**		
Cost of Equity / Debt (%)	**18.41** % Own funds	**10.57** % Borrowed capital	

Appendix C. Cost Calculation in the Model

Depreciation, Interest for borrowed capital, Cost, Savings **Project:** PLEASE INSERT THE NAME OF THE PROJECT

Depreciation	EUR	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Total residual value (straight line)				29,774	28,714	26,729	24,744	22,759	20,774	18,789	16,804	14,819	12,834	10,850	8,865	6,880	4,895	2,910	925
TOTAL Depreciation				1,060	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	925
Interest	EUR																		
Interest on Project		0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Interest on Operating Invest & Working Cap.		0	0	1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4
Total Interest after construction Interest		0	0	1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4

Back to the Finance Plan-Sheet

Cost		EUR			2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030
Power ASU	0.415 kWh/Nm³	73.83 €/MWh			473	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,892	1,419
Power GOX 25bar	0.180 kWh/Nm³	73.83 €/MWh			168	670	670	670	670	670	670	670	670	670	670	670	670	670	670	503
Power GAN Compr.	0.140 kWh/Nm³	73.83 €/MWh			18	72	72	72	72	72	72	72	72	72	72	72	72	72	72	54
Power Liquefier	0.62 kWh/Nm³	73.83 €/MWh			306	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	1,225	918
Cooling Water	2,100 m³/h	0.010 €/m³			39	158	158	158	158	158	158	158	158	158	158	158	158	158	158	158
Steam	1 m³/h	- €			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Sanitary Water	2 m³/h	- €			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
M&R	1.2%	29,774 T€			89	357	357	357	357	357	357	357	357	357	357	357	357	357	357	357
Insurance	0.6%	29,774 T€			45	179	179	179	179	179	179	179	179	179	179	179	179	179	179	179
Admin & Overhead		- €			0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
Oper. Personnel	10,000 EUR/a	12 Empl.			45	120	120	120	120	120	120	120	120	120	120	120	120	120	120	120
Exchange Rate	EUR / Base Currency	1.00																		
Add. Liquefaction																				
Operating Hours		7,500																		
Total Cost			0	0	1,183	4,672.6	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	3,708

Appendix D. Calculation of the Cost of Debt

PLEASE INSERT THE LIMIT FOR DEBT / EBITDA	**2.5**	**times**
Please enter the date of the end of financing:	**2015**	
Please select the currency	EUR	

EXERPT FROM A COMPANY STRATEGIC PLAN		**2013**	**2014**	**2015**	**2016**	**2017**
In thousands LC	EBITDA	15,143	15,017	15,572	16,095	16,556
	Aggregate EBITDA:	15,143	15,017	15,572	16,095	16,556
	Existing Debt	18,349	13,085	9,564	5,846	3,061
	New Debt	19,507	24,459	29,366	34,390	38,330
	TOTAL DEBT CAPACITY:	37,857	37,544	38,930	40,237	41,391
	TOTAL BALANCE*:	123,176	118,688	117,466	116,909	117,475
	Debt Proportion in TB:	31%	32%	33%	34%	35%

* - Dividend payments foreseen in 2014-2016

Maximum LOAN AMOUNT	**29,366**	TEUR
LOAN TERM (YEARS)	**10**	
Margin	**10.57%**	
6M EURIBOR SWAP	**0.00%**	*(not applicable for the Ukrainian financing)*
TOTAL INTEREST:	**10.57%**	
Upfront fee:	**0.1%**	
Cost of Guarantee:	**1.2%**	
Commitment fee:	**1.00%**	

Amounts in TEUR	1				2				3				4	5	6	7	8	9	10
Period / year	**2013**				**2014**				**2015**				**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**
Quarter	I	II	III	IV	I	II	III	IV	I	II	III	IV							
Residual Amount	**6,476**	6,476	6,476	10,652	14,828	19,004	19,004	23,180	29,366	29,366	29,366	29,366	26,325	22,962	19,243	15,131	10,585	5,558	-
Upfront fee	29																		
Principal Payment	-	-	-	-	-	-	-	-	-	-	-	-	3,042	3,363	3,719	4,112	4,546	5,027	5,558
Payment on Guarantee	19.43	19.43	19.43	31.96	44.48	57.01	57.01	69.54	88.10	88.10	88.10	88.10	-	-	-	-	-	-	-
Interest Payment	171	171	171	282	392	502	502	613	776	776	776	776	3,104	2,783	2,427	2,034	1,599	1,119	588
Commitment fee	57	57	57	47	36	26	26	15	-	-	-	-	-	-	-	-	-	-	-
Total payment	**277**	**248**	**248**	**360**	**473**	**585**	**585**	**698**	**864**	**864**	**864**	**864**	**6,146**	**6,146**	**6,146**	**6,146**	**6,146**	**6,146**	**6,146**

Appendix E. Discounted Cash Flow Calculation

TEUR **Project:** **PLEASE INSERT THE NAME OF THE PROJECT**

Year	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	2023	2024	2025	2026	2027	2028	2029	2030	2031
Sales			2,695	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	10,780	8,085	0
- Cost	0	0	1,183	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	4,673	3,708	0
- Depreciation	0	0	1,060	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	925	0
- Interest cost	0	0	1	6	6	6	6	6	6	6	6	6	6	6	6	6	6	4	0
= Income beforeTax	0	0	450	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	4,117	3,448	0
- Taxes			77	700	700	700	700	700	700	700	700	700	700	700	700	700	700	586	0
= Income after Tax			374	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	3,417	2,862	0
+ Depreciation			1,060	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	1,985	925	0
+/- delta Working Capital			-141	-423	0	0	0	0	0	0	0	0	0	0	0	0	0	144	419
= EBITDA			1,575	5,824	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	3,642	-419
Residual Value of Equipment	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	5,955	0	0
= Cash inflow	0	0	1,575	5,824	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	11,356	3,642	-419

Cash flow			1,575	5,824	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	11,356	3,642	-419
- Capital expenditures	10,673	13,561	5,540	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
= Free cash flow	- 10,673	- 13,561	- 3,965	5,824	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	5,402	11,356	3,642	- 419
Discounted Investment CF	- 9,263	- 10,215	- 3,622	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Discounted Operating CF	-	-	1,030	3,305	2,660	2,309	2,004	1,739	1,510	1,310	1,137	987	857	743	645	560	1,022	284	- 28
Accumulated DCF	-9,263	-19,478	-22,071	-18,766	-16,106	-13,797	-11,793	-10,053	-8,544	-7,233	-6,096	-5,109	-4,253	-3,509	-2,864	-2,304	-1,282	-997	-1,026
Discounted Payback Period	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****	*****

PRESENT VALUE OF INVESTMENT CF **- 23,100** **TEUR**

Period #	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Year	**2013**	**2014**	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	**2031**
Net Present Value	**- 9,263**	**- 19,478**	**- 22,071**	**- 18,766**	**- 16,106**	**- 13,797**	**- 11,793**	**- 10,053**	**- 8,544**	**- 7,233**	**- 6,096**	**- 5,109**	**- 4,253**	**- 3,509**	**- 2,864**	**- 2,304**	**- 1,282**	**- 997**	**- 1,026**
IRR	#NUM!	#NUM!	#NUM!	-54%	-29%	-15%	-6%	-1%	3%	6%	8%	10%	11%	12%	13%	13%	14%	14%	14%

Appendix F. Calculation of the Cost of Equity

	Histoical Sector Beta (Developed Markets)	Yngde Gases (EM)	Linde AG	Air Liquide	Praxair, Inc.	Average of Peers
Historical Beta Ratios	**0.72**	0.37	0.90	0.55	0.83	**0.76**
	Source of Data: Bloomberg Terminal		*Source data: Reuters*			

Company Beta Approximation	0.72	Histoical Sector Beta (Developed Markets)
5Y Sovereign bond yield (UAH denominated)	14.30%	10Y Gov Bond Yield, source Reuters http://www.reuters.com/article/2013/02/05/ukraine-eurobond-idUSL5N0B50G320130205
CDS default spread as of Jan. 2013	6.51%	Source: Aswath Damodaran, Country Default and Risk Premiums http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ctryprem.html
Approximation of a risk-free rate	**7.79%**	
Equity risk premium	14.80%	Source: Aswath Damodaran, Country Default and Risk Premiums http://pages.stern.nyu.edu/~adamodar/New_Home_Page/datafile/ctryprem.html
E (RM)	**22.59%**	Equity risk premium plus risk-free rate

Aggregate Cost of Equity	**18.41%**

Appendix G. Calculation of the Default Premium

Data for Calculation of Z' and Z'' Scores
In TEUR

	2012	2013	2014	2015	2016	2017
TOTAL ASSETS	118,983	118,983	123,176	118,688	117,466	116,909
WC	3,902	3,902	5,002	5,178	5,284	5,387
Retained Earnings	23,115	27,434	34,655	41,375	48,519	56,132
EBIT	6,030	9,066	8,913	9,320	9,654	9,967
BV of Equity	76,002	82,887	89,975	97,612	104,321	110,675
BV of old Debt	17,479	18,349	13,085	9,564	5,846	3,061
BV of new project debt		3,537	4,494	1,836	-	-
Total BVD	17,479	21,887	17,579	11,400	5,846	3,061
Sales	38,833	43,539	44,892	45,774	46,769	47,868
Z' Score Calculation for the Company						
0.717 WC / TA	0.02	0.02	0.03	0.03	0.03	0.03
0.847 RE / TA	0.16	0.20	0.24	0.30	0.35	0.41
3.107 EBIT / TA	0.16	0.24	0.22	0.24	0.26	0.26
0.42 BE / BVD	1.83	1.59	2.15	3.60	7.49	15.19
0.998 Sales / TA	0.33	0.37	0.36	0.38	0.40	0.41
Total Z' score:	**2.50**	**2.41**	**3.01**	**4.55**	**8.53**	**16.30**
Z'' Score Calculation for the Company						
6.56 WC / TA	0.22	0.22	0.27	0.29	0.30	0.30
3.26 RE / TA	0.63	0.75	0.92	1.14	1.35	1.57
6.72 EBIT / TA	0.34	0.51	0.49	0.53	0.55	0.57
1.05 BE / TA	0.67	0.73	0.77	0.86	0.93	0.99
3.25 Interception	3.25	3.25	3.25	3.25	3.25	3.25
Total Z'' score:	**5.11**	**5.46**	**5.69**	**6.06**	**6.38**	**6.68**

Implied Rating of a Company	**Ba1**	
15Y Cummulative Default probability (Moody's research)	**41.94%**	**2.36% default probability per annum**
Acuired Rating for a Customer	**B3**	
15Y Cummulative Default probability (Moody's research)	**58.70%**	**3.13% default probability per annum**
Weight of the proportion of sales to Customer	**55%**	
Estimated Default Risk Element in the Cost of Debt	**2.78%**	

Table of US Corporate Rating vs. Z'' Score

US Bond Rating (S&P)	US Bond Rating (Moody's)	Average Z'' Score (with interception)	US Bond Rating (S&P)	US Bond Rating (Moody's)	Average Z'' Score (with interception)
AAA	Aaa	8.15	BB+	Ba1	5.25
AA+	Aa1	7.6	BB	Ba2	4.95
AA	Aa2	7.3	BB-	Ba3	4.75
AA-	Aa3	7	B+	B1	4.5
A+	A1	6.85	B	B2	4.25
A	A2	6.65	B-	B3	3.75
A-	A3	6.4	CCC+	Caa1	3.2
BBB+	Baa1	6.25	CCC	Caa2	2.5
BBB	Baa2	5.85	CCC-	Caa3	1.75
BBB-	Baa3	5.65	D	C	0

Source: J.M. Hartzell, M. Peck, and E.I. Altman, Emerging Market Corporate Bonds - A Scoring System, Salomon Brothers, New York, May 15, 1995, p.9.

Appendix H. WACC Calculation

COST OF DEBT:		
Risk-free rate	7.79%	
Corporate Default Risk Premium	2.78%	
Adjusted Coupon Rate	**10.57%**	
Marginal Tax Rate	17.0%	
Cost of Debt	**8.77%**	
weight of debt	33%	
COST OF EQUITY:		
Risk-Free Rate	7.79%	Data source: National Bank of Ukraine (http://www.bank.gov.ua/control/uk/index)
Risk Premium	23%	
Beta	0.72	Estimation based on beta of competitors
Cost of Equity	**18.41%**	
weight of equity	67%	
Weighted-Average Cost of Capital	**15.22%**	

Appendix I. Valuation of Additional Business Opportunity

NPV CALCULATION OF ADDITIONAL INVESTMENT INTO LIQUEFIER

PLEASE INSERT THE NAME OF THE PROJECT 04/15/13 04/15/13 11:04

Investment Value 2,300 TEUR

(total value of additional liquefier together with cost of delivery to site and cost of erection activities)

Indicate the additional volume of LOX 1,100 Nm3 / h **The maximum capacity is not exceeded. O.K.**

				1	1	1	1	1	1	1	1	1	1	1	1	1	1	0.75	
Number of period	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19
Year	2013	2014	**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
Sales of LOX ADDI																			
Nm3 / h	1,100	Production volume (Nm3)	2,063	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	8,250	6,188	
EUR / Nm3	0.21																		
TOTAL ADDITIONAL TURNOVER (in TEUR):			**433**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,733**	**1,299**	
Additional Working Capital			**2015**	**2016**	**2017**	**2018**	**2019**	**2020**	**2021**	**2022**	**2023**	**2024**	**2025**	**2026**	**2027**	**2028**	**2029**	**2030**	
	Inventories																		
	Accounts Payable		(15.42)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(61.67)	(46.25)	
	Accounts Receivable		172	688	688	688	688	688	688	688	688	688	688	688	688	688	688	516	
	Working Capital		**156**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**626**	**469**	
EXPENSES																			
Depreciation	15 Y		- 38	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	- 153	
Electricity	Kw / Nm3	1.035																	
	Price, EUR / Mw	73.83																	
TOTAL Electricity Cost:			- 185	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 740	- 555	
M&R	1.2%		- 7	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 28	- 21	- 21	
Insurance	0.60%		- 3	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	- 14	
Interest on financing WC			- 17	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 66	- 50	
TOTAL COSTS:			**- 250**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 1,001**	**- 994**	**- 792**	
INCOME BEFORE TAXES			**183**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**732**	**738**	**507**	
TAXES			**- 31**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 124**	**- 126**	**- 86**	
INCOME AFTER TAX			**152**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**607**	**613**	**421**	
EBITDA			190	761	761	761	761	761	761	761	761	761	761	761	761	761	766	574	-
Delta WC			156	469	-	-	-	-	-	-	-	-	-	-	-	-	-	- 156	- 469
Depreciation Tax Savings			7	26	26	26	26	26	26	26	26	26	26	26	26	26	26	26	-
FCF			40	317	787	787	787	787	787	787	787	787	787	787	787	787	792	757	469
DCF			26	180	387	336	292	253	220	191	166	144	125	108	94	82	71	59	32

PRESENT VALUE OF OPERATING CASH INFLOWS	**2,766**	**TEUR**	*Equivalent of Stock Price in Real Option Analysis*
PRESENT VALUE OF AN INVESTMENT	**1,980**	**TEUR**	*Equivalent of a Strike Price in Real Option Analysis*

Appendix J. Real Option Valuation

PLEASE INSERT THE NAME OF THE PROJECT

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http://investexcel.net

This spreadsheet compares Option Pricing results calculated via a Binomial method and via an analytical solution of the Black Scholes equation

Read this tutorial so you fully understand the principles http://investexcel.net/736/binomial-option-pricing-excel

Parameters	
Stock Price S_0	2,766
Exercise Price X	1,980
Interest Rate r	7.79%
Volatility (Monte-Carlo Method)	9%
Time to Maturity	5
Number of Steps	5
Dividend Yield	0

Results		
	Binomial	
Call	1,425	TEUR
Put	0	

Calculations						
Time Interval	1					
Up movement	1.090882	u				
Down movement	0.91669	d = 1/u				
Up probability	0.943354					
Discount Factor	0.925057					
Step	0	1	2	3	4	5
Time	0	1	2	3	4	5
Stock Price	2765.715	3017.068	3291.264	3590.380001	3916.68	4272.63477
		2535.302	2765.715	3017.067743	3291.264	3590.38
			2324.085	2535.302047	2765.715	3017.06774
				2130.464748	2324.085	2535.30205
					1952.975	2130.46475
						1790.27191
Option Price	1424.763	1567.479	1724.238	1896.401821	2085.465	2293.06464
		1085.715	1198.688	1323.089563	1460.049	1610.80987
			757.0861	841.3238667	934.4997	1037.49761
				437.0063417	492.8701	555.731916
					131.6792	150.894617
						0

$S_n u$

$d\,S_0$

$d^2\,S_0$

S_N

$\max(S_N - X, 0)$

Call Price