Investment Appraisal in the Public Sector – Incorporating Flexibility and Environmental Impact

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***Abstract*—Real asset investment appraisal in the public sector often requires that objectives beyond return on investment are taken into account. Recently, environmental impact and climate change issues are often used to motivate investments, but despite this formal approaches are seldom being used for this purpose. In this paper we investigate the application of real option valuation and multi-criteria decision analysis in the appraisal of a public sector investment in the form of a logistics park, aimed to reduce the emissions from cargo traffic. Although this appraisal approach captures important features of the real situation in terms of that flexibility is considered and multiple criteria is taken into account, the requirement for the information needed for the model led to a need to use best-estimates, and a systematic approach to sensitivity analysis is therefore desired.**

***Index Terms*—Investment appraisal, public sector, decision analysis, real options**

I. Introduction

The public sectors act in the public interest by providing numerous services, such as health care, education and infrastructure, where large investments follows [1]. In this sector, the owner interests differ from shareholder interests in the private sector, where the monetary aspect, i.e. return on investment (ROI) outranks other aspects and needs to be satisfied. The public interests are more complex and assessment of investments goes beyond ROI only, involving stakeholders with different needs and wishes [2]. It is argued that public sector investments only should occur “if their return exceeds the opportunity cost of available projects,” where the costs include displaced private capital and reduced consumption [3]. Thus, the monetary aspect is not the only aspect that should be included in a systematic investment appraisal in a public sector context [4]. It is troublesome to include non-monetary aspects in investment appraisals due to a lack of know-how and guidelines aimed for public sector use.

Still, an investment decision basis needs to be formed, and when appraising a project the absence of market prices, discounted cash flow (DCF) analysis is the prevailing approach, used to obtain a net present value (NPV) for each project under consideration, i.e. the present value consisting of discounted future cash flows minus the investment cost. However, this approach assumes that the project will be initiated immediately, that it will operate according to plans during its estimated lifetime, and that the yearly cash flows are deterministic. In practice this is seldom the case, as project plans can be put on hold and managerial flexibility along with associated decisions will affect the projects value over time. Accommodating for this flexibility, it is argued in the literature that the appraisal technique “real options analysis” (ROA), provide a better estimate of a projects value, see, e.g., Ref. [5].

In this context an option is the right but not the obligation to implement an investment decision during some coming time period. Beyond the wait-and-see option, a variety of different real options have been defined, e.g., options to contract/outsource, option to expand the business, option to abandon the business or a project, switching options and compounded options which include more than one option (such as both the option to expand and abandon at the same time). When activities are separated into different phases, are when succeeding phases depend on the outcomes of a preceding phase, it is called a sequential option, see, e.g., Ref. [6]. From this flora of models one can be selected or combined as desired to reflect the investment decision option at hand. The value of the investment is then its NPV plus the value added from the flexibility embedded in the option.

In the context herein, the values, as perceived by the stakeholders and citizens, focus on how publicly funded organizations makes investments increasing the quality of living on short and long term while doing so in a fiscally sound manner. The underlying standpoint in this paper is therefore that in order to equitably value real assets owned by publicly owned organizations or companies, it is of great interest for decision makers to incorporate non-monetary aspects and managerial flexibility since both these elements are prominent. However, when organizations below the national level consider non-monetary aspects, it is often done in an unstructured manner and therefore not part of a formal decision basis

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making it hard to formally justify decisions based upon these aspects, cf. Ref. [7]. When formalizing the non-monetary aspects, there are essentially two method families to employ; cost-benefit analysis (CBA) or multi-criteria decision analysis (MCDA). Ref. [8] compared the use of MCDA towards unaided environmental decision-making in Australia and concluded that it is a helpful tool, and Ref. [9] argues that MCDA don't correspond towards a conventional cost-benefit analysis (CBA) when applied to a transport project, but it does correspond towards the final decision by the authority. Further, Ref. [10] states that public decision-making when our natural environment is involved, is exposed to high conflict potential. MCDA is suggested as a beneficial tool due to its ability to overcome the shortcomings of cost-benefit analysis.

Ref. [11] discusses how the appropriate method for environmental appraisal should be chosen. Based upon on three dimensions; *Rationality*, *The good* and *Human interaction*. MCDA is expressed to be a candidate as a suitable deliberative method, due to its structural technical core during the deliberative process. However, it is stressed that it is the actual usage of the methodology that creates the value, choosing the right methodology is merely a prerequisite for obtaining a good result [11]. Steward et al. discusses the integration of MCDA and scenario planning (SP) and concludes that synergies between the two methods can be of considerable advantage when addressing decision context [12]. Ref. [13] tests the integration of MCDA and SP in three public sector decision-making instances in Trinidad and Tobago. It is concluded that this approach does aid the strategical planning through the mindset towards options (what options exists and how they can be improved and aid the process in the future).

Ref. [7] assess how managers confronts with socially responsibility in their investments, by investigating how they handle and evaluates objectives beyond ROI. By interviewing several managers in different sectors, it is concluded that organizations are in general exposed to uncertainty depending in both micro and macro variables and that the non-monetary objectives are considered informally in discussions and by "gut-feeling". Real options in combination with decision analysis modeling is suggested as an approach to further improve the structuring of the problem and to create more informative decision support. Furthermore, the theoretical applicability of real options and decision analysis is investigated by exploring the need of models capable of:

a) "Account for different aspects of the investment decision problem."

b) "Enable decision evaluation with multiple sources of uncertainty."

It was concluded that ROA had good applicability in a majority of the companies investigated. However, the methods combined abilities need to be further tested in real-life situations in order to assess the practical applicability [7].

This paper therefore demonstrates an application of ROA and MCDA in a real-life public sector investment, assessing the applicability based upon their ability to fulfill the desires i) and ii) above. Applicability also implies whether the value of flexibility is captured whilst incorporating more than one criterion.

II. The Case

An ongoing logistics park project in Sundsvall, called Sundsvall Logistikpark[1] (SLP), which is initiated by the public sector is used as subject for a case study. The project aims to be one of Sweden's most important transportation hubs. Furthermore the project will connect road-, freight- and maritime transportation to increase efficiency and to meet the industries future needs [14,15] This project is a public-private partnership and will require a large investment from the public sector.

The pragmatic approach selected is to test a combined approach to value real assets by re-evaluating the logistics park project in Sundsvall, SLP, using ROA for both a monetary criterion measured in SEK and a non-monetary criterion *reduction of carbon dioxide emissions*, abbreviated with RCDE and measured in tons of carbon dioxide per year reduced, tCO_2/y.

One of the main stakeholders of this project is the municipality of Sundsvall and therefore the main interest will not just be ROI. Non-monetary values such as growth of the region, development potential and attractiveness to establish companies in the region are considered to be of high importance and are part of the municipality's strategic plan. Another non-monetary value, of primary importance regarding the result of the project, is the environmental effect. According to SLP, this derives from that the logistics park specifically aims to reduce the negative environmental effect that truck transports generate in a long-term perspective [14].

A report of the estimated environmental impact of the project was produced by the company Profu. This report uses estimations of how the transport market demand will develop in the region until the year 2025, provided that the logistics park is completed at this point. The environmental impact of the suggested project is estimated and compared to a zero-alternative, an alternative where the logistics park is not built, but the transport demand is the same [16].

From the environmental impact report, estimated figures regarding the project's environmental effect can be obtained, however, there are no actual figures associated with the zero-alternative. In the zero-alternative, trucks are assumed to handle the freights put on cargo vessels in the scenario projected in the Profu report, where cargo vessels alone stand for two thirds of the emitted carbon dioxide in the project estimation [16]. Since cargo vessels are stated to be three times as efficient as trucks in the measurement of emitted tons carbon dioxide per kilometer, a rough estimate of the emitted carbon dioxide in the zero-alternative can be done. The net present emitted carbon dioxide reduction value (NPRCDE) has been obtained by subtracting the present emitted carbon dioxide reduction value from the

[1] Sundsvall Logistics Park

zero-alternative with the present emitted carbon dioxide reduction value from SLP, which can be seen in Table I.

TABLE I. EMISSION ESTIMATES

	Estimation of emitted CO_2 (ton/year)
SLP	15900
Zero-alternative	37100
NPRCDE	37100-15900=21200

III. APPRAISAL MODEL

In this study, a re-appraisal using ROA and MCDA focusing on the value of the establishment area will be done. This area constitutes the geographical part of the entire logistics park project. This area can either be leased to tenants or sold. Furthermore it can be expanded, and the expanded area can also be leased or sold.

A. Option Identification

The case's major strategic choices in the future have been formulated by using already existing plans [17] as a basis for discussion during a brainstorm meeting with key employees of the case firm (the CEO and the chief controller). The joint workshop lasted for two hours facilitated by the authors. The focus has been to investigate the projects options regarding the establishment areas. At the start point there are approximately four hectares to either lease or sell.

B. Volatility Estimation

The factor that gives flexibility value is the underlying uncertainty, expressed in the measurement *volatility* [6]. Thus, it is necessary to calculate the annual volatility of future cash flows [6]. In this case, the volatility of future cash flows has been based upon the historical volatility of the transport demand, because the project's revenue stream comes from goods handling and other activities closely related to the transport market. More specifically, the volatility has been derived from the amount of goods transported during domestic and international transports in Sweden, expressed in tons. The calculation is based upon statistics from the governmental agency *Trafikanalys* [18]-[20]. SLP aims to handle goods from railroad, road and maritime transports and thus these three segments have been used to estimate the volatility.

The actual calculation used quarterly data ranging from 2010-2014 and the annualized volatility from each segment has been compounded according to the "principle of insufficient reasoning" due to lack of information regarding how large impact each segment has on the project. It is therefore advocated to assume that all segments have equal probability to affect the total outcome [21].

C. Option Strategy Valuation Model

The model has been based upon the binomial lattice approach and modeled in the Super Lattice Solver software. The case requires the model to be able to value a sequential compound option in both monetary terms and in emissions of carbon dioxide.

D. Evaluation Workflow

The entire project already has a traditional NPV-analysis, valuing the project to 680 MSEK (about 70 MEUR), which has served as the underlying value in this study. The first step of the evaluation workflow is:

1. Define existing options and their associated values (cost and profit) and if possible, aggregate these into different strategies consisting of a compounded option.

This step can be troublesome due to lack of reliable information regarding the actual values of the options, wherefore the following steps have been applied:

2. Calculate the option values, in this case two options values consisting of the monetary ROI value and the RCDE-value, of a base case strategy having the most reliable data.
3. Use an MCDA model to capture criteria weight preferences and conduct a sensitivity analysis to determine thresholds for when the other strategy/strategies is/are preferred to the base case strategy.

E. Option Strategy Comparison with MCDA

A two criteria setup has been applied (the ROI and the RCDE value) with corresponding weights to be elicited. Thus, evaluating the strategy S_i with corresponding ROI of x_i and RCDE of y_i is done with the following formula

$$V(x_i, y_i) = w_1 \cdot v_1(x_i) + w_2 \cdot v_2(y_i) \quad (1)$$

where w_1 is the weight for the ROI criterion, w_2 is the weight for the RCDE criterion, and v_1 and v_2 are the corresponding value functions.

Only one strategy (the conventional base case Strategy 1) has known values, and the other strategy is as of yet unvalued. The aim with this comparison is to investigate at the level of ROI required for the unvalued Strategy 2 in order for that strategy to be preferred to the evaluated Strategy 1, i.e. when $V(S_1) \geq V(S_2)$ cease to hold. By doing so, the result will provide guidance as how to act when information is revealed regarding the unvalued strategy or if this information is worth pursuing is the inequality holds for reasonable levels.

F. Preference Capture

For the comparison it is necessary to obtain equitable criteria weights. These weights should come from decision makers but may also stem from other stakeholders. In this specific case, the local society in general is a major stakeholder wherefore it needs to be included when capturing preferences. It is advocated to do both surveys as well as in-depth interviews with key agents and representatives of a larger population of stakeholders [22].

In a setting such as this, Ref. [23] argues that preference capture, or weight elicitation can successfully be improved by following a gradual approach to the evaluation problem. It is suggested to start by a holistic approach where the participants are asked to give an initial rank of the presented criteria (based on background information), which after a more elaborated comparison of each criterion is requested offering the participant means to offer ratio relative importance in numerical and verbal representation. Ref. [24] emphasizes the need to give the participants guiding and technical support in order to minimize their cognitive burden. It is recommended that this guidance is continuous throughout the entire weight elicitation process. In this paper the approach of [24] has been followed to a certain extent.

Initially, each participant was asked to provide an initial ranking, and he/she is presented with the basic information about the case. In addition to this, the participant was made aware of the estimated alternatives' values for the two criteria. These estimations are derived from the model on Strategy 1 and early goals formulated for Strategy 2.

The participants were then asked to develop the answer by stating which range is larger than other preference-wise, and how much larger on a verbal five-point scale. This step serves as a base for the participant to further develop into a more precise estimate of the weights. The participants were then asked to score the weight by assigning a factor to the least important criterion which states how much it is valued compared to the more important criterion on a ten point scale. Formally, they were asked for β such that $w_y = \beta \cdot w_x$ where $\beta \in \{0.0, 0.1, 0.2, \ldots, 1.0\}$ given that w_x is the weight of the least important criterion.

The weight results from each participant are then aggregated into an interval and used to calculate a mean value, analogous to the procedure in Ref. [25]. The criterion with the highest mean value is ranked highest from the pairwise comparison. The weight w_i of each criterion can be obtained by assigning a relative score of 1 to the initially first ranked criteria, and then normalize.

Interviews have been held with members of the city council and with members of the board of SLP. A total of six representatives have participated. The selection of the members of the city council has been done randomly, where two members of each political party represented in the city council have been asked to participate.

The interview have given the participant a short description of the project and the formulated strategies followed as well as an indication as to which intervals the criteria can differ, depending on the action taken. The upper boundary of the monetary value and the lower boundary of the reduction of carbon dioxide are set according to the conventional strategy valuation. The lower boundary of the monetary value is estimated by assuming that the strategy still needs to the profitable, and the upper boundary of the reduction of carbon dioxide is estimated by setting a limit, which most likely will not be met, but serves it purpose as to see that there is a limit.

IV. Case Specifics

It is reasonable to assume that the population will have grown or at become least stabilized in the future. It is also reasonable to assume that future generations will be affected by environmental impact to a greater degree, such as emissions, than current population. Thus, it is reasonable to apply a negative discount rate with the implicit meaning that reducing environmental impact today is of greater value than postponing, see Table III for arguments according to Ref. [26].

TABLE II. Arguments for Positive and Negative Discount Rates.

Positive discount rate	Negative discount rate
The emissions have no significant impact due to low or non-existing population in the future.	The population has grown in the future and therefore more are affected by environmental degradation.
Future technology will remedy the consequences of emissions.	No future technology can decrease the consequences of emissions to a satisfying level.
Future generations don't get affected to a harmful degree by emissions.	Future generations get affected to a harmful degree by emissions.

A low discount rate of -2% has been applied and thereafter further investigated in a sensitivity analysis. The parameters and values in Table IV have been used.

TABLE III. First Comparison Value Specification.

	ROI	RDCE
Underlying asset	680 MSEK	21200 tCO_2/year
Volatility	15%	15%
Discount rate	1%	-2%

A. Define and Calculate Existing Options

Two strategies was formulated, the conventional Strategy 1 and a "green" Strategy 2. Strategy 1's main assumption is that the firms, which the municipal companies normally would cooperate with, are considered to execute each option. Strategy 2's main assumption is that all firms, which operate under a high environmental standard (using newer machines decreasing the amount of emissions and other environmental effects), are preferred and could be subsidized. Thus, Strategy 2 will result in a lower monetary ROI and a higher value of reduction of carbon dioxide emissions.

The strategies are assumed to be carried out during a 50 year time period partitioned into three phases, where Phase 1 creates revenue for the entire period and Phase 2 is executed after 20 years, followed by Phase 3 which starts generating revenue for another 30 years, see Fig. 2. Hence, the setup is a sequential option. Each strategy consists of three phases and hold the same options, but with different values. Each phase suggests involving a third party, either by allowing a firm to lease or purchase land (lease and sell option in Phase 1 and 3) or by hiring a firm to expand (expand option in Phase 2).

In Table IV, V, and VI the input values for the different options for the Strategy 1 are shown.

TABLE IV. Option to Expand, First Comparison Value Specification.

Strategy 1	ROI	
Profit	0	
Cost	200 MSEK/12ha	100 MSEK/6ha

Strategy 1	**RCDE**
Strategy	1
Profit	0
Cost	30 000 tCO_2

The cost for both the monetary-and the RCDE-criterion are estimates acquired from the case firm, and should not be viewed as absolute figures. Furthermore the cost of the option to expand in regard to the RCDE-criterion arises due to the extensive usage of machines that emits carbon dioxide, which are necessary for the expansion.

TABLE V. OPTION TO LEASE, FIRST COMPARISON VALUE SPECIFICATION

Strategy 1	**ROI**
Profit	400 SEK/m^2*y
Cost	0
Strategy 1	**RCDE**
Profit	500tCO_2/ha*y
Cost	0

TABLE VI. OPTION TO ABANDON/SELL, FIRST COMPARISON VALUE SPECIFICATION.

Strategy 1	**ROI**
Profit	8000SEK/m^2
Cost	0

Strategy 1	**RCDE**
Profit	500tCO_2/ha*y
Cost	0

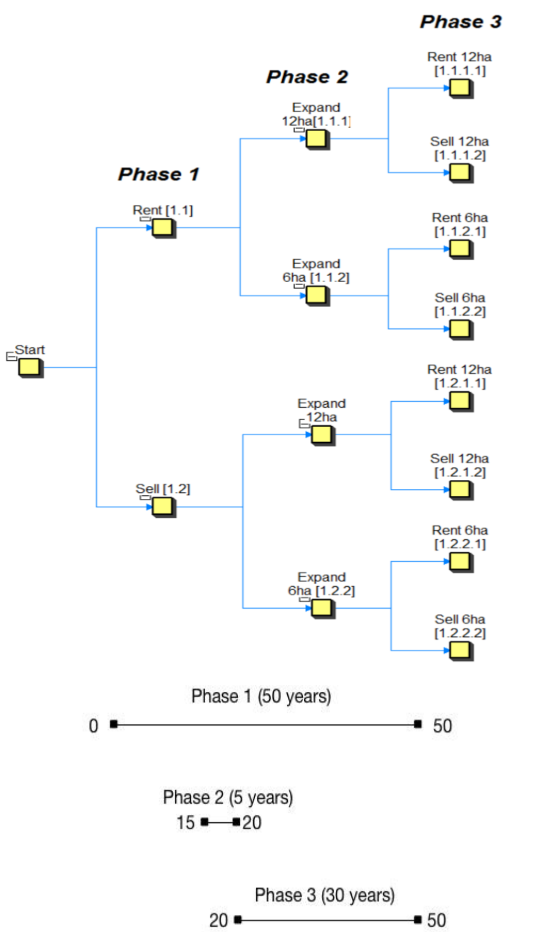

Figure 1. Underlying strategy and the year distribution of phases.

B. Uncertain Parameters and Sensitivity Analysis

In this model there are several parameters that are uncertain to an unsatisfying degree, the most prominent of these are the volatility for both the monetary option valuation and the RCDE option valuation, and the discount factor (risk-free interest rate) of the RCDE value. The discount factor for the monetary option valuation is not as uncertain, since a risk-free interest rate is available from the municipality's internal bank. In order to investigate the uncertain parameters' influence on the model and draw conclusions regarding the outcome's reliability, a basic sensitivity analysis have been applied.

A basic sensitivity analysis is usually done by varying one parameter at a time while observing the change in the total outcome [27]. The volatility parameter was varied within in the interval [5%, 25%] and the discount rate of the RCDE value in the interval [-3%, 1%].

C. Use MCDA Model and Determine Thresholds

The comparison between the two strategies will use the values calculated from the option valuation for Strategy 1, and best estimates on Strategy 2, based upon a target for the RCDE-value and a slightly lower ROI due to the higher price of environmentally beneficial vehicles. Monetary valuation conventional strategy

The monetary NPV is 680 MSEK and the option valuation (Phase 1) value is 796 MSEK. Hence, the sequential compound option value is 796 - 680 = 116 MSEK. In other words, the flexibility in how the establishment areas can be exploited is worth 116 MSEK.

D. RCDE Valuation Conventional Strategy

The RCDE is 21200 tCO_2/year and the final option valuation (Phase 1) value is 29351 tCO_2/year. Hence, the sequential compound option RCDE value is 29351 - 21200 = 8151 tCO_2/year. In other words, the flexibility in how the establishment areas can be exploited is worth a reduction 8151 tCO_2 per year.

TABLE VII. STRATEGY VALUES FOR THE MCDA MODEL

	ROI (MSEK)	
Strategy	1	2
Value	680 + 116 = 796 MSEK (NPV + Monetary option value)	768 MSEK (Estimate)

	RCDE (tCO_2/y)	
Strategy	1	2
Value	21200 + 8151 = 29351 tCO_2/y (PV + RCDE option value)	21200 + 14000 = 35200 tCO_2/y (PV + Estimate)

V. RESULTS

A. Option Valuation with Sensitivity Analysis

Fig. 3 and Fig. 4 show the results from the sensitivity analysis performed on the volatility for the monetary value and the RCDE value, and Fig. 5 show the results from the sensitivity analysis performed on the discount factor for the RCDE value.

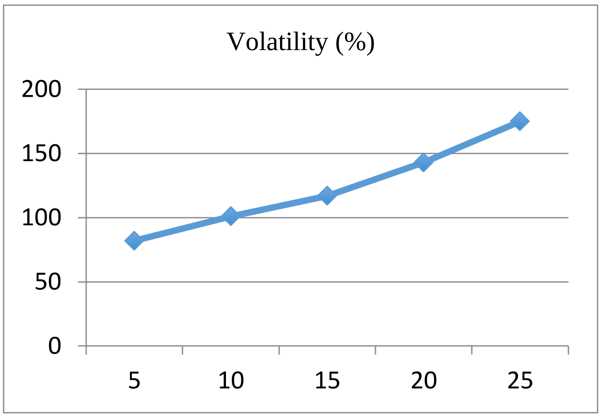

Figure 2. Sensitivity analysis of the volatility parameter for the monetary criterion.

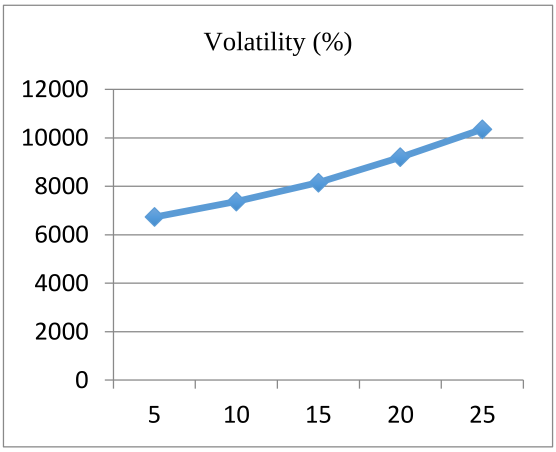

Figure 3. Sensitivity analysis of the volatility parameter for the emission criterion.

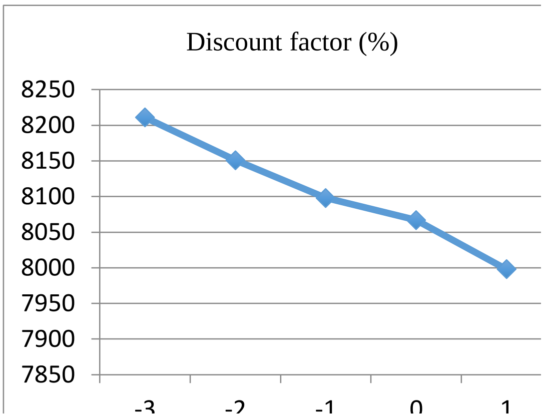

Figure 4. Sensitivity analysis of the discount factor parameters for the emission criterion.

B. *Preference Capture*

Preference capture was done using a survey where the participants first are to give a ranking of the criteria based upon the ranges given in Table VII and using linear value functions of Eq. 2 and 3 below.

$$v_1(x) = (x - 768) / (796 - 768) \tag{2}$$

$$v_2(y) = (y - 29351) / (35200 - 29351) \tag{3}$$

This was followed by a specification of the weight as described in Section III. The mean weights obtained from the elicitation run can be seen in Table VIII.

TABLE VIII. CRITERIA WEIGHTS

Weight	Criteria
56%	RCDE
44%	ROI

C. *Multi-criteria Evaluation*

The results show that Strategy 2 is preferred, since

$$V(x_1, y_1) = 0.44 \cdot v_1(x_1) + 0.56 \cdot v_2(y_1) = 0.44 \tag{4}$$

$$V(x_2, y_2) = 0.44 \cdot v_1(x_2) + 0.56 \cdot v_2(y_2) = 0.56 \tag{5}$$

From the weights and scales we can identify the marginal rate of substitution $t(x, y)$ between the two criteria.

$$t(x,y) = \frac{w_y(x_{max} - x_{min})}{w_x(y_{max} - y_{min})} = \frac{0.56(796-768)}{0.44(35200-29351)} \approx 0.006 \tag{6}$$

In other words, based upon the weight elicitation, one tCO_2/y increased RCDE can be compensated for by a decreased ROI with approximately 6 000 SEK. Accordingly, the ROI required for Strategy 2 should be at least 761 MSEK for that strategy to remain the preferred choice according to the preferences stated.

TABLE IX. INDIFFERENCE THRESHOLD

	ROI (MSEK)		RCDE (tCO_2/y)	
Strategy	1	2	1	2
Value	796	761	29350	35200

VI. DISCUSSION OF THE RESULTS

The real option valuation results were based upon Strategy 1, the conventional strategy where no subsidies were given to environmentally friendly leasers/buyers/contractors. In monetary terms it yielded the result of a 116 MSEK option value, which would increase the total value of the project with 17%. In order to obtain more equitable results however, variables such as the ratio between leased, bought and available land throughout the time period could be incorporated. Furthermore the lease- or purchase contracts could include facilities and other cost-related posts which would affect the total value.

The sensitivity analysis shows that the volatility has a significant impact on the results of the monetary valuation. The current volatility estimation of 15% is based upon the transport market segments freight, maritime and truck over the last four years. This estimation could benefit from using a wider range in the time period of data collection where perhaps a trend could be identified.

In terms of RCDE the option result yielded an increase of 8150 tCO_2/y, which is an increase of 38% of the total RCDE value of the project. The sensitivity analysis shows that the RCDE valuation is not as sensitive to changes in volatility as the monetary valuation is. Furthermore, the sensitivity analysis on the discount rate shows that the results are only marginally affected by the changes. However, since the feasible interval regarding the discounting of the environment is not established, it's hard to conclude that this sensitivity analysis is fair. When arguing for a negative discount factor regarding the environment, no actual figures are suggested in previous research.

The preference capture shows that the two criterions are considered to be of significant importance. However, stakeholders who are not versed in this sort of investigation might have a hard time understanding the context and to issue their preferences. The interview approach gave each participant the opportunity to ask questions and further elaborate their answers. For generic validity (how much the preferences actually reflects the municipality as a whole), more participants would have been beneficial. When acquiring preferences and/or weights in an MCDA, it is important that these preferences are obtained from the actual stakeholders. Herein lies a substantial problem, due to the challenge of stating who the right stakeholders are. In this case, the society is a major stakeholder since it's a public sector project wherefore several of the participants were members from the city council. In a private sector setting, the same reasoning might not apply.

The acquired weights regarding the ROI and the RCDE criteria only reflect the preferences for this specific case, i.e. they are not universal from the perspective of the municipality.

In strategy comparison using MCDA using input from the ROA analysis in Strategy 1 and "best estimates" as input in Strategy 2, Strategy 1 is clearly preferred. When participants were asked to judge preferences based upon how the strategies differed, the RCDE criterion was awarded with a higher weight and the "green" strategy was to be preferred.

In a sequential interpretation of these weight preferences, a threshold for the monetary value in Strategy 2 was obtained, provided that the RCDE value in Strategy 2 is fixed to an increase of 5850 tCO_2/y compared to the RCDE value in strategy 1. It is then explicitly shown how much the gain in RCDE value is allowed to cost, or rather how much of the profit the organization is willing to subsidize in order to increase the RCDE value. In this specific case, it is shown that an increase in the RCDE value of 5850 tCO_2/y allows for a reduction of the ROI monetary value by 35 MSEK. If the ROI would decrease any further, Strategy 1 would be preferred.

A. Discussion of Combined Abilities of ROA and MCDA

The results show that ROA and MCDA can be combined in order to obtain decision support with regards to strategic planning. More specifically, the combined abilities tested are those applied when comparing future strategies that are based upon sequential compound options, while including the value of flexibility and the non-monetary aspect RCDE.

ROA and MCDA interacts in a sequential manner where the first step is to calculate the value of flexibility for those criteria that have values by using ROA, followed by the second step where MCDA is used to compare the formulated strategies/alternatives. A comparison based upon existing input in the different strategies, is not the only possibility to obtain the final decision support. The final step can also yield a threshold for a given parameter, for when the compared strategies are equally preferred. This result can be used to formulate policies of how to take action when new information is revealed. However, the threshold approach is not suitable if there are several unknown parameters since the amount of combinations to obtain a threshold are too many to consider. In a case where there are more than one unknown parameter (such as in this paper, where both parameters of Strategy 2 are unknown), a workaround is to specify one of the parameters according to goals or regulations.

There might be qualitative criteria that holds a significant weight and therefore should be included, but cannot be quantified in numbers. These criteria might be measured on an ordinal scale or in a yes/no-format. The problem that arises is how the flexibility should be included in these criterions since the ROA approach is not suitable for a yes/no-format. If these criterions still were to be included, they would not benefit from the flexibility value, which leads to a certain degree of inconsistency in the MCDA comparison. This might not be a problem, as long as it is clearly stated in the finalized decision support that those criterions do not have the value of flexibility incorporated.

VII. Concluding Remarks and Future Work

This paper has demonstrated a combination of ROA and MCDA in a real-life public sector investment setting. The value of flexibility does provide better insights, due to its ability to take into account the flexibility of the project in terms of utilization of the establishment area. The ROA and MCDA support each other, in a setting where ROA provides better coverage of the total value, and MCDA provides the comparative abilities, if there are several strategies or alternatives how to execute a project or a part of a project.

To improve and better understand the benefits of the suggested approach, more insight into how the value of flexibility and the comparison of the strategies interact is necessary. The model should be further elaborated, where more criterions are included and several strategies are compared. Of great interest for future work in the direction of this paper is how to adapt a process such as the one described herein explicitly connecting the criteria weights and trade-offs to strategies communicated by the municipality leadership.

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