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A real life ICAT investment analysis with Real Options

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Abstract: - Traditional investment appraisal techniques, such as net present value (NPV) do not capture the flexibility in the investment deployment strategy inherent in most of the technology projects. In this paper, we use Real Options (ROs) to capture the value of flexibility in the evaluation of a real-life telemetry and automation investment, for a water management utility company. We examine the investment's profitability of an Information, Communication and Automation Technology (ICAT) platform on which a SCADA (Supervisory Control And Data Acquisition) system will be built and operate. The investor is faced with the problem of valuing a number of investment opportunities based on the initial base scale of ICAT infrastructure investment. We treat these opportunities as ROs, quantify flexibility by adopting step-wise investment deployment strategy and estimate the overall value of the investment opportunity. The results prove that ROs evaluation can increase profitability of investments, especially in cases where their NPV value is negative or marginally positive.

Key-Words: - Information Communication Technology, Automations, SCADA, investment evaluation, real options, Net Present Value

1 Introduction

A Supervisory Control And Data Acquisition (SCADA) system consists of a computer placed at a central location, communication lines and equipment, programmable logic controllers (PLCs), sensors and other devices that monitor and control a utility, such as a water system. SCADA provides multipurpose utility management, operating flexibility and more complex system control from a distance. Remote telemetry units (RTU) are also placed at remote locations. Telemetry gives system operators the ability to monitor and control the system's performance remotely, with real time efficiency. Operators can monitor and automatically collect data from multiple remote sites. Telemetry eliminates many time-consuming trips out to the field, reducing operation and maintenance costs, as well as ensuring system reliability. We characterize all these systems with the term ICAT (Information, Communication and Automation Technologies).

Previous research on ICT (Information - Communication Technologies) and Automation System Investment analysis does not consider the risk inhered in the business activity. This is the first work to apply real option methodology for analyzing a real life ICAT investment for a water management utility in order to achieve a balance between reward and risk. Actually, a Cost-Benefit analysis is performed for the techno-economic evaluation of a project concerning the planning, installation and operation of a new ICAT/SCADA system for a real Greek Water Supply & Sewerage Company. The Company's principal business is the supply of water and sewerage services to over 1.5 million people. Among the main strategic targets of the Company are the rationalization and effectiveness of the water resources management, the optimization of customers' services and the decrease of its operational expenses. In order to achieve these targets, the company, among others, has already established a fully operational Information System. In parallel, it has decided the implementation of a new Telemetry system to control the operation of the water management equipment. As business needs changed, driven by higher customer and community expectations, the limitations in reliability and capability of the old technology were beginning to become increasingly apparent. This led the company to plan the complete replacement of the current ICAT/SCADA equipment, taking advantage of the opportunities for operational improvement due to the fast advances in electronic and information technologies.

The Company is challenged on several areas. First, there is an opportunity for the Company to offer advanced water management services to its existing customers. This results to enhanced service quality and efficient control of its operating expenses. In addition, its service area is going to significantly increase attracting new customers. The second challenge is to define the future IT investment opportunities enabled by the initial ICAT investment and identify how these opportunities could transform the company's relationships with customers, suppliers and environment regulators. The third challenge is to understand the risk factors inherent in this project and look for the optimum deployment strategy in order to mitigate this risk. Finally, in order to estimate more efficiently the economic performance of the whole business opportunity, the managerial flexibility applied to investment deployment strategy should be quantified in monetary terms.

In Section 2, we present the relationship of ROs thinking and ICAT infrastructure investments. In Section 3, we present the content of the investment and Company's management point of view for the optimum deployment strategy. We also apply the ROs methodology and compare it with NPV analysis. In Section 4, we present the steps of proposed methodology. Finally, in Section 5 we conclude and suggest further work.

2 ICAT infrastructure investments and ROs

An option gives its holder the right, but not the obligation, to buy (call option) or sell (put option) an underlying asset in the future. Financial options are options on financial assets (e.g. an option to buy 100 shares of Nokia at 90€ per share on January 2007)[1]. Real Options (ROs) approach is the extension of the options concept to real assets. For example, an ICT investment can be viewed as an option to exchange the cost of the specific investment for the benefits resulting from this investment. An investment project embeds a real option when it offers to the management the opportunity to take some future action (such as abandoning, deferring or expanding the project) in response to events occurring within the firm and its business environment.

ICAT infrastructure investments provide the base for launching other applications by enabling follow-on projects in future periods. We treat the launching of these applications as expansion and growth options. Table 1 summarizes the parameters' analogy between a call options and an investment opportunity.

Investment Opportunity	Variable	Call option
Present value of a project's expected benefits.	V	Stock price
The amount of money spent for the investment, Investment expenditure required to exercise the option (cost of converting the investment opportunity into the option's underlying asset, i.e., the operational project)	X	Agreed Exercise price of the Option
Length of time where the investment's decision may be deferred	T	Option's time to expiration (i.e., the maximum length of the deferral period).
Time value of money	r_f	Risk-free rate of return
Variance (Riskiness) of the investment's project assets (Costs, Revenues)	σ^2	Variance of returns on stock

Table 1, Parameters' analogy between a call option and an investment opportunity

The total value of a project that owns one or more options is called Expanded (Strategic) Net Present Value (ENPV) and is given by Trigeorgis [3]:

$$ENPV = NPV + \text{Value } of\ future\ ROs \qquad (1)$$

The flexibility value named as option premium is the difference between the NPV value of the project as estimated by the Static or Passive NPV method (PNPV) and the Strategic or Expanded NPV (ENPV) value estimated by the ROs method. The ROs thinking emphasizes the sources of uncertainty inherent in ICAT investments. ICAT risks may include company-specific risks, competition risks, market risks, and environmental (regulatory) and technological risks. In our case, there are mainly company-specific risks, environmental and technological risk since the Company does not experience any customers demand uncertainty or any competition threat. In particular, many of the ICAT investments projects either completely fail, or deliver reduced functionality [4]. Risk factors that can affect the ICAT/SCADA investment performance can be, lack of users acceptance, employee morale or organizational dynamics, dependencies between interrelated projects that some of them are delayed. Also, risk factors may concern unrealistic implementation schedule and environmental complexities such as installation of complex equipment in a large scale that can cause inconvenience to the customers.

Most previous research considers only ICT investment that embeds a single and a-priori known option. However, real life ICT investments concern multiple real options, which should be considered during the analysis in order to find the optimum investment deployment strategy, minimizing risk and maximizing performance [5]. Actually, a Telemetry and SCADA automation investment may embed a series of cascading (compound) options. Previous research on investment evaluation has applied real options to ICT, pharmaceuticals and petroleum [6]. Applications in ICT can be found in [7],[5]. For a general overview of real options, Trigeorgis [1] provides an in-depth review and examples on different real options. For more practical issues the reader is referred to Mun [6]. Finally, Angelou & Economides [8] present an extended survey of real options applications in real life Information Communication Technology (ICT) investment analysis. In this paper, we apply, for the first time in literature, real options to ICAT/SCADA investment evaluation. ICAT platforms not only generate direct value from their operations but they also enable future applications implementation based on them. We treat these new applications as real options.

Option valuation models can be categorized in continuous time and discrete time domains. Black-Scholes formula is the most popular continuous time model, while Binomial model is the best representative of discrete time domain [1]. For valuating series of cascading options, we start with the log-transformed binomial model (LTBM) finding it intuitive and relatively easy to use for investments plans that contain more than one option. The LTBM has been applied to IT in [5], however, only the revenue uncertainty is considered, while the cost is certain. In addition, we apply the extended log-transformed binomial model (ELTBM) [10] to SCADA investment analysis, for the first time in the literature. This model is more suitable for complex investments involving both stochastic payoffs and stochastic costs on a compound options analysis. We estimate the impact of cost uncertainty in the investment profitability.

3 The ICAT scenario

Concerning the current situation, some early automation and telemetry systems, from various vendors, were installed in some of the main bumping stations of the company in order to increase the efficiency of the water management process operation. However, at this moment there is no homogenous ICAT system for the supervision and control of the water management operation equipment. The current telemetry and automation equipment has been used to monitor the performance of the 50% water pumping stations, and water reservoirs. This telemetry was designed, assembled and installed occasionally, and eventually featured a variety of technologies, depending on the "era" of installation at each site.

Actually, the Company uses a combination of different automation and supervision systems (PLC, SCADA & manual systems), different platforms and communication ways. Especially, communication connections between the water management plants are either leased PSTN lines or private telecommunication cables or low power transmission radio communications or licensed radio communication systems in UHF or mobile telephony.

The current situation of automation and telemetry in the water management plants of the Company is presented in Figure 1.

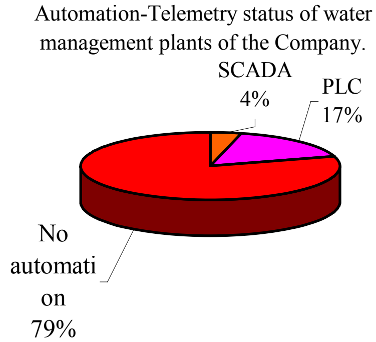

Fig. 1. Automation status for water management sector of the Company including all the geographical areas (bumping stations, reservoirs, boreholes etc…)

This lack of homogeneity results in missing information, problematic monitoring, inadequate control and ineffective water management. The Company's management believes that the current system is not meeting the company's needs any more.

The Company's vision for the new ICAT system is that it would enhance the automation level and also significantly decrease the expenses of the water management operation. In addition, it would provide integrated information and modern capability to a wide range of users including planners, operators, contractors, business strategists and senior management. Initially, the investment includes the planning, procurement, installation, configuration of a complete ICAT platform system, dedicated to the control and supervision of water management plants of the company.

3.1 Investment's deployment strategy

The Company's management decided to proceed in a step-by-step investment implementation of two automation capability upgrades. In addition, a couple of grow opportunities have been recognized based on the initial ICAT platform.

3.1.1 Options to expand operation capability

In the base scale ICAT topology, there are 6 Regional Control Stations (RCS) and 1 Central Control Station (CCS) which are staffed and used to control a functional part of the water network topology that is related to each of them. Local Area Networks topologies and technologies are used in the CCS as well as in the RCS offering connectivity to the other company's Information Systems. Ethernet networking technology is used to connect all CCS and RCS to the Company's Local Area Network. Full transparency and connectivity are required from any control station to any main water pumping station up to the instrumentation level.

After 3 years, the company will examine the possibility to enhance the performance of its water management operation by adopting higher automation in order to save even more on personnel. Actually, the management considers the full automation in the process, at a later stage, by spending a significant amount of money X2 in order to upgrade the rest of the electromechanical equipment. This upgrade will allow further personnel savings from the water management process since almost no personnel supervision is required. Also, after 2 years, the management can further consider the operation enhancement by adopting full automation level with almost no need of "human" supervision as everything concerning water plants operations will be fully automated and controlled by the PLCs.

In general, the management believes to a smooth transition via phases from the current situation to more advanced automation of the water management. This can result in a better exploitation of the investment benefits. Usually, more time is required for adopting new technologies which although they enhance the business processes, they also cause employees cognitive overload and confusion. So, the public state requires incremental improvement steps instead of radical jumps. Hence, flexibility in the investment deployment is a strong requirement for the Company management. Figure 2 presents the cost outlays per investment stage as well as the expansion and growth options embedded in the initial investment plan.

3.1.2 Further Growth opportunities

The Company examines the possibility of integrating two extra tools into the ICAT platform:

1) ArcInfo, a Geographical Information System (GIS), that allows users to create, view, access and analyze map (geo-referenced) data.

2) StruMap, a Hydraulic Analysis simulation tool, which helps the Water Network Modeling and therefore the Water Management.

This investment will in general enhance information handling and decision-making.

The Company also examines the possibility of developing a web-based support tool for customer services optimization. In particular, information coming from the ICAT system can be used from the customer services process in order to increase its efficiency. Of course, this requires re-engineering of the company's internal processes that are related to the customer support and information. The Company's management considers that it could take place in an efficient way after 3-4 years of operating the ICAT platform.

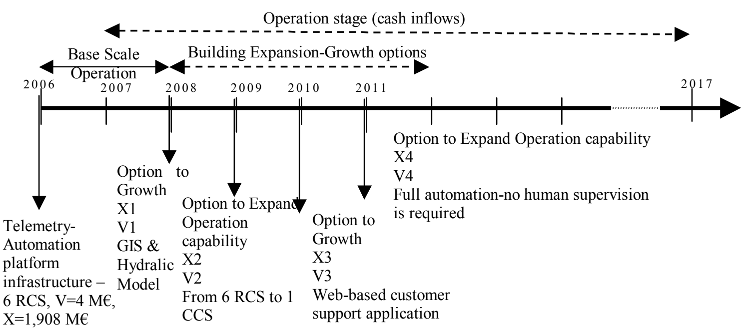

Fig.2. The ICAT investment configuration involving four real options – deployment strategy

3.2 Analysis of costs and benefits

Investment costs are categorized into systems purchase costs, implementation costs, maintenance costs, and operation costsDue to space limitations we do not analyze further the investment cost, however, they are available to the interest reader.

Concerning benefits, we focus on tangible ones that can be quantified in monetary terms. We divide benefits to automation, information and transformation ones. First, the automation benefits refer to the efficiency deriving from substituting the labor by the ICAT. Within this dimension, the ICAT value associated with automation is derived primary from productivity improvement, labor savings and operation cost reductions. Second, information benefits are related to the ICAT ability to collect, store, process and disseminate information. Third, transformation benefits are related to the ICAT ability to facilitate process innovation and transformation such as total quality management and business process reengineering. We mainly focus on Automation and Information Benefits. Analytically, we take into account the following benefits (cost savings):

- Personnel cost savings due to standardizing operating procedures and utilizing the staff productively.
- Operation & Maintenance (O&M) cost savings due to personnel transfer reduction as a result of more efficient network supervision process.
- Operation expenses Cost Savings due to more efficient water management using the Telemetry System. Actually, the management considers that up to 3% of the energy operation expenses can be saved.
- Operation expenses Cost Savings for more efficient electromechanical equipment supervision using the ICAT system.
- Operation expenses Cost Savings due to more efficient water management using the GIS & Hydraulic Model.
- Better Customer Support due to web based tool integration with the Telemetry Platform.

3.2 Economic analysis

The analysis horizon is 12 years, from 2006 until and including 2017. The risk free discount rate r_f is 4% which is also used in the NPV analysis. Finally, the required time to built and integrate each phase with the rest system at each stage is one year. The NPV value of the ICAT infrastructure investment (base scale SCADA investment), including all the automation upgrades, is 467 k€. So, this indicates a marginal profitability for the project. The NPV value of the overall investment plan, as defined by the company's management, is 205 k€.

We now introduce the ROs analysis. We first discuss methodological issues involved in establishing the suitability of the real options analysis to the Company's situation and in eliciting relevant information for the analysis. In order to verify the existence of option value in the Company's case, the following questions has been answered in corporation with the company's management:

What kind of options does the Company possess concerning the ICAT investment? The Company possesses a couple of upgrade/expansion options concerning the ICAT-SCADA system itself. In addition, it possesses a couple of growth options concerning the GIS and HM integration with the SCADA system, as well as the web based customer support tool development that uses information collected and handled by the SCADA system.

Where did the options come from and at what cost? Unlike a financial option that is purchased for a cash fee, the Company obtains its options at no direct cost coming from any possible competitive threat of loosing the deferred investment opportunity. This is clearly true in the case of a monopoly as it is in our case. However, options costs to defer upgrades and further growth opportunities are coming from revenues losses during the deferral period.

Where do the Company's options values come from? The option value stemmed from the management's belief that it could resolve some of the uncertainties, described before. Alternatively, the options value comes from the managerial flexibility in investments deployment. The Company has the ability to wait and learn more about the investment, to be able to better assess it and subsequently avoid it if the expected revenues turned out to be unattractive due to possible company's internal or external factors. These factors can influence the optimum investment deployment as well as the exploitation of the new SCADA system and its growth opportunities.

For the valuation of options we use the LTBM with 50 steps time resolution. Also, the volatility of payoffs is assumed to be between σ = 50% and 70%. These values have not been extracted by quantitative analysis. The interview process with the company's management revealed the degree of uncertainty for the various phases of the investment. The company's management expressed the uncertainties level for each investment phase in qualitative way, since it had difficulties in expressing the volatility of the expected value of investments benefits. Similar, values have been applied in IT literature [9],[2].

The valuation of separate options is given below. The options are valued as a European call options. This means that they are exercised at their expiration dates.

There are the options to expand operations at T=2009 and at T=2011. The management assumes that the company posses the option to expand the automation of the water management operation and supervision system after 3 years of the basic ICAT platform deployment. In case of ensuring the necessary funding and reallocating its personnel, the company can expand the capability of its supervision operation by concentrating all the RCS to a CCS.

This option is valued analogous to a European Call option to acquire part of the project (expansion) by paying an extra outlay as exercise price X2. It is given by:

OV(E2) = max (V2-X2, 0) where V2 are the incremental revenues obtained from the automation expansion minus the operation expenses required for the operation of this part of the project, while its value is 2,877 k€.

Similarly, a second expansion of the automation mode treated as option to expand at 2011 is assumed and it is given by OV(E4) = max (V4-X4, 0), while its value is 80 k€. The quantification of the managerial flexibility for this option is related to some of the automation technology risk mitigation and the degree to which the water management critical issues can be fully automated, taking into account the economic situation of the company at that time.

ICAT investment also yields capabilities that open up future investment opportunities for a company. Unlike to the operating options, a strategic growth option may have an underlying asset (the payoffs expected from future investment opportunities) that is different from the asset (current investment) that spawns it in the first place.

Growth options could be embedded in almost every IT investment, and especially in IT investments that aim at creating capabilities which confer preferential access to future investment opportunities [5].

In our analysis we consider the existence of two growth options at T=2008 and T=2010. In particular, during the first year of the ICAT platform operation, the company will examine the possibility of developing and integrating GIS and HM tools with the SCADA system. We consider this opportunity as the first option to growth related to the GIS and HM tools integration with the ICAT platform. It is given by OV(E1) = max (V1-X1, 0). V1 is the revenues minus the operational expenses for the specific investment stage, while X1 is the sunk cost outlay to exercise this option. Finally, its value is 11.4 k€.

Finally, the second option to growth is related to the development of the web-based customer support tool, which will be integrated with the ICAT platform investment. It will provide information extracted from the SCADA database. The management's intention is to reach the target operation level after the necessary business process reengineering. In this case, the more efficient manipulation of information collected using the ICAT system will result to a better customer support via a dedicated tool.

This second to growth option is given by the expression OV(E3) = max (V3-X3, 0). V3 is the revenues minus the operational expenses for the specific investment stage, while X3 is the sunk cost outlay to exercise this option. Finally, its value is 40.5 k€.

As it can be seen in table 2, all the values of the investments stages as calculated by the ROs analysis are positive and clearly higher than the values given by the NPV analysis. Similar, results are applied for various values of benefits uncertainties (volatilities).

In addition, we apply the ELTBM for more complex investments involving both stochastic payoffs and stochastic costs. It is the first time in ICT literature where both costs and benefits uncertainties are considered in compound ROs analysis.

However, the complexity of the model is increasing dramatically as the number of steps is increasing. For this reason we examine the case for one time step, since our purpose is to show intuitively the influence of the cost uncertainty in the investment's performance We use the 1 step LTBM method to calculate the option to explore and compare it with the ELTBM where both benefits and investment cost uncertainty are considered. However, this is not a problem since, the ELTBM appears to be more stable for small number of steps (here 1 step) compared to the single LTBM and especially for large value of cost and benefits volatility. The correlation between costs and benefits change plays an important role in having positive up and down probabilities for cost and benefits assets diffusion process. Actually, if the revenues and costs are uncorrelated then the log-transformed up and down probabilities in the lattice analysis are strictly positive [10].

Similar to the benefits uncertainty analysis, we assume a variance for cost equal to 40% and a correlation between benefits and cost equal to –0.5. Especially, the cost uncertainty for the base scale ICAT project is mainly coming from the installation process of the flow meters in the water distribution network. During the waiting phase, the technical management of the Company can examine installation ways for the flow meters, which will not cause any disturbance in the network. Actually, any problem that could be caused due to flow meters installation can dramatically contribute to the Company's operation expenses to support the lack of water provision to the customers.

The rest of the investment phases experience uncertainties coming from the risk factors expressed in a previous section of this work. Some of these uncertainties can be partially resolved during waiting period.

We consider the stochastic changes in the asset value to be negatively correlated with the stochastic changes in the investment cost. In particular, a negative ρ_{vx} could represent, for instance, that the inability to control the costs of the development project are associated with lower benefits after the project is completed. In the table 2 of (column c, d, e), we present the results of our analysis for the various investment stages. As we can see, the value of each option, which is considered as a stand alone investment opportunity is higher in case of considering both cost and revenues uncertainties compared to revenues uncertainty only. The same applies for the combination of the options as defined by the overall investment deployment strategy of the Company.

ICAT & grow opportunities investment justification				
Investment Description (a)	*NPV value (b)*	*Option value 50 steps LTBM (c)*	*Option value 1 step LTBM (d)*	*Option value 1 step ELTBM (e)**
Base Scale ICAT (SCADA) investment (no option value)	**-2092 k€**			
First Automation upgrade (1st upgrade) – Investments Part (X2=3 M€, V2=5.405 M€) σ_{v2}=50%, T=2, σ_{x2}=40%)	2530 k€	2877 k€ at 2007	2895 k€	3527 k€
Full Scale Automation (2nd upgrade). We consider first option to upgrade as prerequisite for this option (X4=0.4 M€, V4=0.341 M€) σ_{v4}=70%, T=1, σ_{x4}=40%)	-25 k€	80 k€ at 2009	107 k€	147 k€
Compound options for 1st and 2nd automation upgrade		2931 k€ at 2007	2932 k€	3611 k€
Overall ICAT investment with two options to expand	**467 k€**	**839 k€**	**840 k€**	**1519 k€**
GIS&HM integration with ICAT platform (X_1=0.4 M€, V1=0.175 M€) σ_{v1}=70%, T=1, σ_{x1}=40%)	-163.7 k€ at 2006	11.4 k€ at 2007	0	35.1 k€
Web-based customer support tool investment (X_3=0.3 M€, V_3=0.184 M€) σ_{v3}=50%, T=1, σ_{x3}=40%)	-98.7 k€ at 2006	40.5 k€ at 2007	49.3 k€	95.5 k€
Overall Investment Profitability with all options	**205 k€**	**891 k€**	**889 k€**	**1650 k€**

Table 2. Results of analysis

4 Presentation of the method

We consider the following steps in applying the real options methodology, Figure 3 in appendix.

- Define the content of the investment opportunity – Qualitative Analysis. The Company's management has to decides which of the projects, initiatives or strategies are viable for further analysis, taking into account the company's mission, vision and overall business strategy.
- Define the stages that investment opportunities will be deployed. Every project that passes the initial qualitative analysis is assigned to a specific stage or the overall investment opportunity of the company.
- The options embedded, in every stage, of the deployment strategy are recognized and described. Define the risks at each stage of the investment deployment strategy and how they are resolved using option analysis.
- The project's characteristics are mapped onto the option variables. This means determining the initial values of the five input variables (V,X,σ,T,r_f), where the volatility has to be calculated or estimated. Actually, The Discounted Cash Flows projection is rearranged in phases so that the options input values can be isolated. Also, we estimate the Net Present Value of each investment stage, mainly for comparison purposes with the option analysis results.
- The value of the five input variables is calculated.
- Starting from the end and going backwards we estimate the option values at each investment stage. We adopt compound option analysis. Finally, we estimate the overall ENPV value, which includes all the embedded options in the selected deployment strategy.
- Perform real options update analysis. Real options analysis assumes that the future is uncertain and the management has the right to change decisions concerning investment deployment strategy when uncertainties become resolved or risks become known. Actually, when some of these risks become known, the analysis should be revisited to incorporate the decisions made or revisiting any input assumptions such as investment volatility. In practice, for long-horizon projects, such as our case, several iterations of the real options analysis should be performed, where future iterations are updated with the latest data and assumptions [6].

In Figure 3 (appendix) we provide the proposed methodology for staged ICAT investments.

5 Conclusion

We study a new ICAT/SCADA system investment for a water utility Company from techno-economical point of view. The specific ICAT/SCADA investment scenario appears to be profitable when we adopt the ROs instead of the NPV analysis. The main contributions of this work are the following.

- It is the first time that SCADA, Telemetry and Automation technologies are justified by ROs analysis.
- We apply, for the first time, the ELTB model in the ICT field. We model both benefits and cost uncertainties in our multi-option analysis and show the impact of the investment's cost uncertainty in options value as well as in overall economic performance. The investment profitability appears even higher. Actually, by taking into account also the investment cost uncertainty, the managerial flexibility achieved

by adopting ROs contributes even more to the enhancement of the final economic performance.

Finally, it is the subject of further work to consider real options models and multi-objective/ multi-criteria analysis in order to better combine the tangible and non-tangible effects of the ICT investments, taking also into account any possible goals and constrains.

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Appendix

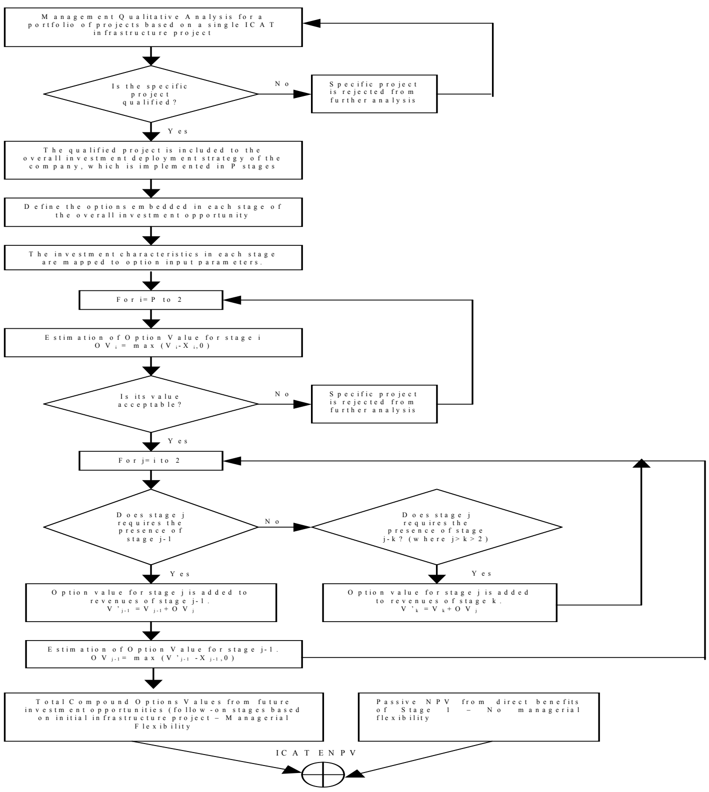

Fig. 3. The proposed real options methodology applied in this work