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Broadband Investments as Growth Options Under Competition Threat

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***Abstract*- In this paper, we estimate the overall value of an Information Communication Technology (ICT) infrastructure project, which supports a number of future investment opportunities. We treat these opportunities as Real Options (RO) and assume that there is competition threat that can influence negatively or even worst to eliminate their values. Our proposed model is applied for a real life broadband investments' scenario. The results of our models prove that ROs analysis may increase the overall business value of broadband investment opportunity compared to Net Present Value analysis.**

Keywords: Real Options, Broadband investment, NPV, Investment Analysis

I. INTRODUCTION

The valuation of Information and Communication Technologies (ICT) investments is a challenging task because it is characterized by high level uncertainty and rapidly changing business conditions. Traditional finance theory suggests that firms should use a Discounted Cash Flow (DCF) methodology to analyze capital allocation requests. However, this approach does not properly account the flexibility inherent in most ICT investment decisions. Real Options (ROs) analysis provides an alternative method since it takes into account the managerial flexibility of responding to a change or new situation in business conditions [14]. 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. 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. For a general overview of ROs, Reference [15] provides an in-depth review and examples on different real options. Reference [3] provide a literature review of the ROs applications to real life ICT investments analysis. In the broadband technology literature, ROs are applied in investment's evaluation concerning upgrade from ADSL (Asymmetric Digital Subscriber Loop) to VDSL (Very High Data Rate Subscriber Loop), services [5][6][10]. Finally, Reference [8] examine the economics and risks associated with a broadband network roll out along the Greek modern motorway "Egnatia Odos". We extent this work concerning competition modeling and multiption analysis. After the liberalization of the telecommunications markets the ICT business activities do not belong exclusively to only one firm but may also be shared by other competitors. Viewing ICT projects as ROs, this paper develops a methodology for evaluating ICT investments decisions in the joint presence of uncertainty and competition. We adopt financial option theory and enhance it with competition modeling theory to guide decision-making regarding the management and evaluation of ICT investments. As the number of players is increasing the exogenous competition modeling should take place since market conditions converge to perfect competition. In this case, a competitor's entry into the market will only cause a degradation of the overall ICT investment opportunity "pie". In case of exogenous competition modeling the firm has to weight the value of waiting against the possible erosion of value of competitor's actions. The firm has to determine what information has available about competition. In reality, the firm might have a rough idea about the intensity of competition and its impact without having full information about when and how other firms act. References [15][12] model competition assuming that the competitors are entering into the market following Poisson distribution. We also consider that the competitors are entering the market randomly according to an exogenous Poisson distribution. We relax existing literature assumptions by considering that: i) the expected arrival rate of competitors and ii) the impact of each competitor's arrival, during waiting period is following a joint diffusion process with investment revenue. Finally, we provide a compound RO model under competition threat.

A good example of many players in an ICT market, is the Greek telecommunication market [9][11]. After liberalization of the Greek market in 2001, an increasing number of new players has entered the market and started competing with the incumbent OTE in the value-added services. However, none of them pose a significant threat to OTE. However, each of them may subtract some value from the overall business value of any new investment opportunity from OTE if the latter remains "inactive". For any new value added service, there is a market "pie" concerning its business activity that is usually growing over time. Some parts, of the whole "pie" will be subtracted by the competitors as they are entering in the market. So, the OTE's management has to determine whether it should exercise the option and implement the investment opportunity early or whether it should wait despite a competitive damage.

The rest of the paper is organized as follows. In Section 2, we provide a compound ROs model under competition modeling. In Section 3, we provide a real life case study to illustrate the application of our model. Finally, in Section 4, we conclude and suggest possible future research.

II. A Compound Real Options Model Under Competition Threat

A. *Life cycle of an investment opportunity and ROs*

The lifecycle of an investment starts at the inception stage. During this period the investment exists as an implicit opportunity for the firm that can be facilitated by a prerequisite investment, Fig. 1. The firm posses a shadow option. At the recognition stage, which we also call it "Wai-and-See" (WaS) period, the investment is seen to be a viable opportunity. Actually, the opportunity can be treated as a RO. The building stage follows upon a decision to undertake the investment opportunity. In the operation stage, the investment produces direct, measurable payoffs. Upon retirement, the investment continues to produce indirect payoffs, in the form of spawned investment opportunities that build on the technological assets and capabilities it has yielded. When these assets and capabilities no longer can be reused, the investment reaches the obsoleteness stage. Each stage of the investment opportunity is relevant to a number of operating and growth ROs, such as option to defer, stage, lease, expand [4]. The reason is that each type of RO essentially enables the deployment of specific responses to threats and/or enhancement steps. In addition, each stage is also experiences a variety of risks inherent in the specific ICT business activity. These risks include firm-specific risks, competition risks, market risks, and environmental and technological risks [4]. We model competition risk during inception, recognition period and part of the operation period where the real option to invest is possessed by the market players, Fig. 2.

ICT infrastructure investments provide this managerial flexibility to expand or launch other applications across different platforms. ICT projects may involve a "wait-and-see" component that gives ICT managers the option to defer decisions for future investment opportunities until some uncertainty is resolved [4].

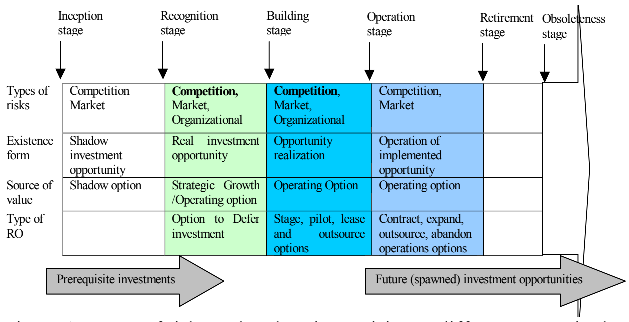

Figure 1. Types of risks and real options arising at different stages in the investment lifecycle

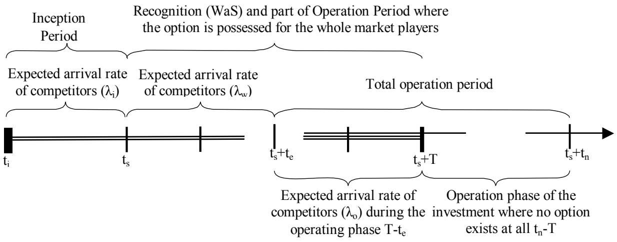

Figure 2. Inception, waiting (recognition) and operation periods competition modeling for a single RO

The total value of a project that owns one or more options is given by:

$$ENPV = NPV + Value\ of\ Options_{from\ future\ Opportunities} \quad (1)$$

B. *The model*

We model competition up to the operation period where competitors may still enter the market. The target is to estimate the RO value, and define the optimum time to invest, taking into account competition threat that can decrease or even more eliminate its value for the owner of it.

Inception period - Competitors may enter the market and subtract part of the investment opportunity that could be available to the firm under investigation. The inception period start at t_i (i.e. when the analysis process in taken place, ti=0). We define the term *Elimination Threat from Competitors (ETC)* for modeling the competition conditions in the market during this period, where the firm is only "watching" without being able to preempt its future competitors.

Recognition-WaS period - The WaS period starts at t_s when the option is available to the firm. The maximum WaS period, T, is separated in two sub-periods, as seen in Fig. 2. In the first sub-period, the firm is not investing and is waiting for resolving some of the uncertainties associated with this investment opportunity. The second sub-period starts when the firm exercises its option. Finally, t_e is the real exercise time of the option (implementation of the investment opportunity). Finally, the part of the operation period where the firm can still face Competition Threat (CT) is T-t_e.

We define two terms for modeling the competition conditions: i) *Preemption Threat from Competitors* (PTC) and ii) *Preemption Capability of Firm* (PCF). PTC indicates the threat, which is experienced by the firm during the WaS period of the option that other competitors may enter into the market and decrease or even more eliminate the option value. PCF indicates the capability of the firm to preempt the subsequent competitors after its entry time at t= t_e into the market.

During these periods competitors may enter the market randomly causing degradation of the investment opportunity for the firm. We call this competitive erosion. It indicates the decrease of the investment revenue that are available to the firm, caused by each competitor's entry into the market. We assume that competitors are entering the market randomly following a Poisson distribution.

The business target of the firm is to minimize the threat from competition that can significantly decrease or even more eliminate the option value and exercise its option at the optimum time compensating competition threat and uncertainty control. An important characteristic for each business opportunity is to provide a strong capability for the firm to preempt subsequent competitors' entry after its entry in the market. The final investment value that will be available to the firm is given by

$$V_f = V - I_{ci} - I_{cwte} - I_{co} \quad (2)$$

where I_{ci}, I_{cwte}, I_{co} are the total competitive erosions during the inception, WaS and operation periods respectively. Assuming expected competitor's arrivals $n_i=\lambda i*(t_s-t_i)$ during the inception phase, $n_w=\lambda_w*(t_e-t_s)$ competitors' arrivals during the waiting phase and $n_o=\lambda o*(T-t_e)$ competitors' arrivals during the operation phase, the overall option value when it is exercised at $t=t_e$ is given by:

$$\begin{aligned} OV_{cte} &= \max(V_f - X, 0) = \\ &= \max\left[V(1-c_i)^{n_i}(1-c_w)^{n_w}(1-c_o)^{n_o} - X, 0\right] \end{aligned} \quad (3)$$

where λ_i, λ_w, λ_o are expected arrivals rates of competitors during inception, WaS and operation periods respectively. Finally, c_i, c_w and c_o are competitive erosion parameters during these periods.

References [1][2] analyze the cases for PCF as well as the correlation between V and competition parameters. Especially, in case of "No PCF" it is more preferable to wait up to time T, since V_f will be the same independently of the option exercise strategy. In case of "Full PCF" *t*here are two effects negatively correlated between each other: i) the uncertainty control assured by both the ROs analysis and the managerial flexibility to deploy investment in a longer deferral period, and ii) the PTC that may fully eliminate the option value for the firm. Finally, in case of "Partial PCF" by investing earlier a level of preemption capability can be achieved. It might be optimal for the firm to invest earlier in order to ensure the highest possible level of the investment's revenues. Of course, it is still a matter of compensation between managerial flexibility and CT as before.

Incentive of investing earlier can also be applied when WaS strategy results to significant revenues losses from the operation phase that overcome the value of the uncertainty control provided by the ROs approach. A divided yield parameter may indicate these revenues losses [15]. Here, we assume that this divided yield is zero.

Competition parameters can be either positively or negatively correlated with V. Someone may assume that the bad business conditions compared to the favorable ones experience no network externalities effects. Also, the bad business conditions indicate no achievement of the critical mass for the customers demand indicating so a relatively small subtraction of the overall investment opportunity available to the firm. The opposite can be in case of favorable business conditions. In addition, there can be cases, where while the market value appears appealing, the competitors cannot extract significant option value. Particularly, when competitors do not have the adequate ICT infrastructure to fully utilize their own investment's opportunity benefits, an increase of the overall market value V might finally decrease the part of the market share that a specific competitor can subtract from firm.

We consider, a joint diffusion process for the c_w, λ_w V and X, Fig. 3, while we assume that the rest competition parameters are constant. We adopt an extended log transformed binomial model (ELTBM) with 4-parameters that follow joint diffusion process [7].

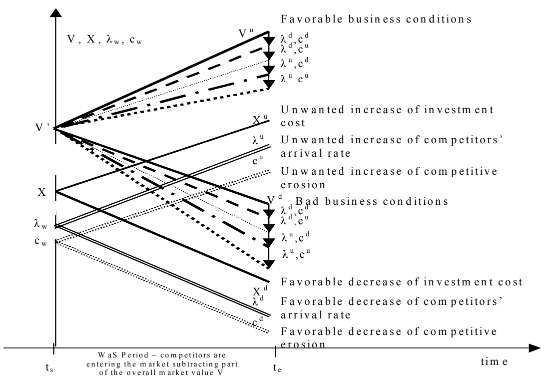

Figure 3. Investment revenue and cost, competitors arrival rate λw and competitive erosion cw joint diffusion process during WaS period, one time step

III. A REAL LIFE CASE STUDY

In this work the firm under investigation is Egnatia Odos S.A. (EO). Its core business activity is the management of design and construction, the operation, maintenance, and exploitation of the 680 kilometres long "Egnatia Odos" motorway (EOM). The transportation network of EO can be used for the installation of optical network backbone infrastructure along it. The commercial exploitation of this network is the business activity to be analyzed. First (phase 0), EO decides to enter the market of broadband networks, installing optical dark fibers, along the EOM, looking afterwards for their commercial exploitation. Second (phase 1), EO goes a step ahead and decides to light the optical fibers. This means that the customers are able to buy wavelengths. Hiring wavelengths requires the installation, operation management and maintenance of active equipment. We consider this opportunity as a growth real option. Finally (phase 2), the company examines the possibility of entering the market of network services provision, like Fast Internet and Virtual Private Networks. We also consider this opportunity as a growth real option, which is based on two prerequisite projects, Fig. 4.

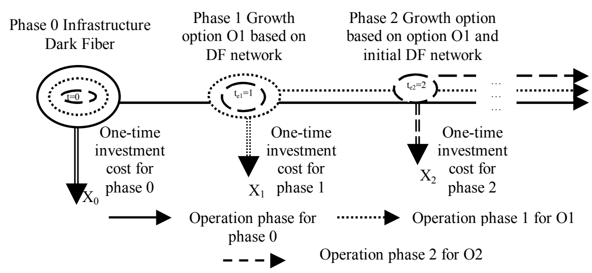

Figure 4. Infrastructure project and future projects treated as growth options

Initially, EO possesses a couple of growth shadow options to enter the broadband market. In order to modify them to ROs the initial infrastructure dark fiber project should take place. The options values stemmed from EO's belief that they could resolve some of the uncertainties.

Such uncertainties are: the broadband services demand in the region of interest and the capability of the company to enter a new market. EO may adopt the strategy 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. However waiting to learn more is not without cost. Actually, since the specific growth ROs are shared among competitors into the market they may experience significant degradation by first movers (competitors) entry into the market. For each of the growth investment opportunities we consider different level of competition threat and we estimate the overall value of the broadband investment opportunity.

References [8] provide an analysis for the market demand for the EO case study. The total value of an initial infrastructure project (IP), can be represented as a nested options model and is given by:

$$ENPV_{(IP)} = NPV_{(phase\ 0\text{-}IP)} + Option\ Value[phase1\text{-}\ IO + Option\ Value_{(phase\ 2\text{-}IO)}] \quad (4)$$

We work on compound options analysis [4]. It is the first time in the literature where a multioption analysis is taking place under competition modeling, assuming a high number of competitors in the market sharing a couple of ROs. We do not provide real numbers, to protect EO confidentiality, but present the application of our methodology to a real life case study.

The project begins with cost outlay at $t=t_{i0}=t_{s0}=0$, $X_0=200$, for the dark fiber installation along the motorway. For simplicity we assume that implementation time for each of the phase is zero. The present value of initial revenues are $V_0=200$. We make the assumption that competitors may enter into the market, and subtract from V_0 to the specific geographical area up to $T_0=2$ years after its EO entry with $\lambda_{o0}=1$ and $c_{o0}=0.1$, while inception and WaS periods do not exist. At $t_{e1}=1$ a second cost outlay $X_1=150$ takes place to provide bandwidth services based on phase 1 dark fiber network. Present value of overall investment revenues at t=0 is $V_1=250$ with $\sigma_{v1}=40\%$. The first growth real option faces competition threat during WaS period with $\lambda_{w1}=2$ and $c_{w1}=0,1$, with $\sigma_{\lambda w1}=\sigma_{cw1}=50\%$. It also faces competition threat during operation period for a length of 2 years after the implementation of this phase, with $\lambda_{o1}=1$ and $c_{o1}=0,05$. Afterwards, the management of EO examines the possibility of entering into the network services market after a period of time. Entry, dates to be analyzed are at $t_{e2}=2,3,4$ where a third outlay $X_2=140$ takes place. Present value of investment revenues $t_{e2}=1$ is $V_2=220$ with $\sigma_{v2}=40\%$. The second growth real option faces competition threat during inception period with $\lambda_{i2}=1$ and $c_{i2}=0,7$. Respectively, it faces competition during WaS periods with $\lambda_{w2}=2$ and $c_{w2}=0.2$, $\sigma_{\lambda w2}=50\%$ and $\sigma_{cw2}=30\%$. In addition, it faces competition threat during operation period for up to T=5 years from now with $\lambda_{o2}=1$ and $c_{o2}=0,05$. Finally, we assume zero correlation between V_1 and competition parameters. Actually, in case of correlation 1, competition parameters have linear relationships with V_1 V_2, however, as mentioned before a smaller correlation values can be applied in real life cases under competitors' asymmetries such us investment cost, initial infrastructure ownership and other physical resources availability. Especially, EO owns a competitive advantage against the rest of competitors coming from the physical resources availability along the motorway.

In addition, we model uncertainty for the one-time cost at expiration date assuming that it is stochastic too with $\sigma_{x1}=30\%$ and $\sigma_{x2}=20\%$ and 0%. Waiting can give a decision maker more information about costs. Costs can change through the introduction of new technologies, changes in the regulatory environment, new partnership possibilities, or the availability of grants to offset some of the development costs. However, sometimes, though, it is not waiting but investing that reveals information about costs. We consider a negative correlation value between V_1 and X_1 (i.e. –0,5). It could represent, for instance, that the inability to control the costs of the development project are associated with lower revenues after the project/phase is completed. Finally, the annual risk-free interest rate is $r_f=4\%$, while the discounted factor for the revenues is r=8%.

First the passive NPV (exercising second growth option at $t_{e2}=2$) is marginally positive:

$$\begin{aligned} PNPV &= V_{f0} - X_0 + V_{f1} - \frac{1}{1+r_f}X_1 + \frac{1}{1+r}V_{f2} - \frac{1}{(1+r_f)^2}X_2 = \\ &= 162 - 200 + 182.7 - 144.2 + 107 - 129 = -21 \end{aligned} \quad (5)$$

The picture changes drastically once we consider the ROs analysis under competition modeling as presented before. The analysis starts from the last growth real option at t_{e2} and working backwards we estimate the ENPV. Using the ELTBM we estimate the option value given by 3 assuming 4 parameters multi-diffusion process which is given by:

$$OV_2=\max(V_{f2}-X_2,0) \quad (6)$$

As mentioned before management examines the possibilities of exercising the ROs in one of the dates $t_{e2}=2,3,4$ meaning that WaS period will be 1, 2 and 3 years respectively. For the estimation of the optimum deployment strategy of the investment we follow the rule applied by References. [8], [2]:

Decision Rule: Where the maximum deferral time is T, make the investment (exercise the option) at time t_e, $0<t_e<T$, for which the option, OV_{cte}, is positive and takes on its maximum value.

$$OVct_e = \max_{(t=0\ldots T)} OVct \quad (7)$$

As it can be seen, at $t_e=3$, the option value takes the highest value concerning a high level of uncertainty for $\sigma_{\lambda w2}$, σ_{cw2} (i.e. 40%), Fig. 5.

It is a matter of compensation between, uncertainty control assured by ROs thinking and competition threat caused by the incoming competitors during Inception, WaS and operation period for EO.

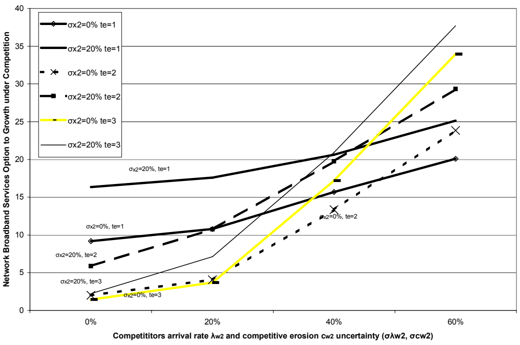

Figure 5. The effect of the competitors arrival rate λ_{w2} and competitive erosion c_{w2}, uncertainty on growth option value to provide Broadband Network Services for WaS period, 1,2,3 years, zero correlation, (NPV=-22,33, -58,97, -83,65 respectively)

The higher amount of uncertainty existence during Was period the higher option value since more uncertainty will be resolved. This is the core idea of ROs. Afterwards, we estimate the option value OV_1 at t=0. It is given by:

$$OV_1=\max(V_{f1}-X_1+OV_2,0) \tag{8}$$

OV_2 is estimated with the competition parameters (t_{e2}=1, λ_{i2}=1, c_{i2}=0.7, λ_{w2}=2, c_{w2}=0.2, $\sigma_{\lambda w2}$=50%, σ_{cw2}=30%, λ_{o2}=1, c_{o2}=0,05, σ_{x2}=20%) and its value is 21. The option of offering bandwidth services provision (OV_1) is 77.8. The respective NPV for the first and second growth investment opportunity is 57, while in case of ignoring the NW services provision growth option the OV_1 is 66. Finally, the ENPV of the overall investment opportunity is given by:

$$ENPV=V_{f0}-X_0+OV_1= 39.8 \tag{9}$$

We see that ROs analysis enhances investment performance of the overall investment opportunity by a factor of 300%. Fig. 6 shows the effect of expected competitors arrival rate λ_{w1}, λ_{w2} and competitive erosion c_{w1}, c_{w2} to the overall investment value. We observe that both NPV (no ROs analysis) and ENPV (with ROs analysis) decrease, with increase in the competition parameters. However, the ROs analysis increases significantly the overall value of investment opportunity.

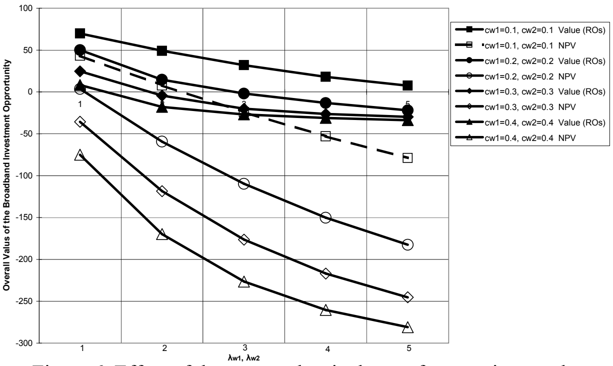

Figure 6. Effect of the expected arrival rate of competitors and competitive erosion during WaS period to the ENPV

IV. Conclusion and Future Research

The results of our model prove that ROs analysis may enhance performance of ICT business activities. We consider one time step multi-diffusion process. Multiple time steps result to increased granularity and so to increased accuracy in the results. Though the complexity of the model is increasing dramatically we capture more efficiently the additional dimension of competition entry. Finally, someone could adopt endogenous competition modeling assuming that each one of the competitors in the market experiences a different level of the competition parameters. In this case endogenous competition modeling requires the integration of ROs with Game Theory.

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