

Angelou, G.N. & Economides, A.A.: **ICT investments under competition threat**,
Proceedings 18th Hellenic Conference on Operations Research, 2006.

ICT investments under competition threat

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Abstract. In this paper, we estimate the value of an Information Communication Technology (ICT) investment opportunity, modeled as a Real Option (RO), when there is competition threat that can influence negatively its value or even more eliminate it. So far in the ICT literature, competition modeling is mainly focusing on duopoly market conditions, where investment actions taken by the firm may likely result in strategic answers by its competitors. However, after the ICT liberalization, the number of firms has been increased and the market structure tends to change from oligopoly to perfect competition. So, it is not practical to employ endogenous competition modeling. We relax the existing literature assumptions concerning exogenous competition modeling by considering that the competitors' arrival rate and the competitive erosion during the waiting phase for the RO to invest follow stochastic processes in discrete time domain. We provide a ROs model, which estimates the value of a future investment opportunity when competitive entry can take part of the overall market value away from the firm that possesses this option. The results of our models prove that longer "wait-and-see" periods before exercising the ICT real option may indicate higher options values compared to the shorter ones, for some specific business conditions despite the competition threat for possible elimination of the future investment opportunity.

Keywords. Information Communication Technologies (ICT), Real Options (ROs), Competition Modeling, Net Present Value (NPV), Investments Analysis.

1. INTRODUCTION

Information and Communication Technologies (ICT) lie at the convergence of Information Technology, Telecommunications and Data Networking Technologies. The valuation of 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. ROs analysis presents 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. Financial options are options on financial assets (e.g. an option to buy 100 shares of Nokia at 90€ per share on January 2007). Real Option (RO) 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. By adopting the philosophy of managerial flexibility (also called active management) we decrease the possibility of experiencing losses while increase the possibility of gaining. This is achieved by waiting and learning about the changing business conditions and generally resolving over time part of the overall investment's uncertainty [3]. For a general overview of real options, Trigeorgis [15] provides an in-depth review and examples on different real options. For more practical issues the reader is referred to Mun [13]. Finally, Angelou & Economides [1] provide a literature review of the ROs applications to real life ICT investments analysis.

After the liberalization of the telecommunications markets their market structure has changed from monopoly to oligopoly or perfect competition where many market participants are present. The real life 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. Our target is to develop a RO model closely related to the ICT industry characteristics to support ICT evaluation under competition conditions. 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 to the market will only cause a degradation of the overall ICT investment opportunity "pie", while the rest of the competitors will not react to this entry by changing their business strategy. On the other hand, in oligopolistic markets, actions taken by the firm may result in strategic reactions by its competitors. In this case, competition should be modeled endogenously requiring the combination of ROs and game theory [17].

Previous research has applied exogenous competition modeling to the shared investment opportunities where anticipated competitive loss can be viewed as the impact of dividends on a call option [7],[11],[12],[15]. Examples include the opportunity to introduce a new product, which is influenced by the introduction of close substitutes or to penetrate a new geographic market without barriers to competitive entry.

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, which it cannot influence. The firm has to determine what information has available about competition. If for example the firm knows in advance the strategies of its competitors and their impact on the firm's value function, the situation is completely deterministic. However, this case is quite unrealistic. In reality, competitors are entering randomly the market and exercise their ROs. 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. Trigeorgis [16], [15] and Kumar [12] model competition exogenously assuming that the competitors are entering into the market following Poisson distribution. They assume that the underlying asset (investment value V) under random competitive arrivals can be modeled as a mixed diffusion-jump process.

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 arrival rate of competitors during waiting period follows a joint diffusion process with overall value of the investment revenues V , and ii) the impact of each competitor's arrival is also following a joint diffusion process with V . So far in the literature the arrival rate of competitors as well as the impact of competitive erosion are assumed to be constant [16], [15], [12]. Here, we focus on the Incumbent Operators (IO) site, which is facing a threat from other competitors. We model this threat and try to estimate its impact to the value of an investment

that can be treated as RO to invest, in the near future, if the business conditions become favorable.

A good example of many players in an ICT market, which is dominated by a strong player, is the Greek telecommunication market, which is dominated by the incumbent fixed telephony operator OTE (Hellenic Telecommunications Organization) [9], [10]. 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. Actually, there are about 12 more players who possess low market shares compared 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 IO here faces a tradeoff between the value of flexibility to wait and the value of the possible competitive erosion during waiting period. The OTE’s management has to determine whether it should exercise the option and implement the investment opportunity early or whether it should follow “wait-and-see” (WaS) strategy despite a competitive damage caused by the competitors’ entry in the market.

The rest of the paper is organized as follows. In Section 2, we provide a ROs model under exogenous competition modeling. In Section 3, we specify our analysis in the ICT market mapping its characteristics to the competition parameters of our model. We also put our analysis in the context of a specific illustration. Finally, in Section 4, we conclude and suggest possible future research.

2. A RO MODEL UNDER COMPETITION THREAT

We define T as the maximum deferral or “Wait-and-See” (WaS) period of the real option. During this period the option is shared among competitors. We assume that after this period no option exists at all for any competitor. The maximum deferral period is separated in two sub-periods, as seen in Figure 2. In the first sub-period, the IO is not investing and is waiting for resolving some of the uncertainties associated with this investment opportunity. The second sub-period starts when the IO exercises its option. For simplicity, we assume that the investment period (construction period for the specific project) is zero. The WaS period starts at t_s (assume $t_s=0$) when the option is available to the IO. Also, t_e is the real exercise time of the option (implementation of the investment opportunity). Finally, the part of the operation period where the IO can still face Competition Threat (CT) is $T-t_e$. All the notations used in our models are given in Table 1 in Appendix. In addition, we define two terms for modeling the competition conditions: i) *Preemption Threat from Competitors* (PTC) and ii) *Preemption Capability of Incumbent* (PCI). PTC indicates the threat, which is experienced by the IO during WaS period of the option that other competitors may enter the market and decrease or even more eliminate the option value. PCI indicates the capability of the incumbent to preempt the subsequent competitors after its entry time at $t = t_e$ into the market.

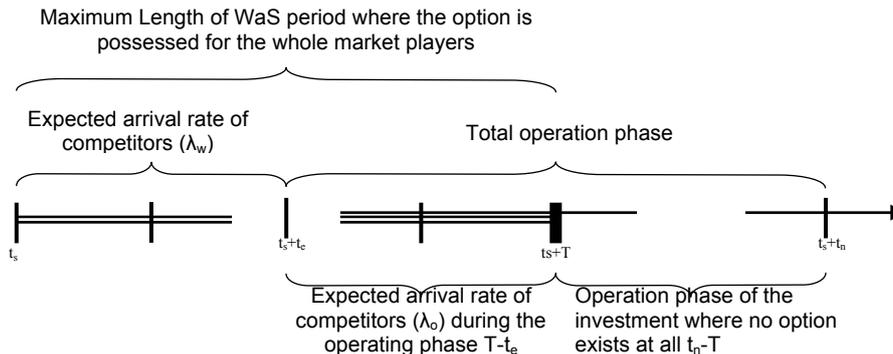


Figure 2. Waiting and operation phase for a single real option ($t_s=0$)

During the WaS period, competitors may enter the market causing degradation of the investment opportunity for the IO. We want to estimate the option value when there is a PTC against the IO. We model the PTC assuming that the competitors' arrival follows a Poisson distribution with an expected arrival rate λ_w and an expected competitive erosion c_w . The competitive erosion indicates the decrease of the investment revenues, that are available to the IO, caused by each competitors entry to the market.

The business target of the IO 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 PTC and uncertainty control.

After the implementation of the investment (option exercise) the IO may also experience PTC up to time T that can further decrease its expected value of the operation's revenues. The target of the IO is to preempt the subsequent competitors, after this time. However, in case of hard competition, as it is in the ICT field where many competitors are sharing the same option, this is not realistic. Alternatively, the IO wants to minimize the effect of competitors' arrivals during the operation phase. Hence, an important characteristic for each business opportunity is to provide a strong capability for the IO to preempt subsequent competitors' entry after its entry in the market. At exercise time t_e , the revenues of the investment opportunity, which are available to the incumbent are $V - I_{c_{wte}}$, where $I_{c_{wte}}$ is the total competitive erosion of competitors who have already enter the market and V is the overall market investment revenues when no competition exists at all. This value is fully available to the IO when there is full PCI to the following competitors, so no any competitor arrival is expected during the operation phase. However, as mentioned before, it seems more realistic to consider that a number of subsequent competitors can also enter the market after IO's entry into the market. We model a partial PIC by considering that during operation phase and up to $t=T$, competitors may also arrive with an expected competitors' arrival rate λ_o . The smaller the arrival rate λ_o is the higher the PCI is. Each of the arrivals during this period will cause a percentage decrease of the investment revenues defined as c_o . Hence, the final investment value that will be available to the incumbent is given by

$$V_f = V - I_{c_{wte}} - I_{co} \quad (1)$$

where I_{co} is the total competitive erosion during the operation phase. Here, for simplicity we assume that competitive erosion during the WaS period is the same for any competitor's entry. The same applies for the operation period. We could easily extent our analysis to consider different competition effect for each competitor's entry into the market. However, the multi-diffusion analysis would become very complicated. Alternatively, we might consider that competition effects may follow the same diffusion process having different amplitudes.

The competitive erosion of the investment value, for the incumbent, during the waiting period is given by:

$$I_{c_{wte}} = V - g_w^{n_w} V \text{ for } n_w=0,1,2,\dots \text{ competitors entry during the waiting period} \quad (2)$$

and the competitive erosion during the operation period is given by:

$$I_{co} = g_w^{n_w} V - g_o^{n_o} g_w^{n_w} V \text{ for } n_o=0,1,2,\dots \text{ competitors entry during the operation period} \quad (3)$$

Hence, the overall option value when it is exercised at $t=t_e$ assuming n_w competitors' arrivals during the waiting phase and n_o competitors' arrivals during the operation phase is given by:

$$OV_{cie} = \max(V_f - X, 0) = \max \left[V \left[\sum_{n_w=0}^{\infty} P_{n_w} (1-c_w)^{n_w} \right] \left[\sum_{n_o=0}^{\infty} P_{n_o} (1-c_o)^{n_o} \right] - X, 0 \right] \quad (4)$$

where

$$P_{n_w} = P_{(c=n_w)} = \frac{e^{-\lambda_w(t_e-t_s)} (\lambda_w(t_e-t_s))^{n_w}}{n_w!} \quad (5)$$

$$P_{n_o} = P_{(c=n_o)} = \frac{e^{-\lambda_o(t_s+T-t_e)} (\lambda_o(t_s+T-t_e))^{n_o}}{n_o!} \quad (6)$$

are the probabilities of having specific number of competitors' arrivals, during the WaS and operation periods. In particular, P_{n_w} indicates the probability of n_w competitors are arriving during the WaS period, while P_{n_o} indicates the probability of n_o competitors are arriving during the operation phase. As seen, the value of shared ROs with random competitive arrivals is a weighted sum or an expected value over a Poisson distribution. We do not consider any competitive "divided payout" as Trigeorgis [15] (pp. 287). Instead we consider the overall competition threat, which we treat it as "competition cost" denoted as I_c . The magnitude of I_c depends on the competitive intensity, λ_w and λ_o , the market structure parameter c_w and c_o and the number of players n_w and n_o , which are finally entering the market.

PCI cases

No any PCI - We assume that $I_{c_wT} - I_{c_wTe} = I_{c_o}$. So, the IO has not any preemption capability. This results to wait up to $t=T$. It is more preferable to wait up to time T , since V_f will be the same independently of the option exercise strategy. Hence, it is the same as a proprietary option with revenues V_f and waiting period T . There is no reason to exercise this option earlier since longer waiting period indicates more efficient control of the uncertainties and higher option value [14]. In this case, we want to estimate the impact of the PTC, during the WaS period, to the option value of the IO.

Full PCI - We assume that $I_{c_wT} - I_{c_wTe} = I_{c_o} = 0$ for $t_e < T$. So, the IO has full preemption capability and exercises its options at $t=t_e$. In this case, we want to estimate, for the IO, the optimum time to invest (exercise its option). There 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 IO.

Partial PCI - It seems more realistic in real life business conditions that the IO may have a partial preemption capability. Actually, by investing earlier a level of preemption capability can be achieved. It might be optimal for the IO 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.

Finally, 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.

3. ANALYSIS PROCESS

We assume that the IO as well as the rest of the competitors posse a shared RO that can be exercised up to $t=T$. In this work we consider the first two cases, no PCI and full PCI, while the other competitors have no preemption capability at all. We consider a joint diffusion process for the λ_w , c_w and V (Figure 3). The results of our analysis show that sometimes the IO may be

better to adopt longer WaS period despite of the PTC that may eliminate the option value. We adopt an ELTBM with 3-parameters that follow joint diffusion process [5]. For small number of steps or volatilities values of the stochastic parameters with respect to the r , the Binomial Method becomes unstable since the up and down probabilities of asset parameters can be negative. ELTBN does not present this disadvantage being so fully stable and efficient.

value of λ_w the more severe the competition is. So far in the literature, the competitors' arrival rate is assumed to be constant. We here relax this assumption by considering that competitors' arrival rate is stochastic with expected value λ_w and can be correlated or not with the overall investment' market value V .

3.1. Correlation between V and competition parameters

In the following we examine the correlation value between V and competition parameters. One of our research interests is to examine the mapping of these parameters into real life ICT business activities.

c_w is positively correlated with V - If business conditions are bad, market demand is low, business opportunity seems to be not favorable and the possible competitor's entry can only capture a small part of the overall business opportunity. Someone may assume that the bad business conditions compared to the favorable ones experience no network externalities effects. The opposite may be assumed in case of favorable business conditions. 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 IO.

c_w is negatively correlated with V - Such cases may occur when while the market value appears appealing, the competitors cannot extract significant option value (e.g. not adequate ICT infrastructure to support high customers demand, cost disadvantage of other competitors compared to incumbents case, other idiosyncratic issues). Particular, when competitors do not have the adequate ICT infrastructure value 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 incumbent. *Finally*, there might be cases where competitive erosion c_w is uncorrelated with V .

Correlation between V and λ_w - In general, it seems more realistic to consider that λ_w is positively correlated with V . However, there might be cases where λ_w is not fully correlated with V . Such examples can be when there is information asymmetry for the overall market level between IO and the rest of competitors. Also, when there is cost asymmetry between IO and other competitors, meaning that investment cost seems very high for the latter compared to the IO cost structure. A cost advantage may be indicated by the availability or not of an initial ICT infrastructure investment for some players, we here assume for the IO, which enhances the investment capability. This specific ICT infrastructure may be able to support future investment opportunities in a more efficient way. Finally, another example can be when the market value increases more for the IO than for the rest of the competitors. However, this means that the real option to invest is not fully shared between IO and the other competitors.

Correlation between λ_w and c_w -It is reasonable to consider that λ_w is positively correlated to c_w since the higher the competitive erosion is the higher the competitors' incentive to invest will be too.

3.2. Presentation of analysis

In case there is full PCI the target of the IO is to find the optimum time to exercise the option. For the estimation of the optimum deployment strategy for the investment we follow the rule suggested by [4] and applied by Iatropoulos et al. [8]:

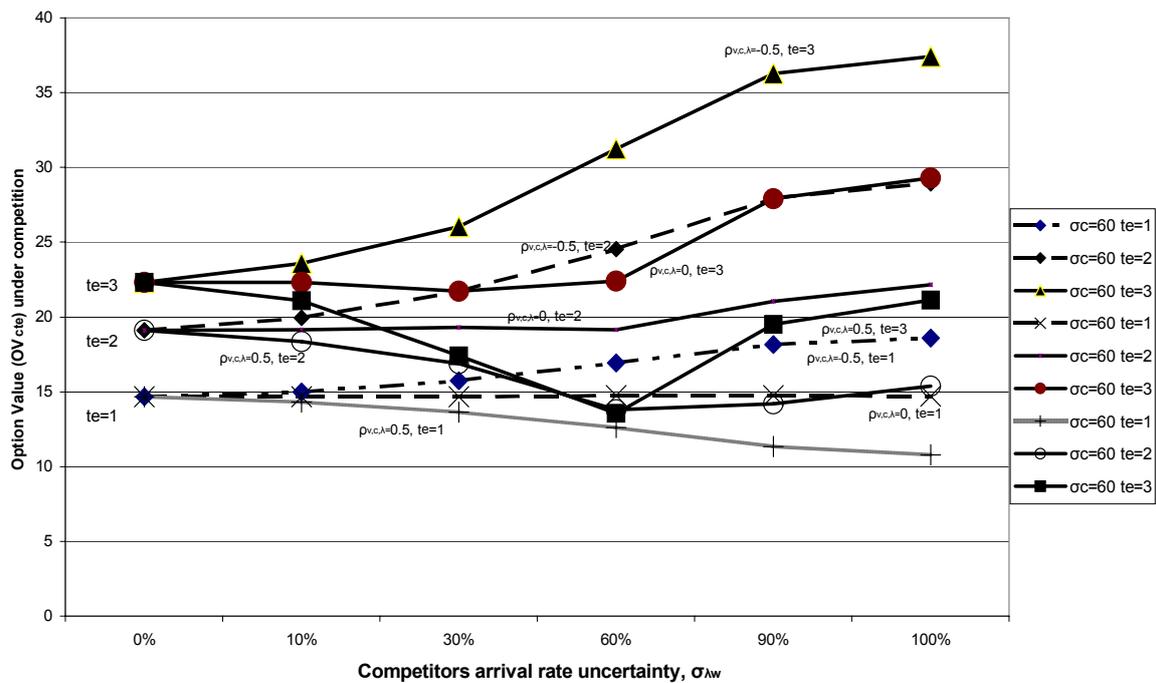
Decision Rule: *Make the investment (exercise the option) at time t_e , $0 < t_e < T$, where T is the maximum deferral time, for which the option OV_{ct_e} is positive and takes on its maximum value.*

$$OV_{ct_e} = \max_{(t=0 \dots T)} OV_{ct} \quad (7)$$

Next, we present the results of our analysis for three exercise times, $t_e=1, 2, 3$ (Figure 4). We consider various values of competitors arrival rate uncertainty σ_{λ_w} , while the competitive

erosion uncertainty is $\sigma_{c_w}=60\%$. In addition, we examine three cases of correlation between V , λ_w and c_w , $-0.5, 0, 0.5$. As it can be seen, the longer WaS period clearly indicates higher option values despite PTC to eliminate part of the investment value. When we consider both uncertainties for λ_w and c_w simultaneously with uncertainty of V OV_{cte} is higher compared to the respective values when no uncertainty is considered at all for the competition parameters ($\sigma_{\lambda_w}=0, \sigma_{c_w}=0$), as seen in Figure 4. In addition, longer WaS period may be more appropriate since higher amount of uncertainty will be resolved indicating so higher OV_c values.

If there is no preemption capability at all for the incumbent as well as for the rest of the competitors, as mentioned before, this indicates the adoption of the longest possible WaS period for all the competitors ($t_e=3$). For correlation values between V, c_w, λ_w smaller than zero, the option value increases when σ_{λ_w} increases (Figure 4). In addition, for positive correlation values of the aforementioned parameters the option value OV_{cte} , as σ_{λ_w} is increasing, is initially decreasing, while afterwards is increasing. For negative correlation values between V, c_w and λ_w , this increase may be even higher converging to option value with no competition threat at all. In particular, option values without any competition threat (proprietary option) are about 22, 31 and 38 for exercise times $t_e=1, 2$, and 3 respectively for the specific example.



For $\sigma_{c_w}=0\%$ and $\sigma_{\lambda_w}=0\%$: $OV=9.8$ ($t_e=1$), $OV=7.44$ ($t_e=2$), $OV=3.85$ ($t_e=3$)

Figure 4. The effect of competitive erosion and competitors arrival rate uncertainty on option value for various values of correlation ρ between competition parameters and investment revenues V , ($r=5\%$, $\lambda_w=2$, $c_w=0.1$, $\sigma_v=40\%$, $\sigma_c=60\%$)

4. CONCLUSION AND FUTURE WORK

This paper investigates the impact of Preemption Threat from Competitors (PTC) to the value of ICT investment opportunities, modeled as ROs. We adopt exogenous competition attributes such as competitors arrival rate, competitive erosion and existence of preemption capability and estimate a single growth option. We relax existing literature assumptions considering uncertainties for the aforementioned competition modeling parameters. The results of our

models prove that sometimes it is more preferable to adopt longer WaS period for an investment opportunity despite competition threat that can subtract part of it.

A limitation of our model can be in the way we estimate the up and down coefficients in the multi-diffusion process for the competition parameters. We adopt the risk neutral probabilities for competition parameters in a similar way as the overall market value V . These assumptions may be an issue of criticism that requires further discussion for their validation. However, our intention is to show how the uncertainty in competition parameters influences the value of a future investment opportunity being treated as RO. Extensions of our work can be the modeling of partial PCI during the operation phase of the project. In addition, in our analysis we consider one time step multi-diffusion process. Of course, 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 λ_w and c_w . Actually, the smaller values these parameters for a player in the market are, the stronger its market position for the specific investment opportunity is. In this case endogenous competition modeling requires the integration of ROs with Game Theory.

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Appendix

Table 1. Notations used in the proposed mathematical models

Parameter	Description
t_s	Time where the option is possessed for the first time by the IO and the rest of competitors.
T	Maximum deferral period in years for the option to be exercised at t_s+T . We assume that T is the same for all the competitors in the market.
t_e	Time where the option is finally exercised by the IO and the investment is implemented. Final waiting period is t_e-t_s .
λ_w	Expected arrival rate of competitors per unit time during waiting phase.
λ_o	Expected arrival rate of competitors per unit time during operation phase.
n_w	The actual number of competitors' entry that will take place during deferral waiting period.
n_o	The actual number of competitors' entry that will take place during operation phase where the option is still possessed by the competitors in the market.
c_w	The expected competitive erosion that each competitor's entry in the market will cause to the IO's investment revenues value during waiting period, $c_w=(V_{\text{before entry}} - V_{\text{after entry}})/V_{\text{before entry}}$. ($g_w=1-c_w$)
c_o	The expected competitive erosion that each competitor's entry in the market will cause to the incumbent's investment revenues value during operation period, $c_o=(V_{\text{before entry}} - V_{\text{after entry}})/V_{\text{before entry}}$. ($g_o=1-c_o$)
V	The overall market value for the growth investment opportunity.
OV_{cte}	Option value under exogenous competition modeling when it is exercised at $t=t_s+t_e$.
I_{cwT}	Total competitive erosion during waiting period up to t_s+T
$I_{c_w t_e}$	Total competitive erosion during waiting period up to t_e , where $t_s < t_e < t_s+T$
I_{c_o}	Total competitive erosion during operation period t_{e_o} after option exercise at $t=t_e$. If $I_{cwT}-I_{c_w t_e}=I_{c_o}$ the incumbent has no preemption capability, while if $I_{cwT}-I_{c_w t_e}<I_{c_o}$ has preemption capability. If $I_{c_o}=0$ there is full preemption capability for the incumbent (PCI)
I_c	$I_{c_w t_e}+I_{c_o}$, total competitive erosion cost.
V_f	$V-I_c$. Final investment revenues for the incumbent.
r	The risk free interest rate
X	Investment One-time cost
σ_v	Investment revenues uncertainty V
σ_{λ_w}	Expected arrival rate λ_w uncertainty (volatility)
σ_{λ_o}	Expected arrival rate λ_o uncertainty (volatility)
σ_{c_w}	Competition effect c_w uncertainty (volatility)
σ_{c_o}	Competition effect c_o uncertainty (volatility)