

# Design & Development Project Valuation and Investment Decisions\*

## - A Real Option Analysis for the Mobile Phone Industry in Korea -

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We value design and development (D & D) projects by applying option analysis and draw some important implications for the D & D strategies of the mobile phone producers in Korea.

Assuming that the value follows a mixed jump-diffusion process, we show that the uncertainties associated with the D & D project and the development cost are the two key variables to the valuation. In a market where the future outcomes are more unpredictable, our model implies that an aggressive strategy returns more because it keeps more options (*i.e.*, models in the development process) in the pipeline against the future uncertain states of the world.

Key words: Design and Development, Real Option, Multiple Option, Strategic Value, Monte Carlo Simulation

### I . Introduction

Option analysis provides a useful technique to assess the values of development projects and thereby assists the management of a firm in making its capital budgeting decisions. In this paper, we value design & development (hereafter D & D) projects by applying option analysis and discuss the implications

of our valuation analysis for the D & D strategies of the mobile phone producing firms in Korea.

Our paper is motivated by some casual observations in the Korean mobile phone industry in which if and when newly released models hit the market, even though the chances are low and hard to predict, the returns are tremendously high like a lottery-win. One story that we were told deserves merits

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in this regard: A Korean producer one time newly released a palm-size slide phone model, but consumers at home were not so much excited about it, and the home sales went very slow. By luck, later, Bill Gates, Chairman of Microsoft Corp., saw it, and grabbed it and liked it very much. Eventually, the new model hit the bigger global market. These casual observations motivated us to apply option analysis to D & D project valuation because the returns resemble what one expects to get when he or she buys deep-out-of-the money call options.

Traditional capital budgeting procedure is based on the net present value method (hereafter NPV). This assumes that the future cash flow will meet its expectation, and there will be no intervention made by the management in the process. The decision process is static in the sense that the management accepts to invest or reject once and for all. However, this procedure may lead to a significant undervaluation of the project when the future outcomes face a great uncertainty and the management can intervene in the process as the uncertainties are revealed. The intervention may involve a continuation of the project in a good state or an abandonment in a bad state.

In the early 1980s Harvard professor Scott Mason made an intuitive observation that we could improve our valuation if we apply option analysis in such occasions. It is

because the management's flexibility to abandon or otherwise continue to invest creates an option value to the project.

A number of option analyses of development projects have been thereafter done in the literature. Among many others, Brennan and Schwartz (1985) applied to value mines, Paddock, Siegel and Smith (1988) to value leases, Schwartz and Moon (2000) and Schwartz (2001) to value R & D projects, and Cortazar and Schwartz (1998) and Yang and Blyth (2007) to value Energy & Development projects. Pindyck (1993) applied option analysis to projects with uncertain cost.

D & D entails a great deal of uncertainties in most instances. An iconic designer model, which may look esthetic in the designer's mind, could turn out to be not quite feasible on engineering grounds, or may not be much appealing to the ultimate consumers. The management may have to step in to abandon the project in such events.

If design development costs are not prohibitively high, the management of a firm may well keep multiple models in the pipeline till it can be ensured that the right product will be delivered to the market. A typical D & D process passes through various stages till its completion. In such an event, the management has to ask what design models to continue to invest in and what other design models to abandon at various

stages of the process. In the end of process, the management may come up with one production model out of the many competing models.

The mobile phone producing firms in Korea develop new handset models on a product by product basis. This is contrasted with the D & D strategy of a leading handset maker in the world, Nokia. The firm designs and develops a platform and subdivides it into modules which can be mixed in any combination and thereby can deliver a full offerings to the market. Designing and developing a handset platform usually requires a huge sum of initial fixed investment spending, while designing and developing on a product basis needs relatively small amount of variable expenses. The Korean firms may be able to afford to design and develop multiple models for a new product based on such a costing.

This paper values D & D projects for the Korean mobile handset producers. Depending upon the decision rules by the management on how many options (*i.e.*, models) to keep alive in the pipeline at various stages of the process, we show that the volatilities (*e.g.*, the uncertainties involved) and the development costs are the key variables to the valuations. By conducting Monte Carlo simulations, particularly, we illustrates that as the volatility increases, an aggressive strategy in which more options (*i.e.*, models) are

kept alive returns more relative to a conservative strategy in which less options are in the pipeline.

By doing so, we think that our paper makes an additional contribution to the existing literature. The existing studies such as Brennan and Schwartz (1985) and others which applied option analysis considered whether to continue to invest in or abandon the single option (*i.e.*, project). Depending upon the assumed distribution of the underlying value process in such an event, one can easily make use of the analytical solution which has been already derived in the financial option literature.

Our paper, on the other hand, applies option analysis to the case of a multiple options (*i.e.*, models). These models are competing each other, and the management decision is choosing a best hit chance model out of the competing models. In that event, one can not easily obtain an analytical solution for valuation and has to rely on simulation. To the best of our knowledge, our study is a first simulation work of a multiple (competing) options. We think that this simulation study can be also applied to the option analysis for other industries such as the game industry in Korea. A game software firm also chooses one best hit chance model out of the competing models.

The paper is organized as follows: Section II briefly discusses option analysis applied

in capital budgeting decisions in the literature, and offers an explanation why option analysis might be more useful for D & D project valuation and making investment decisions. In Section III, for its application to the mobile phone D & D, some industry features and facts are introduced regarding the handset makers' D & D strategies and benchmark D & D process. Section IV develops a valuation model under the Martingale measure  $Q$ , borrowing a valuation technique from the commodity futures literature. Section V conducts Monte Carlo simulations to value D & D projects and extracts some important implications. Finally, concluding remarks are made in Section VI.

## II. Option Analysis for Capital Budgeting

The traditional discount cash flow (DCF) method values an investment project by discounting the expected future cash flow that will be generated by the project. It usually assumes that the future cash flow will meet its expectation and the management of a firm will not have the flexibility to reverse the decision. The decision process is static in the sense that the management accepts to invest or rejects the investment project once and for all, and period.

However, for the development projects whose

future outcomes entail a great uncertainty, the traditional approach may not be an appropriate capital budgeting procedure. It is because it does not allow for the management to abandon in a bad state, and hence the future cash flows are severely discounted. This is why the traditional *NPV* (or *DCF*) method significantly undervalues the investment projects facing a great uncertainty.

In reality on many occasions, as Mason and Merton (1985) observed, the management of a firm has the flexibility to intervene in the process, and its capital budgeting decision is a dynamic process in this regard. This observation has thereafter led researchers to apply option analysis to the valuation of real assets, which is now referred to as real option analysis. This analysis shares many things in common with option analysis on financial assets such as the Black-Scholes option model (1973).

A number of real option analyses have been applied in valuing investment projects. Brennan and Schwartz (1985) have valued mines, Paddock, Siegel, and Smith (1988) for oil leases, and Schwartz (2001) R & D for a new drug, among many others.

These real option analyses allow for the management's flexibility to abandon or otherwise modify its actions as the uncertainties are revealed in the process. This management's option skews the distribution of possible outcomes towards the upside and creates an

option value to the project.

Option analysis for capital budgeting is now being practically applied in some industries, including the pharmaceutical industry. In an interview with the CFO at Merc & Co. by Nichols (Nichols, 2001), we quote:

“When you make an initial investment in research project, you are paying an entry fee for a right, but you are not obliged to continue the project. .... An option analysis offers a more flexible approach because we have to ask whether we continue to invest at successive stages of a project.”

As clearly pointed out in the above quote, investment in R & D creates an option, not obligation, and the management has to ask whether to keep the option alive or abandon at successive stages of the process.

We think that option analysis could offer an useful tool for D & D project assessment, as it does for R & D's. Returns on D & D investments are a lot unpredictable and investment in D & D creates an option, but not obligation. Particularly, the strategic value of an option created by D & D is no less appreciated in a competitive market, such as in the global mobile handset industry, by being able to deliver the right product at the right time.

### III. Design & Development Strategy and Process

D & D processes and their development costs and periods differ and vary depending upon the firms' D & D strategies. The Nomura study conducted by Windsor et al. (2005) has shown that there is a wide spectrum of vendors' positions on their D & D strategies in the global handset industry. Figure 1 shows two extreme positions in the global handset industry.

In a product basis strategy, the handset maker usually runs many independent development teams, each of whom is assigned to design a single product in its portfolio from scratch. For most voice/features-phones, the development cost is around \$5 million per handset and most are variable expenses. The development period usually runs from around six months to one year (Windsor et al., 2005).

In the platform 2.0 strategy, the handset maker builds and subdivides its platform into modules that can be mixed in any combination to enable the maker to design a full range of handset models. The platform 2.0 offers the flexibility to meet changes in market demand more quickly by being able to interchange different features. The handset maker only needs one but it is very expensive. Windsor and et. al. (2005) showed that the

development usually requires a huge sum of initial fixed investment cost, estimated around \$500 million, and takes more than two years. They also concluded that “product focus” would be optimal for the high price-low volume market and “platform 2.0” for low price-high volume market as seen in Figure 1.

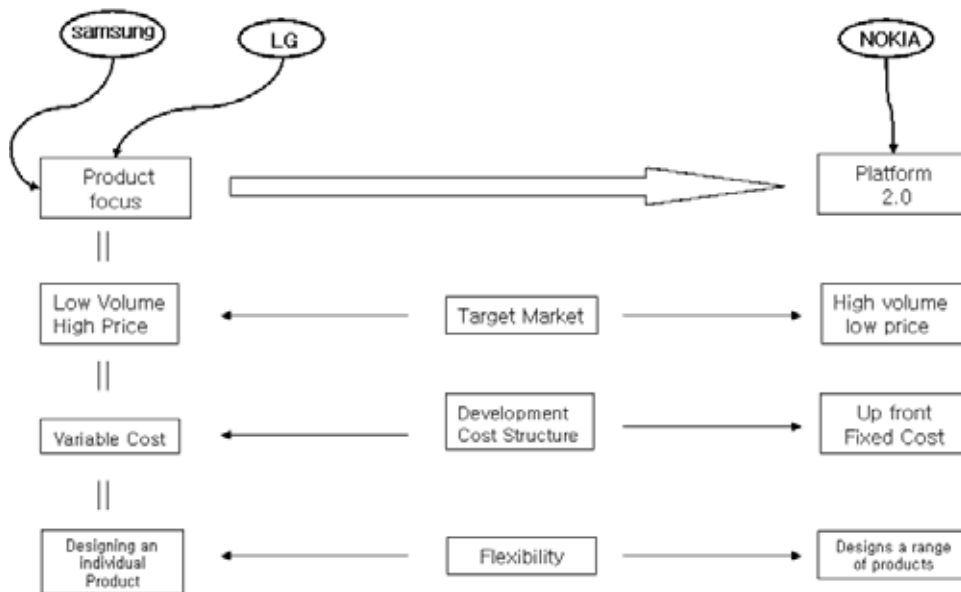
D & D process begins with an idea for a product (product basis) or a range of products (platform). Oliver, Gardiner and Mills (1997) remarked that the idea might come from a new application of technology (technology push) or from an implicit or explicit user need for new features/styles (market pull). The process ends when the product enters

volume production. Figure 2 displays various stages of a benchmark D & D process.

For our analysis of D & D project valuation and investment decisions, we will focus on the main D & D process between the stages of firm-concept and volume production in Figure 2.

When the Korean handset makers design and develop on a product basis, the maker usually starts with multiple competing models, and ends with one best hit chance model. In the interim process, the management should decide to continue to invest in or to abandon the models.<sup>1)</sup>

On the other hand, when the handset



Source: The Nomura study conducted by Windsor et al. (2005)

〈Figure 1〉 Vendors' Position on D & D Strategy

1) A relatively small and variable cost feature allows the management to pursue this kind of decision rule in reality.

maker designs and develops on the platform 2.0 strategy, the management rather starts with a single shot because of the huge sum of up front fixed investment cost. In this case, the investment decision is irreversible, and the relevant decision is when to invest.<sup>2)</sup>

In the following section, we will apply option analysis to the valuation of the D & D projects invested in by handset makers in Korea such as Samsung and LG, who design and develop on a product basis.

#### IV. Valuation of D & D Project in the Handset Industry: Product Basis Strategy

Borrowing from the commodity futures literature,<sup>3)</sup> we posit that

$$\begin{aligned}
 V_T &= V_0 + \text{Carrying Cost} + \text{Random Factorst} \\
 &= V_0 + \text{Development Cost} + \text{Financing Cost} \\
 &\quad + \text{Random Factors}, \tag{1}
 \end{aligned}$$

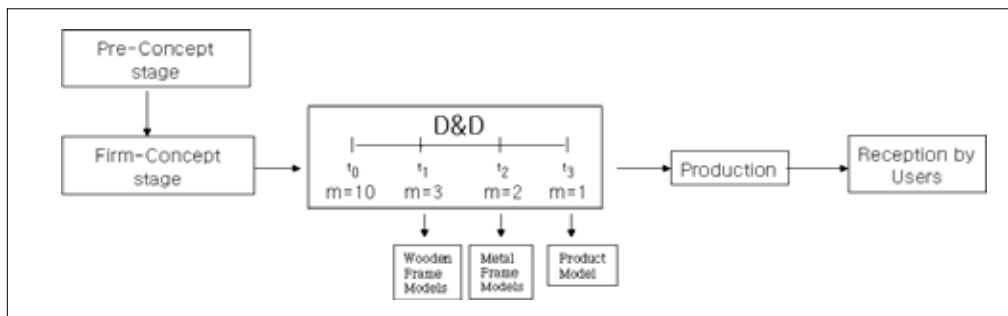
where

$V_T$  = Value of D & D project at  $T$  when the project is completed,

$V_0 = I_0$  = initial investment cost at  $t_0$  when the project is started.

Rather than for a futures price in (1), we have an expression for  $V_T$  with random factors since the D & D project has not a traded contract written in the futures markets.

The value of D & D project at  $T$ , *i.e.*,  $V_T$  may reflect the NPV (expected at  $T$ ) of a stream of the net future earnings from the production and sales of the new model. Once the firm produces the model, it effectively exercises the option. The NPV



Source: Oliver, Gardiner, and Mills (1997)

<Figure 2> Benchmark D & D Process

2) According to the phrase by Dixit and Pindyck (2001), "When a company exercises its option by making an irreversible investment, it effectively 'kill' the option."

3) Salih N. Neftci (2004), Principle of Financial Engineering, Elsevier Academic Press, 344-345.

expected at  $T$  is random at  $t_0$  as the uncertainties are revealed in the development process. The random factors in (1) are due to the uncertainties associated with engineering and/or market demand factors.

As we pointed out in Section III, the handset makers in Korea develop multiple competing models at an early stage, and determine the models to continue to invest in or to abandon at each successive stages till the management finds a right product to deliver to the market. Development usually takes six months to one year. As shown for an illustrative purpose in Figure 2, the management reduces the models from  $m = 10$  to  $m = 3$  at the wooden frame model stage, and then further reduces from  $m = 3$  to  $m = 2$  at the metal frame model stage. Finally the management chooses one best hit chance model at the production stage. According to an informed industry source in Korea, the net income from the handset production could go high about 20~100 times as much as the development cost.<sup>4)</sup>

In order to capture such characteristics as an extraordinarily high return, even though it is infrequent, we assume that the value follows a mixed jump-diffusion process (Fujihara and Park, 1990) which we may express in a discrete time as

$$V_{t_i}^j = V_{t_{i-1}}^j + I_{t_{i-1}}^j + rV_{t_{i-1}}^j\Delta + V_{t_{i-1}}^j\xi_{t_i}^j$$

for  $j = 1, \dots, m,$  (2)

where

$V_{t_i}^j$  = value of the  $j^{th}$  design model at time  $t_i$ , and the values of the  $m$  models are independent of one another,

$I_{t_i}^j$  = investment cost of the  $j^{th}$  model at time  $t_i$ ,

$\Delta$  = time interval between  $t_i$  and  $t_{i-1}$  in years,

$r$  = risk-free interest rate,

$\xi_{t_i}^j$  = random variable whose probability density function is given below in (3).

The probability density function for  $\xi_i^j$  in (2) is given as:

$$f(x_{(t)}|\Omega) = \sum_{n=0}^{\infty} \frac{\exp(-\lambda\Delta)(\lambda\Delta)^n}{n!} \times N(x_{(t)}|0, \sigma^2\Delta + n\delta^2)$$
 (3)

In (3),  $N(x_{(t)}|0, \sigma^2\Delta + n\delta^2)$  is a standard normal density function with mean 0 and variance  $\sigma^2\Delta + n\delta^2$ , and  $\sigma$  is an annual diffusion volatility, and  $\delta$  is a jump volatility given the incidence of a jump respectively. The Poisson count  $n$  has an intensity parameter  $\lambda$  and  $n$  jumps are independent of one another.<sup>5)</sup>

4) However, we do not claim that the net income is entirely due to the design effect even though it is mostly.

5) For a full description of the probability density function associated with a mixed jump-diffusion process, see Fujihara and Park (1990).

Mixed jump-diffusion processes are often employed to describe the asset price movements such as exchange rate and stock price movements. These processes are especially suitable for the situations in which the asset price changes by small amount most of the time, but by very large amount infrequently. The small frequent changes are described by a diffusion process with the normal distribution, but the very large infrequent changes by a jump process with the Poisson density. The Poisson-distributed "event" (*i.e.*, jump) is caused by the arrival of an important piece of information. The probability of an event occurring in any short-time interval ( $t, t+h$ ) like in a day can be written for any practical purpose as:

Prob (the event does not occur in the interval) =  $1 - \lambda h$ ,

Prob (the event occurs once in the time interval) =  $\lambda h$ ,

Prob (the event occurs more than once in the time interval) = 0,

where  $\lambda$  is the mean number of arrivals per unit of time.

Given the return dynamics on the D & D

project described by (2), we follow Ahn (1992), and express  $V_{(s)}^j$ , the value at time  $s \geq t$  of D & D project as:

$$V_{(s)}^j = V_0^j \exp \left[ \left( \alpha_j + r - \frac{1}{2} \sigma_j^2 \right) (s - t_0) + \sigma_j (z_j(s) - z_j(t_0)) \right] Y_j(n), \quad (4)$$

where  $\alpha_j = I(s)/V(s)$  is the investment ratio,  $z$  is a standard normal variable, and  $Y_j(n) - 1$  is the random proportional change of  $V_j$  if  $n$  jumps occur. We may consider the initial investment cost,  $V_0 (= I_0)$  as an entry fee for the right as remarked by the CFO at Merc & Co.

We need for valuation to transform the probability density function (3) under the real probability measure  $\mathbf{P}$  into a risk-neutral probability density under the Martingale measure  $\mathbf{Q}$ . It is because we can value the D & D project by discounting the expected value of  $V(T)$  at a risk-free rate under the Martingale measure  $\mathbf{Q}$ .<sup>6)</sup>

Using the general equilibrium models such as Cox, Ingersoll, and Ross (1985) model and Ahn and Thompson (1988) model, a risk-neutral probability density function of a mixed jump-diffusion process is derived in Park, Ahn, and Kim (2008). It is shown there that the

6) When one values a risky asset and the risk is systematic, the future asset value has to be discounted at a risk-adjusted discount rate which accounts for a risk premium whatever it is. Another way to value the asset is to transform the real probability distribution of the asset price into the probability distribution under the Martingale measure  $\mathbf{Q}$ , and discount the future asset price under  $\mathbf{Q}$  at a risk-free interest rate. Under the Martingale measure  $\mathbf{Q}$ , the future asset price has no predictable trend, and the asset price is simply an average of the future asset prices.

risk-neutral probability density function particularly depends on the systematic jump volatility and the firm-specific beta of the jump risk with the market. However, if the jump risk is fully diversifiable, there will be an equivalence between the real measure  $\mathbf{P}$  and the Martingale measure  $\mathbf{Q}$  (Merton, 1976).

The handset makers in Korea run many independent development teams and produce distinct handset models for each of the fully segmented markets. Hence it is quite likely that the handset maker is doing quite well in one market, but not in the other market, and it may well be reasonable to assume that the jump risks of the values of D & D projects can be diversified away and will not be priced.

Under the Martingale measure  $\mathbf{Q}$ , therefore, we can express the value of the D & D project as follows:

$$\begin{aligned} & \text{Value of D \& D Project} \\ &= E_{t=0}^{\mathbf{Q}}[V(T)/e^{-rT}], \end{aligned} \quad (5)$$

where  $E_{t=0}^{\mathbf{Q}}$  is an expectation operator at time  $t_0$  under the Martingale measure  $\mathbf{Q}$ .

The distribution of  $V(T)$  is skewed towards the upside and hence is no longer log-normal, because it is the distribution of the value of a best hit chance model among the

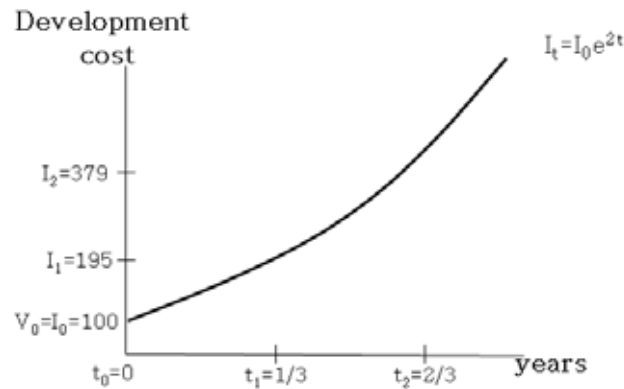
$m$  models, and also depends on the respective decision rules at successive stages. It is very difficult to obtain an analytical solution for (5) and thus we rely on Monte Carlo simulations following Boyle (1977). In Section V, we conduct Monte Carlo simulations under various decision rules.

## V. Monte Carlo Simulation

This section conducts Monte Carlo simulations using the return dynamics for the value of the D & D project described by (4) and the valuation model given in (5). For our numerical calculation, we assume that the handset maker starts with  $m=10$  models<sup>7)</sup> and we set that  $I_0 = V_0 = 100$  for each of  $m$  models. Our informal conversation with an informed industry source revealed that the development period is usually one year and there are two interim stages at  $t_1 = 1/3$  year and  $t_2 = 2/3$  year where the management decides the models in which to continue to invest or abandon.

The investment cost is increasing in time and represented by  $I_t = \exp(2t)I_0$  shown in Figure 3. A higher extra development cost is likely to be incurred as we add greater

7) It used to be an industry practice that a D & D team starts with 10 models, but a new management wants to reduce it.



From an informed industry source in Korea.

〈Figure 3〉 Development Cost over Time

complexity to the models towards later stages of the D & D project.<sup>8)</sup>

We consider four different strategies with respect to choosing the number of models to continue to invest in at successive stages of the D & D project. The four simulation models to be considered are as follows:

*A) Aggressive Strategy*

$$10(t_0) - 10(t_1) - 10(t_2) - 1(T)$$

*B) Moderate Strategy*

$$10(t_0) - 3(t_1) - 2(t_2) - 1(T)$$

*C) Conservative Strategy*

$$1(t_0) - 1 \text{ or } 0(t_1) - 1 \text{ or } 0(t_2) - 1 \text{ or } 0(T)$$

*D) NPV model (An Iconic Designer Model)*

$$1(t_0) - 1(t_1) - 1(t_2) - 1(T)$$

where the numerical values are the numbers of the models chosen at each stages.

The strategies *A* and *B* are chosen for illustrative purposes to distinguish the more aggressive strategy *A* from the less aggressive strategy *B* and to find out which is better under alternative scenarios. Strategy *C* is a typical real option model of project valuation. The project is abandoned when the value becomes negative, *i.e.*, the option becomes out of the money, and otherwise continued. Strategy *D* is the traditional *NPV* model of project valuation, and we may call it an iconic designer model because there is no flexibility of intervention in the process allowed. Except for the case of *D*, the management's intervention will skew the

8) An informed industry source in Korea commented that the development cost per model usually increases exponentially in time.

〈Table 1〉 Simulation Results

Strategy	$\delta=5.0$				$\delta=3.0$			
	value	cost	net income	preference	value	cost	net income	preference
A	15490.6	6757	8733.6	1	4851.7	6757	-1905.3	4
B	8349.3	2343	6006.3	2	3382.5	2343	1039.5	1
C	1477.6	458.9	1018.7	3	820.1	491.5	328.6	2
D	661.3	675	-13.7	4	650.5	675	-24.5	3

- Note: 1) The results are obtained by generating 10,000 random trajectories per model.  
 2) Initially we create 10,000 vectors, each of which contains 10 random number ( $m=10$ ) in Strategies A and B. The best  $m$  models at time  $t_i$  are selected and the rest dropped out of the models at time  $t_{i-1}$  per vector.  
 3) The model is abandoned if  $V_{t_i} \leq 0$  at time  $t_i$  and otherwise carried to the next stage in Strategy C.  
 4) We choose for other parameters that  $r = 0.05$ ,  $\sigma = 0.5$ , and  $\lambda = 3$ . One-year interest rate moves around 5% in Korea, and Anderson, Benzoni and Lund (2002) estimated that  $\lambda = 3$  for a mixed jump-diffusion process using S&P 500 index at daily frequency. Annual return volatility of a typical share is around 50 percent, *i.e.*,  $\sigma = 0.5$ .

distribution of  $V(T)$  toward the upside under strategies A, B, and C.

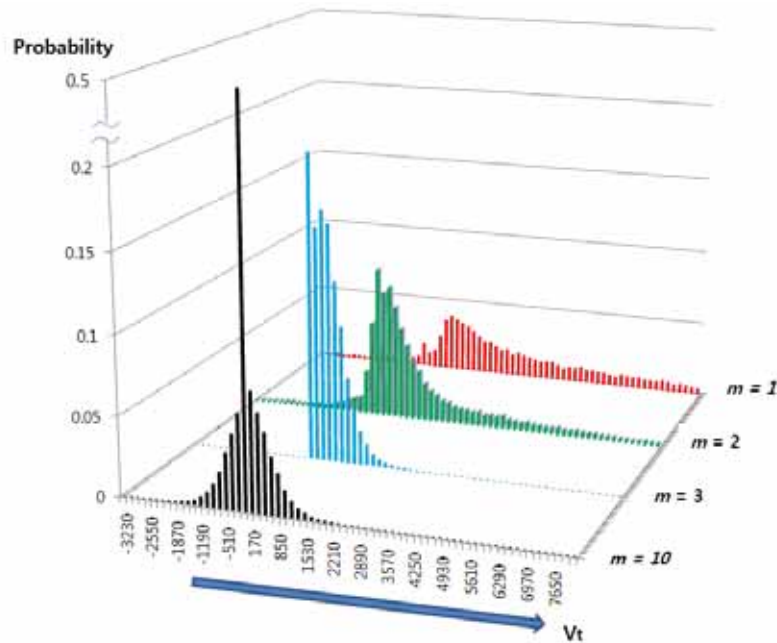
Our simulation results are shown in Table 1. We also show in Figure 4 how the  $m$ -model value process evolves over time for the moderate strategy with  $\delta=5.0$  for an illustrative purpose.<sup>9)</sup> As seen in Figure 4, at the first stage where  $m = 10$ , the distribution centers around the initial development cost,  $I_0$  and exhibits fat-tailed and sharp-peaked leptokurtosis. As the number of models decreases over time from  $m = 10$  to  $m = 1$ , the value distribution become more skewed toward the upside.

Our simulation results have the following implications:

1) When we have a greater uncertainty (*i.e.*, higher volatility), the aggressive strategy returns the highest value. This is shown in Table 1 in which we have the highest net income under Strategy A for  $\delta=5.0$ .

2) However, when the volatility is reduced from  $\delta=5.0$  to  $\delta=3.0$ , Strategy B returns more than Strategy A. It is because the total development cost for Strategy B is much less than that for Strategy A, while

9) Given the parameter choices including delta  $\delta$ , one may want to search for the optimal numbers of model,  $m^*$  at each stages by an iteration.



〈Figure 4〉 An Evolvement of m-model Value Process

Strategy *A* produces not that much more income to compensate for the higher development cost.

3) The real option valuation under Strategy *C* produces a higher net income than that under Strategy *D* both for  $\delta=5.0$  and  $\delta=3.0$ . The management's flexibility to intervene in the process skews the distribution towards the upside and creates an option value to the D & D project. This result is consistent with those obtained by other studies in the literature.

## VI. Concluding Remarks

We have applied option analysis to D & D project valuation for the mobile phone industry in Korea. On the basis of our analysis, we have drawn some important implications for the investment decisions on the D & D projects. When the future outcomes are more unpredictable, an aggressive investment returns more because you have more options against the future uncertain states.

To our best knowledge, our work is a first application of option analysis to D & D project valuation. One striking difference

between ours and other applications in the literature is that we have done option analysis for competing models, while other researchers for a single project. We may call our model a multiple real options analysis, and our model can be easily extended to option analysis for other industries such as the game software industry.

Our multiple real options model has a specific implication for the Korean mobile phone producers. The Korean handset producers develop models targeted toward various segmented markets. Some markets may exhibit greater uncertainty than other markets. In that event, our valuation model suggests that the producers may pursue more aggressive strategy (*e.g.*, Strategy A) for markets with greater uncertainty, such as young stylish consumers market as opposed to old silver market (*e.g.*, Strategy C).

One final point we want to address is that we have valued the D & D projects invested in by the Korean handset producers assuming that the value follows a mixed jump-diffusion process. An appealing feature of the process is that its density function exhibits leptokurtosis and produces a greater probability in the tail relative to the normal distribution. We believe that the fat-tailed distribution better describes the characteristics of the extraordinarily high returns on the D & D projects invested in by the Korean handset producers.

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## 디자인 및 개발 프로젝트의 가치평가와 투자결정 - 한국 휴대폰 산업에 대한 실물옵션 분석 -

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### 요 약

본 논문은 실물옵션 분석기법을 이용하여 디자인 및 개발 프로젝트의 가치를 평가하며, 그 결과로 한국 휴대폰생산업체의 디자인 및 개발 전략에 대한 중요한 시사점을 도출하고자 한다.

특히 디자인 및 개발 프로젝트의 가치가 mixed jump-diffusion 과정을 따른다고 가정할 때, 프로젝트의 불확실성과 개발비용이 가치평가의 중요한 두 가지 변수가 됨을 보여준다. 또한 본 논문은 모형을 통해서 미래 불확실성이 존재하는 상황에서는 공격적 전략이 개발과정에 있어서 더 많은 선택권을 제공하기 때문에 미래의 결과를 예측하기 어려운 시장에서는 공격적 전략이 더 많은 이익을 창출한다는 것을 보인다.

주제어: 디자인 및 개발 프로젝트, 실물옵션, 다중옵션, 전략적 가치, 몬테카를로 시뮬레이션

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