# Decision Making on Wireless Mobility Investment: An Options Approach

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***Abstract*—While wireless mobility have received much attention among researchers, limited research in management field has been conducted to discuss how a company's executive to make the best wireless mobility investment decision for reducing expenditures irreversibility and market uncertainty. This study presents a virtual multi-phased wireless mobility investment case with multiple variables, and focuses on the prediction of long-term benefits associated with wireless mobility project investment.**

***Keywords*—wireless mobility; real options; project evaluation**

## 1. INTRODUCTION

While computer science and telecommunications has recently experienced a notable advance, one rapid-moving area in the IT field is wireless technology. Of course, emerging wireless technologies have an increasing potential as a solution to many present industrial problems, but the challenges that forward-looking industries have to meet are multimedia information gathering and system integration through adopting wireless technologies. However, the underlying technology regarding wireless is more complicated, and the customer base is currently small, such that the cost of implementing wireless mobility (henceforth, "WM") for businesses is still extremely high.

Such a decision process as investment in WM is difficult to estimate and manage due to uncertainty about expected benefits and irreversibility in the costs of implementation. When uncertainty and irreversibility are high, and when executives have flexibility relating to the timing and structure of technology adoption investments, there is empirical evidence to support the fact that managers who are aware of some options-like ideas do a better job of managing risky IT investment ([1], [2]). Thus, the purpose of this study is to analyze WM investment from a real options perspective.

## 2. COMPOUND OPTIONS

A compound option means that there is an option on an option. The exercise payoff corresponding to a compound option implies the value of another option. A compound option possesses two expiry dates and two exercise prices. Suppose we take a European call on a call as the example. On the first expiry date $T_1$, the owner has the right to buy a second call through the exercise price $X_1$. The second call has expiry date $T_2$ and exercise price $X_2$. Let the present time be 0, $S$ be the implying asset price and $C(S,\tau;X)$ express the value of a call with expiration time $\tau$ and exercise price $X$. Let $C_c$ indicates the value of the call on a call at the present time. On the first expiry date $T_1$, the value of the call on a call is given by

$$C_c = \max[X_1,\ C(S,\ T_2 - T_1;\ X_2)] \qquad (2)$$

Let $S^*$ be the decisive asset price such that $C(S, T_2 - T_1; X_2) = X_1$. When $S > S^*$, we possess $C(S, T_2 - T_1; X_2) > X_1$, and therefore, the owner should exercise the first call at $T_1$. The value of the call on a call at the present time relies on the joint likelihood that the asset price is over $S^*$ at $T_1$ and over $X_2$ at $T_2$. Thus, the value of compound options model, developed by Geske in 1979 [3], will be derived from

$$C_c = Se^{-\delta T_2} M(k,h;\rho) - X_2 e^{-rT_2} M(k_-,h_-;\rho) - X_1 e^{-rT_1} N(k_-) \qquad (3)$$

where

$$k = \frac{\ln(S/S^*) + (r - \delta + \tfrac{1}{2}\sigma^2)T_1}{\sigma\sqrt{T_1}},$$

$$h = \frac{\ln(S/X_2) + (r - \delta + \tfrac{1}{2}\sigma^2)T_2}{\sigma\sqrt{T_2}},$$

$$k_- = k - \sigma\sqrt{T_1},$$

$$h_{-} = h - \sigma \sqrt{T_2} \,,$$

and

$S$ = present value of the implying asset,

$S^*$ = critical value over which the first call option will be exercised,

$X_1$ = the exercise price of the first call option,

$X_2$ = the exercise price of the second call option,

$r$ = the risk-free rate,

$\delta$ = the dividend yield,

$\sigma$ = the volatility,

$\rho = \sqrt{T_1 / T_2}$ ,

$T_1$ = the expiration date of the first call option,

$T_2$ = the expiration date of the second call option,

$N(.)$ = the univariate cumulative normal distribution,

$M(a,b;\rho)$ = the two-dimensional cumulative normal distribution.

Here, the first term in the Equation (3) denotes the expectation of the asset value dependent on $S > S^*$ at $T_1$ and $S > X_2$ at $T_2$, the second term denotes the expected expenditures upon exercising at $T_2$ and the final term gives the expected expenditures upon exercising at $T_1$.

## 3. ILLUSTRATIVE EXAMPLE

The ABC Company provides medical R&D, import, manufacturing and sales business. 1000 sales people of the ABC do not actually sell products. Instead, these people, named medical representatives, are functioned with promoting drugs by notifying doctors of the latest pharmaceutical details or medical evidence. They also gather feedback on their products regarding efficacy, safety and quality, as demanded by the company. Suppose today the ABC would decide to implement a WM project to improve overall sales performance and promote its profits. The top managers of the ABC company prefer to deploy modular solutions with features that fit their organization's needs instead of a full-scale WM solution, thus prohibiting the ABC from a large immediate investment in implementing the WM project. If three levels of wireless technology should be involved then at the first level is replacing the entire dial-up access scenario with wireless network access. Second, the adaptation of existing applications or development of entirely new applications for mobile solution needs to be completed; moreover, the deployment of software and hardware, plus the decision to have an in-house, outsource, or hybrid setup must be carefully planned. The third level, security considerations contain data encryption and centralized management of security settings. Even though investing today would provide it the possibility to improve the ABC's competitive advantages, the entire WM investment scenario is impacted by a phased implementation plan, irreversible expenditures, uncertainty, and questionable benefits.

So, at the same time, the company would develop an exit strategy. If something went wrong with prior phase investment and that caused the company not to reach its pre-decided expectation, then it would not launch the investment of next phase. The main success criteria of each phase of the WM project are defined as following: (1) the success criteria of phase two depend on the rate of increase in medical representatives' productivity or decrease in the recording/reporting time to close a deal; (2) the judging criteria of phase three are determined by the rate of increase in customer (i.e., doctors) satisfaction when mobile medical representatives has access to the up-to-date information about inventory levels and pricing from corporate databases; and (3) the success criteria of phase four are judged by the rate of increase in revenue growth and competitive advantage by always-on wireless capability. Suppose Company ABC has a complete stepwise plan utilizing four development phases and the development plan is summarized in Figure 1.

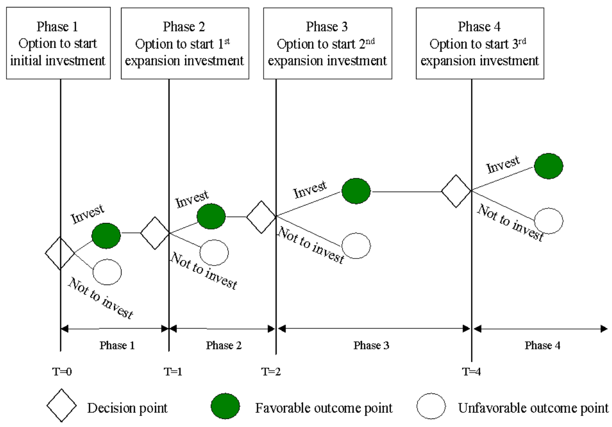


Figure 1. The evaluation model

## 4. REAL OPTIONS ANALYSIS

In order to investigate the value of this investment, Company ABC considers the WM project from an options perspective. The firm believes the real options framework will identify value neglected by NPV. Besides, the firm uses a compound options approach to value the multi-phased WM project investment, because the potential value of follow-on projects or the capabilities that the firm builds in the initial project should be considered when the initial investment is evaluated. While the NPV neglects the benefits learned from the firm's users, the compound options model can more accurately capture and identify value relating to this four-phased WM project.

The NPV of phase 1 may be viewed as the option payment the ABC pays today to obtain the right, but not the responsibility, to invest in phases 2, 3 and 4 in years 1, 2 and 4, respectively. From a decision-making perspective today, the ABC will invest in the upfront outlays if the flexible net present value (FNPV) is positive. Thus the FNPV can be expressed as:

FNPV = $C_I + C_A + C_B$ = NPV of phase 1 + compound option to invest in phase 2 and 3 + compound option to invest in phases 3 and 4 (4)

The $C_I$ denotes the actual amount the ABC plans on expending today in upfront costs, and the $C_A$ and $C_B$ will be calculated using the compound options model. Figure 2 and 3 indicate the cash flow diagram for these two compound options frameworks. The NPV of phase 1 is negative \$0.05M. Upon investing \$0.05M, Company ABC has the option to invest in phase 2 in year $T_1 = 1$. The expenditures of the option to invest in phase 2 will be the NPV of phase 2 in year 1 or $X_2 = 2.0e^{(0.1*1)}$ = \$2.21M. If the firm invests in phase 2, it gets the option in year $T_2 = 2$ to invest \$7M in the phase 3, $X_1$ = \$7M. By solving the following Equation (5), developed by Black (1976), for $S^*$, we get the critical value of phase 3 cash inflows, $S^*$ = \$9.44M, over which the option on phase 3 should be obtained at $T_1$. In another word, if the valuation for the current value of phase 3 cash inflows is greater than \$9.44M (i.e., $S >$ \$9.44M), then the investment in phase 2 will be undertaken.

$$X_2 = e^{-r\tau}[S^* N(d_1) - X_1 N(d_2)], \quad (5)$$

where

$$d_1 = \frac{\ln(S^*/X_1) + \frac{1}{2}\sigma^2\tau}{\sigma\sqrt{\tau}},$$

$$d_2 = d_1 - \sigma\sqrt{\tau},$$

$$\tau = T_2 - T_1,$$

and

$S^*$ = critical value over which the second call option should be obtained at $T_1$,

$X_1$ = the exercise price of the first call option,

$X_2$ = the exercise price of the second call option,

$r$ = the risk-free rate,

$\sigma$ = the volatility,

$T_1$ = the expiration date of the first call option,

$T_2$ = the expiration date of the second call option,

$N(.)$ = the univariate cumulative normal distribution.

Using the data inputs $S$ = \$9.5M (given $S > S^*$), $S^*$ = \$9.44M, $X_2$ = \$2.21M, $X_1$ = \$7M, $T_1$ = 1 years, $T_2$ = 2 years, $\sigma$ = 5%, $\delta$ =0.02, and $r$ = 10%, in Equation (3), the value of the compound option to invest in phases 2 and 3 is $C_A$ = \$0.98M. Similarly, the expenditures of the option to invest in phase 3 will be the NPV of phase 3 in year 2 or $X_2 = 1.3e^{(0.1*2)}$ = \$1.59M. If the firm invests in phase 3, it gets the option in year $T_2 = 4$ to invest \$6M in the phase 4, $X_1$ = \$6M. By Equation (5), we get the critical value of phase 4 cash inflows, $S^*$ = \$7.94M. Once again using the data inputs $S$= \$8M (given $S > S^*$), $S^*$ = \$7.94M, $X_2$ = \$1.59M, $X_1$ = \$6M, $T_1$ = 2 years, $T_2$ = 4 years, $\sigma$ = 5%, $\delta$ =0.02, and $r$ = 10%, in Equation (3), the value of the compound option to invest in phases 3 and 4 is $C_B$ = \$1.41M, and the FNPV = -\$0.05M + \$0.98M + \$1.41M = \$2.34M.

Comparing this FNPV with the traditional NPV value, the ABC's option to invest in phase 2, 3 and 4 is identified to worth an extra \$5.89M. Namely, identifying the value with regard to managing the WM project investment is worth \$5.89M more than conventional NPV approach would express. Hence, the compound options framework identifies and evaluates managerial flexibility when benefits exceed costs at each multi-phased decision point. Eventually, the ABC should determine to begin the implementation of the multi-phased WM project, since the FNPV is positive and implies the significant potential value if Company ABC is to implement the WM project.

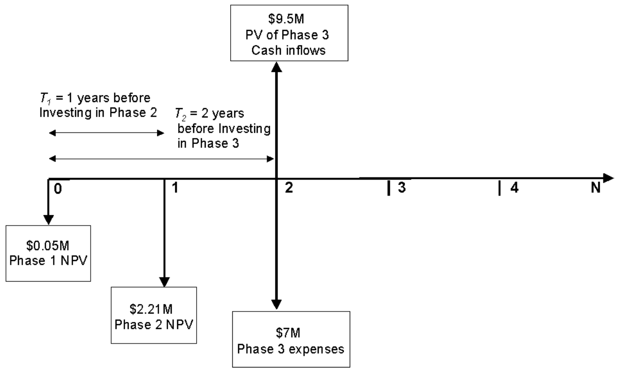


Figure 2. Framework to invest in phase 2 and 3

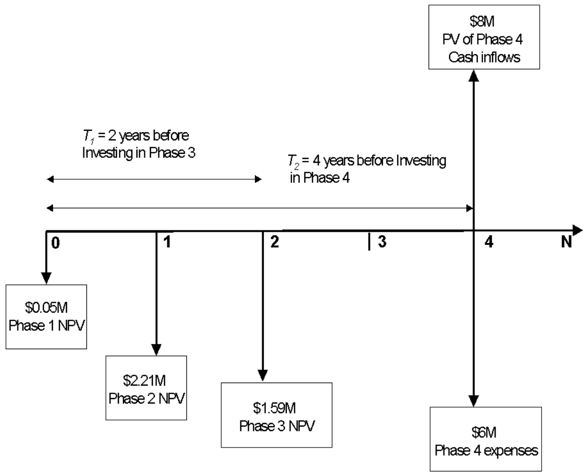


Figure 3. Framework to invest in phase 3 and 4

## 5. IMPLICATIONS FOR PRACTICE

Through the above analysis, a study using a real options approach for valuing a WM investment project was developed, and the compound options model was also revalidated in the context of WM investment projects. This research provided several implications for WM practitioners.

First, this illustrative result emphasized the importance of considering the potential value of follow-on projects when the initial investment was evaluated. Many IT projects fail because of the projects' irreversible capital expenditures, time lag between investment and benefits, and uncertainty. In these situations, evaluating a case using NPV will distort the real value of projects that involve options. In other words, the greater the uncertainty, the greater likelihood the option's value may be underestimated by the NPV. Based on NPV, assessing a WM investment may discourage top managers from investing in it because the investment project value is underestimated. The virtual example of Company ABC illustrates the limitations of NPV, which top managers usually use when estimating the value of WM investment. This represents that CEO-level-business-leaders may decide not to invest in such a huge project, gradually leaving their firms losing competitive advantages.

Second, this study put focus on the benefits of options thinking and of constructing multi-staged WM investment to produce options to expand or contract follow-on projects. Without such kind of thinking, firms could not get sufficient managerial flexibility to learn from their users. In addition, before the options' being exercised, top managers have to lay stress on validating the critical assumptions built into the WM case or evaluating whether the pre-determined expectation is realized or not.

Third, the compound options method, used in this study, is designed to be applicable across a broad spectrum of WM related projects, and will provide a fast and early feedback to the firm. The data scope, when necessary, can be adapted or modified based on a particular firm's request. As the compound options approach with good validity is used to assess a multi-staged WM project, top managers can use this real options approach to enhance their understanding of the investment of WM projects success and take corrective actions if necessary.

## REFERENCES

[1] Amram, M. and Kulatilaka, N., *Real options: Managing strategic investment in an uncertain world*. Harvard Business School Press, Boston, MA, 1999.

[2] Fichman, R.G., "Real options and IT platform adoption: Implications for theory and practice," Information Systems Research, Vol. 15, No. 2, pp. 132-154, 2004.

[3] Geske, R., "The value of compound options," Journal of Financial Economics, Vol. 7, pp. 63-81, 1979.