2 Real Options Applications in the Telecommunications Industry

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Two examples of the application of real options to the telecommunications industry are suggested in this paper. These applications move beyond the traditional capital budgeting procedures, which cannot properly capture management's flexibility to adapt and later revise decisions in response to unexpected regulatory/technological/market developments. Real options techniques can conceptualize and value managerial flexibility to alter initial operating strategy in order to capitalize on favorable future opportunities or to react to mitigate losses. Recognizing a particular capital budgeting project as a real option has value, particularly as the business environment becomes more uncertain.

1. CAPITAL BUDGETING AND REAL OPTIONS

Capital budgeting is the process by which businesses allocate capital. There are three dimensions of allocation decisions: Which project to invest in, how much to invest, and when to invest? Traditional approaches assume an expected scenario of cashflows and presume management's passive commitment to a certain static operating strategy. Such a strategy might be appropriate when the business environment is stable or predictable. However, the current business world is characterized by change, uncertainty and competitive interactions. As new information arrives and uncertainty about market conditions is resolved, management may have valuable flexibility to alter its initial operating strategy in order to capitalize on favorable future opportunities or to react so as to mitigate losses. This managerial operating flexibility is like financial options, and is known as strategic options or real options.

> *We will maintain our highly disciplined approach to capital spending. Our objective remains to maximize return on every dollar we invest — and to invest where we find the very best growth opportunities.*
>
> Richard C. Notebaert,
> Chairman and CEO
> Ameritech (1997 Annual Report)
>
> *Finance theory properly applied, is critical to managing in an increasingly complex and risky business climate. Option analysis provides a more flexible approach to valuing our investments. To me all kinds of business decisions are options.*
>
> Judy Lewent, CFO
> Merck (1992 Annual Report)

Traditional discounted cashflow approaches such as the net present value (NPV) rule cannot properly capture management's flexibility to adapt and later revise decisions in response to unexpected market developments. Considering real options in the capital budgeting process is the appropriate way to incorporate the value of managerial flexibility in the decision-making process.

2. SOURCE OF VALUE IN AN OPTION

Option pricing theory was first developed in the context of financial options, such as call options and put options. Conceptually, financial and real options are quite similar with one exception: The underlying asset for a financial option is a financial asset, like a common stock, while the underlying asset for a real option is a business project.

A call option gives the owner the right, with no obligation, to acquire the underlying asset by paying a prespecified amount (the exercise price, X) on or before the maturity date. Figure 1 illustrates the payoff (on the maturity date) from owning a call option.

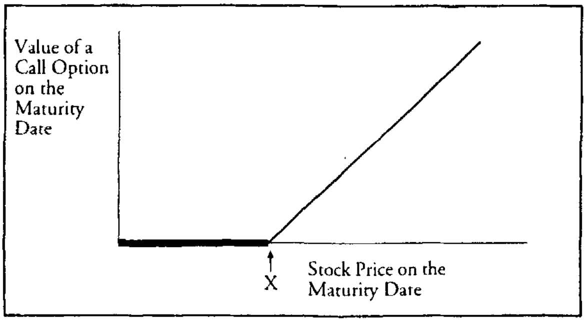

Figure 1

The source of value in an option is the asymmetry from having the right, but not the obligation, to exercise the option (notice the asymmetric nature of payoffs in the above graph). While the source of value in an option is the asymmetric nature of payoffs, this payoff profile makes the valuation of options through traditional methods, such as the discounted cashflow analysis, inappropriate.

3. TRADITIONAL APPROACHES TO DEALING WITH UNCERTAINTY AND COMPLEXITY IN CAPITAL BUDGETING

Real options is a relatively new addition to the tool-kit of capital budgeting decision makers. Traditionally there have been three approaches to dealing with uncertainty and complexity in capital budgeting:

3.1 Sensitivity Analysis

Sensitivity analysis considers the effect on the NPV of varying one variable at a time. It is useful in identifying key drivers in a project. It indicates how large the forecast error on a key driver can before the project becomes unacceptable.

Pro: Sensitivity analysis is easy to implement and understand.

Con: This approach ignores interdependencies among variables (at a point in time) and over time. For example, usually there is an inverse relationship between market share and the price charged; such a relationship is not modeled in this analysis.

3.2 Simulation

There are four steps in implementing the simulation process:

1. Equations specify relationships among variables.
2. *Probability distributions of underlying variables are specified.*
3. Random draws from above distributions. NPV is computed.
4. Steps 1, 2, and 3 are repeated many times.

Pro: Simulation takes into account interdependencies among variables.

Cons: A. This approach makes it difficult to interpret a distribution of NPVs. The traditional view of NPV as an "increase in shareholder wealth from accepting the project" is not applicable.

Solution: Use simulation to assess the distribution of the net cashflows.

B. Step 1 presents problems in specifying interdependencies. For example, while the relationship between market share and the price charged is inverse, the functional form of such a relationship is unclear.

C. This approach cannot handle well asymmetries in the distributions introduced by management's flexibility to revise its prior operating strategy as more information about project cashflows becomes available over time.

3.3 Decision Tree Analysis

The decision tree analysis helps structure the managerial decision problem by mapping out feasible managerial alternatives in response to future events.

Pro: Decision tree analysis forces management to recognize its implied operating strategy and the interdependencies between the initial and subsequent decisions. For example, investment in an R&D project today could give managers an opportunity to invest in an attractive project in the future if the R&D effort were successful.

Cons: A. The number of different paths on the tree increases geometrically. This makes it increasingly difficult to determine the probability of being on a certain branch, and the cashflows associated with the branch.

B. Choice of discount rate: The risk of the project may change over time.

Table 1 summarizes the three approaches to dealing with uncertainty and complexity in capital budgeting and their pros and cons:

Table 1

Traditional Approaches	Description	Pros	Cons
Sensitivity Analysis	Varies one variable at a time	Identifies key drivers Easy to implement and understand	Ignores interdependencies among variables
Simulation	1. Equations specify relationships among variables. 2. Specify probability distribution of underlying variables. 3. Random draws from distributions; compute NPV. 4. Repeat steps 1, 2, and 3 many times.	Interdependencies considered.	Interpretation of a distribution of NPVs is problematic. Traditional view of NPV not applicable. Specifying interdependencies among variables is difficult. Management's flexibility is not easily incorporated.
Decision-tree analysis	Maps future managerial alternatives.	Structures managerial decisions. Recognizes management's: • Implied operating strategy and • Interdependencies between initial and subsequent decisions.	Branches on the tree increase geometrically with a corresponding increase in the difficulty of implementing this procedure. Correct discount rate may change over time.

4. EXAMPLE OF REAL OPTIONS

The following discussion based on Trigeorgis (1996, pp 9 ff.) provides a set of stylized examples of real options.

The SuperCom Project: A large telecommunications company faces an opportunity to invest in an R&D project that will revolutionize the way consumers use telephones, internet, and TV. R&D would be conducted for the first three years. If this R&D effort were successful, commercialization would be initiated. The following diagram notes the real options associated with the SuperCom Project.

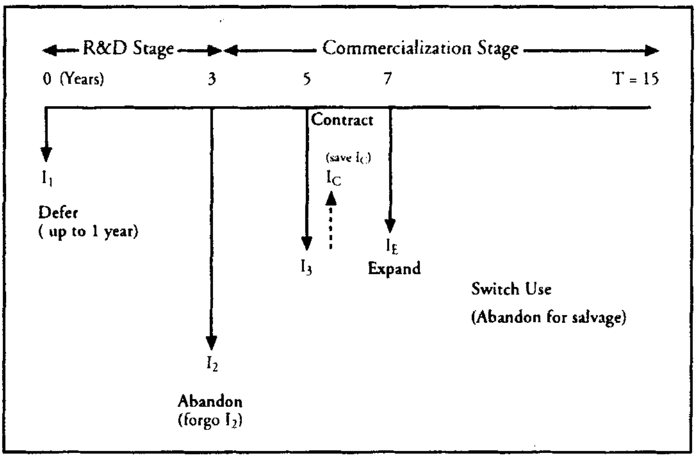

Figure 2. ***Real Options*** **in the SuperCom Project**

SuperCom's cash outflows and inflows are:

- I_1: Required investment in the R&D project.
- I_2: Required investment in the commercial-scale plant, marketing, and distribution, if the R&D effort is successful and if market conditions are favorable.
- I_3: Final investment in the project can be decreased by I_c if the market is weak.
- I_E: Flexibility in the design of the production process allows for output expansion with an outlay of I_E.
- V: Gross present value of the completed project's expected operating cashflows.

Before citing examples of real options associated with SuperCom, it should be noted that while conceptually the above cashflows are easy to describe, in practice, they might be quite difficult to estimate. For example, V incorporates cashflows over *many years* in the future *if* the R&D effort were successful.

1. Option to Defer Investment. Congress is currently debating the viability and the process by which to allocate or auction the airwaves that are crucial to the commercial success of SuperCom. If Congress passes legislation unfavorable to our company, then SuperCom would not be commercially viable. Our lobbyist in Washington advises us that the debate would be resolved within a year. We could initiate the R&D project immediately, or wait a year to see what Congress does. The option to defer investing in the R&D project is similar to a call option whose value is $max\ (V - I_I,\ 0)$.

2. Option to Expand. Given an initial design choice, management may deliberately favor a more expensive technology for the built-in flexibility to expand production/sales if and when it becomes desirable. If the market's response to SuperCom is better than expected, management can accelerate the rate or expand the scale of production by x% by incurring a follow-on cost I_E. The option to expand has value $max\ (xV - I_E,\ 0)$.

The option to expand also applies to complementary markets: Investing in SuperCom in a new geographical area allows for the possibility to expand to other similar markets. For example, besides local and long-distance telecommunication, the market for telephone-via-internet could be explored in the new geographical area.

3. Option to Default during Staged Construction (Time-to-Build-Option). Investing in the R&D project, or investing I_1, provides the opportunity to invest in the commercial stage by investing I_2 or to abandon the project if the R&D and initial test marketing are unsatisfactory.

4. Option to Contract. If the market does not respond to SuperCom as expected, management can reduce the scale of operations by c%, thereby saving I_c of the planned investment outlays. This option to mitigate loss has value $max\ (I_c - cV,\ 0)$.

5. Option to Abandon for Salvage Value. If SuperCom does significantly worse than expected in the market, management may choose to abandon the project permanently in exchange for its salvage value: the resale value of the capital equipment, license, etc. for A. This flexibility to abandon the project has value $max\ (V,\ A)$.

Table 2 describes and notes examples of various types of real options commonly encountered:

Table 2

Real Option	Description	Examples
Defer	To wait before taking an action until more is known or timing is expected to be more favorable	When to introduce a new product or replace an existing piece of equipment
Expand or contract	To increase or decrease the scale of an operation in response to demand	Adding to or subtracting from a service offering, or adding memory to a computer
Abandon	To discontinue an operation and liquidate the assets	Discontinuation of a research project or product/service line
Stage investment	To commit investment in stages, giving rise to a series of valuations and abandonment options	Staging of research and development projects or financial commitments to a new venture
Switch inputs or outputs	To alter the mix of inputs or outputs of a production process in response to market prices	The output mix of telephony/internet/ cellular services for a telecommunications company
Grow	To expand the scope of activities to capitalize on perceived new opportunities	Extension of brand names to new products or marketing through existing distribution channels

5. LIMITATIONS OF THE OPTIONS ANALOGY

While the real options technique has the potential to improve capital budgeting decisions, the conceptualization and valuation of such real options presents some issues and limitations:

1. Valuation Techniques. The standard techniques of valuing options are based on a no-arbitrage equilibrium, using portfolios of traded securities to replicate the payoff to options. Can this valuation technique be justifiably applied to capital budgeting where projects may not be traded? Answer: Yes. The computation of NPV requires the calculation of a discount rate - the weighted average cost-of-capital or the required return on an asset that is traded in the capital markets of similar risk as the project. Hence, the non-tradability of the project is no more problematic for the real options framework than it is for the standard NPV analysis.

2. Exclusiveness of Ownership and Competitive Interaction. The financial call option on a common stock is proprietary; only the owner can exercise it without worrying about competition for the underlying security. Some real options (patents, licenses) are also proprietary. Other real options are shared and can be exercised by any firm in the particular industry. Examples: opportunity to penetrate a new geographic market or to introduce a new product unprotected by the possible introduction of close substitutes.

3. Nontradability and Preemption. Financial call options are traded with minimal transaction costs. Real options are not generally traded. The non-tradability of real options may lead to their early exercise. For example, a firm anticipating an increase in industry demand - and hence subsequent competitive entry - may rush in early to expand its own production/sales capacity to preempt competition. In the absence of such competition, it might have preferred to wait for the uncertainty surrounding future demand to resolve itself.

4. Strategic Interdependencies and Option Compoundness. Financial call options are simple: their value derives entirely from the received shares of the stock. Some real options (such as maintenance or standard replacement projects) are simple. Others are compound: R&D investments are like an option on an option (the second option being the opportunity to invest in the commercial venture generated by the R&D project). Compound real options may have a more strategic impact on firm value than simple real options, and are more complicated to analyze. Compound real options must be looked at not as independent projects but rather as links in a chain of interrelated projects, the earlier of which may be prerequisites for those to follow.

6. THE BOTTOM LINE

Traditional capital budgeting procedures cannot properly capture management's flexibility to adapt and revise later decisions in response to unexpected regulatory/technological/market developments. The real options technique can conceptualize and value managerial flexibility to alter its initial operating strategy in order to capitalize on favorable future opportunities or to react to mitigate losses.

6.1 The Real Value in Real Options!

In option pricing theory, the value of a call option increases with:

- Increase in variance of the underlying asset
- Increase in the value of the underlying asset
- Increase in the time to expiration
- Increase in the risk-free rate
- Decrease in the exercise price.

While the valuation of real options might be non-trivial, *recognizing* a particular capital budgeting project as a real option has value. The above comparative static results from option pricing theory suggest that recognizing and valuing real options becomes more valuable as the business environment becomes more uncertain!

As noted above, the actual valuation of real options is non-trivial. However, real options can be valued! The following numerical example illustrates how real options can be identified, modeled, and valued.

6.2 An Example: LaserTalk

A large telecommunications company, TCOM Inc., is considering the real/strategic options associated with investing in a project in a new country: *The LaserTalk Investment Opportunity (LaserTalk).*

The real options associated with *LaserTalk* are business opportunities that will become available to TCOM only if *LaserTalk* were to be invested in now. What might be the nature of these business opportunities? From an economic and strategic viewpoint, these opportunities would be in TCOM's areas of core competencies. If TCOM has a comparative advantage at doing something in their existing market, they probably enjoy a similar advantage at doing it elsewhere. Additionally, these business opportunities may arise as a result of TCOM's R&D success in the United States, or legal/regulatory changes in the new country.

How are the real options associated with *LaserTalk* valued? Below, a modification of the Black-Scholes call option valuation equation is used to value the real options associated with *LaserTalk.*

$$\text{Value of Call option} = V\, e^{-yt}\, N(d_1) - X\, e^{-rt}\, N(d_2)$$

Where, $d_1 = [\ \ln (V/X) + (r - y + (\sigma^2)/2)\ t\ ]\ /\ \sigma(t)^{1/2}$
$d_2 = d_1 - \sigma\,(t)^{1/2}$. N (.) = cumulative normal density function.

The other variables are described below.

Table 3

Variable	(Financial) Call Option	Real Option
V: Underlying asset	Stock	Business project
Value of V	Stock price	Present value of project's net cashflows
X	Exercise price	Present value of project's cash outflows
t	Time to maturity	Time over which the project decision may be made
r	Risk-free rate	Risk-free rate
σ^2	Variance of the stock price	Variance of the present value of project's net cashflows

Table 3 above also notes the corresponding variables between the call option and real option equations. From this, the following equation for the real option's value is derived:

$$\text{Value of real option} = V\, e^{-yt}\, N(d_1) - X\, e^{-rt}\, N(d_2)$$

Where, $d_1 = [\ \ln (V/X) + (r - y + (\sigma^2)/2)\ t\ ] \ /\ \sigma(t)^{1/2}$, and $d_2 = d_1 - \sigma\ (t)^{1/2}$

N (.) = Cumulative normal density function.

V = Present value of expected cash inflows from investing in future projects in the new country. Obviously, V will depend on the size and scope of such future business opportunities in the new country. The following assumptions can be made (considering the sensitivity of the value of the real options associated with *LaserTalk* to these assumptions):

Price charged as % of price in existing market	=	90%
TCOM's weighted-average cost of capital	=	12.63%
Life of project (years)	=	10
New country market size (fraction of TCOM's current market)	=	0.3
Operating costs (as a % of operating costs in existing market)	=	120%
Capital expenditure (as a % of cap. exp. in existing market)	=	110%

Given the above assumptions and the present value of TCOM's future cashflows, V = $2.5 billion.

X = Present value of the costs of investing in future projects in the new country. Again, X will depend on the size and scope of such future business opportunities in the new country. Given the above assumptions and the present value of TCOM's future cashflows, X = \$3.0 billion.

σ^2 = Variance in the expected net cashflows over time from investing in future projects in the new country, allowing for technological, legal, and market changes. The estimation of this variable has been quite prominent in the empirical option pricing regarding financial options. All the caveats and problems associated with estimating the variance in the empirical option pricing literature regarding financial options are equally applicable here. The problem is further complicated by the fact that even the underlying asset is not known at this time. The underlying assets are the future projects in the new country; the exact specifics of such projects are not known at this time. For illustrative purposes, the historical variability in cashflows in the U.S. telecommunications industry can be considered as the starting point for this analysis; $\sigma^2 = (40\%)^2$. The sensitivity of the value of the real options (associated with *LaserTalk*) to this assumption can also be considered.

t = Number of years during which the real option can be exercised, that is, the number of years during which investments could be made in future projects in the new country. For illustrative purposes, assume that t = 4 years. The sensitivity of the value of the real options (associated with *LaserTalk*) to this assumption is also considered.

$$y = 1 / t.$$

r = Risk-free interest rate for t years. For illustrative purposes, it is assumed that r = 6.40%. The sensitivity of the value of the real options (associated with *LaserTalk*) to this assumption is also considered.

The NPV of the future projects in the new country = V – X = -\$500 million. Hence, this project would be rejected on the basis of simply considering the traditional NPV. However, using the above real option valuation equation and the parameter estimates, the real option value of investing in the new country is \$800 million!

Below, the sensitivity of the value of the real options (associated with *LaserTalk*) to this assumption is analyzed graphically. As a result, for example, the value of the real option associated with *LaserTalk* is quite sensitive to the price that can be charged in the new country, but not very sensitive to the variability in the expected net cashflows over time from investing in future projects in the new country.

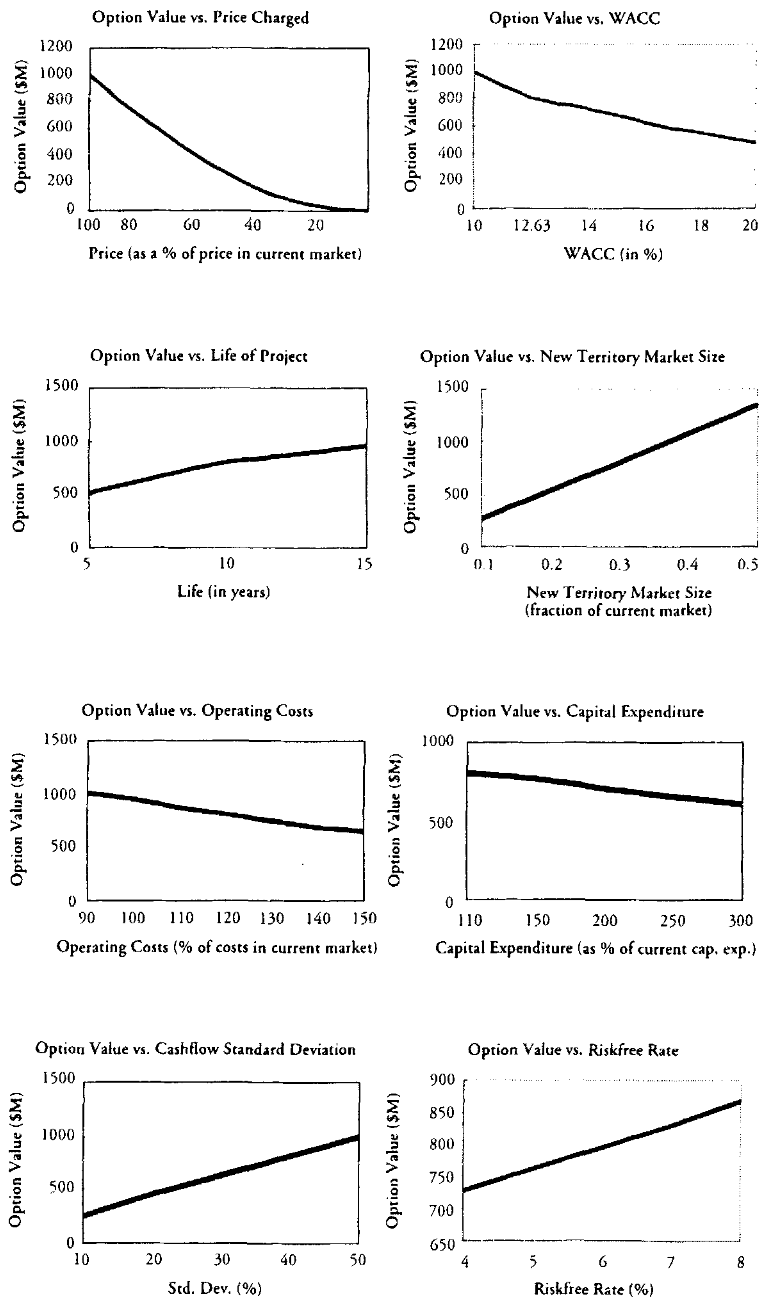

Figure 3. Sensitivity Analysis of Real Option Value of Investing in LaserTalk

7. SUMMARY

Traditional capital budgeting procedures cannot properly capture management's flexibility to adapt and revise later decisions in response to unexpected regulatory/technological/market developments. The real options techniques can conceptualize and value managerial flexibility to alter its initial operating strategy in order to capitalize on favorable future opportunities or to react to mitigate losses. While the valuation of real options might be non-trivial, *recognizing* a particular capital budgeting project as a real option has value, especially as the business environment becomes more uncertain.

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