THE NEW VALUATION PARADIGM: REAL OPTIONS

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Abstract

Conventional capital budgeting techniques such as the discounted cash flow analysis fail to recognize managerial flexibility that may have a huge option value. Such managerial flexibility may include abandonment option, option to defer development, option to expand, option to contract, and switching options. Though the extension of option pricing theory to valuation of other assets is not a novel concept, it has become increasingly popular with the new economy frenzy. Unable to justify the strikingly high market valuations of technology stocks with orthodox techniques, academics and market professionals have started to exploit option pricing technologies that presage relatively much higher valuations, which are indeed justifiable for highly flexible and high-growth companies. Nevertheless, these valuations are also highly sensitive to initial conditions and exact specification of parameters, which can be a viable explanation for the relatively much higher volatility of returns for Internet stocks. Regardless of the discussion whether it makes sense to use real options in order to justify high market valuations, the real option methodology is indispensable in recognizing the managerial flexibility, which may be inherently embedded in any capital budgeting project.

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1. Introduction

Real options would not have been so popular if the so-called "irrational exuberance"[1] for the new economy had not occurred in world markets, particularly in the US market, in the late 1990s. Price multiples and market valuations of new economy stocks were so high that conventional approaches such as discounted cash flow analysis were simply inadequate in explaining market prices. Employment of real options has filled in the gaps between valuations and market prices by taking into account hidden or embedded options pertaining to flexibility possessed by firms. As Copeland et al. (1990) has outlined, these options comprise abandonment option, option to defer development, option to expand, option to contract, and switching options of prospective or ongoing projects that can be exercised at various stages throughout the project lifetime. The right to exercise such options as new information arrives leads to better-informed decisions and, hence, options become valuable for the firm. Copeland (2000) argues that for emerging companies, which are small, high-growth businesses that have yet to establish a track record of profitability but are highly flexible and may have investment or growth opportunities that could greatly increase their cash flows, these opportunities have an option value that often represents a very significant portion of the company's total value. In these cases, it is more appropriate to use a real-options-based valuation technique.

Hence, the new economy, particularly the Internet, frenzy has resulted in a spree of a new valuation technology that is about to become the industry standard in corporate finance.

Application of option pricing theory to valuation is not limited with highly flexible high-growth companies. Damodaran (1994) enumerates three areas that option pricing may be applied to:

• Valuation of Equity in Distressed Firms

[1] An expression used by the Fed Chairman, Alan Greenspan, in 1996.

• Valuation of Natural Resources

• Valuation of Product Patents

In particular, the valuation of natural resources and product patents via real options has had a profound effect on valuation technologies in corporate finance. These three areas can be considered as rather classical examples of real option paradigm.

In this paper, I intend to provide an introduction to real options. I will render a brief survey followed by a comment on the latest direction of real option studies. I shall start by explaining the classical uses of real options, namely the valuation of equity in distressed firms, valuation of natural resources, and valuation of product patents. Then, I will go over the capital budgeting aspects that closely relate with the justification efforts for market valuations of new economy firms.

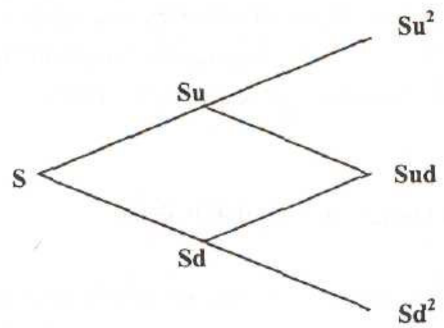
2. Brief Overview of Options and Option Pricing

Figlewski et al. (1990) assert that there are two basic types of options; i.e., calls and puts, and more complex option instruments can generally be treated as packages of these basic types. A call option is the right to buy a specified quantity of some underlying asset by paying a specified exercise price, on or before an expiration date. On the other hand, a put option is the right to sell a specified quantity of some underlying asset for a specified exercise price, on or before an expiration date. There also exists a further categorization with respect to the exercise time of options. American options can be exercised at any time the holder wishes up until the expiration date, while European options can only be exercised on the expiration date itself.

The milestone in option pricing is the seminal paper published by Black and Scholes (1973). They construct their option pricing formula for a dividend-protected European option by employing the lack of arbitrage principle via a replicating portfolio which has the same cash flows as the option being valued.

The concept of replicating portfolio and the Black-Scholes option pricing formula can best be understood by a simplified binomial model. As Damodaran (2003) describes, the binomial option pricing model is based upon a simple formulation for the asset price process, in which the underlying asset, in any time period, can move to one of two possible prices. This simple price process is depicted in Figure 1.

Figure 1
Price Process in a Binomial Model*



* S is the price of the underlying asset; the price moves up to Su with probability p and down to Sd with probability 1− p.

If we only take the first period into consideration and denote the value of a call option in up and down states with c_u and c_d, then a replicating portfolio for the call option, which consists of an investment of **Δ** units of underlying asset by borrowing B at an interest rate r, can be derived from Equations 1 and 2.

$$c_u = \Delta Su - B(1+r) \quad (1)$$

$$c_d = \Delta Sd - B(1+r) \quad (2)$$

Solving Equations 1 and 2 simultaneously, Δ and B can be find in terms of S, u, d, r, c_u, and c_d as follows.

$$\Delta = \frac{c_u - c_d}{Su - Sd} \qquad (3)$$

$$B = \frac{c_u - c_d}{(u - d)\,(1+r)} \qquad (4)$$

Since the replicating portfolio has exactly the same cash flows in each price state as the call option, then the value of the call should be equal to the value of the replicating portfolio at time 0; i.e.,

$$\textbf{Value of the call option} = \Delta S - B \qquad (5)$$

For a multi-period price process, the valuation proceeds iteratively by starting from the last period propagating toward the first period.

In fact, as Damodaran (2003) emphasizes, the Black-Scholes model is not an alternative to the binomial model; rather, it is one limiting case of the binomial. Black-Scholes model applies if the limiting distribution for the price process of the underlying asset is the normal distribution. In other words, if price changes become smaller as the time interval between price movements approaches 0, then the limiting distribution is the normal distribution and the price process is a continuous one with no jumps in asset prices.

Hence, the Black-Scholes option pricing formula for a dividend-protected European call option can be written as:

$$\textbf{Value of the call option} = SN(d_1) - Ke^{-rt}N(d_2) \qquad (6)$$

$$d_1 = \frac{\ln\left(\frac{S}{K}\right) + \left(r + \frac{\sigma^2}{2}\right)t}{\sigma\sqrt{t}} \qquad (7)$$

$$d_2 = d_1 - \sigma\sqrt{t} \qquad (8)$$

S	:	Current Value of the Underlying Asset
N(.)	:	Cumulative Normal Distribution Function
K	:	Exercise (Strike) Price
r	:	Riskfree Interest Rate (Corresponding to the Life of the Option)
t	:	Time till Expiration
σ^2	:	Variance of the ln(Value of the Underlying Asset)

The concept of replicating portfolio can easily be observed in the Black-Scholes model. The option delta for the Black-Scholes formula, corresponding to **Δ** of the binomial model, is $N(d_1)$, whereas the amount to be borrowed, corresponding to B of the binomial model, is $Ke^{-rt}N(d_2)$.

There also exist other versions of the Black-Scholes option pricing formula that take into account the possibility of early exercise for American options or payment of dividends.

Puts can be valued by employing the "put-call parity" that is, again, a result arbitrage relations. The put-call parity can be expressed as;

$$\mathbf{c - p = S - Ke^{-rt}} \qquad (9)$$

where c is the value of a call and p is the value of the put with the same exercise price and expiration date.

3. Real Options and Applicability of the Black-Scholes Model

Mun (2002) defines real options as a systematic approach and integrated solution using financial theory, economic analysis, management science, decision sciences, statistics, and econometric modeling in applying options theory to valuing real physical assets, as opposed to financial assets, in a dynamic and uncertain business environment where business decisions are flexible in the context of strategic capital investment decision-making, valuing investment opportunities and project capital expenditures.

Damodaran (2003) warns about some caveats of applying the Black-Scholes model to real options. First, the underlying asset in real options is not traded as opposed to a financial option. The Black-Scholes model is based on the lack of arbitrage principle which employs a replicating portfolio. When the underlying asset is not traded, it is not clear how a replicating portfolio can be constructed. Second, the price process may not be continuous in the case of real options. When the assumption that the price process is continuous is violated, the Black-Scholes model tends to underestimate the value of deep out-of-the-money options. Third, the assumption that the variance is known and does not change over the life of the option may easily be violated particularly for long-term real options. Finally, the option pricing models assume that the exercise of an option is instantaneous whereas this assumption may be difficult to justify with real options such as those requiring building a plant or constructing an oil rig.

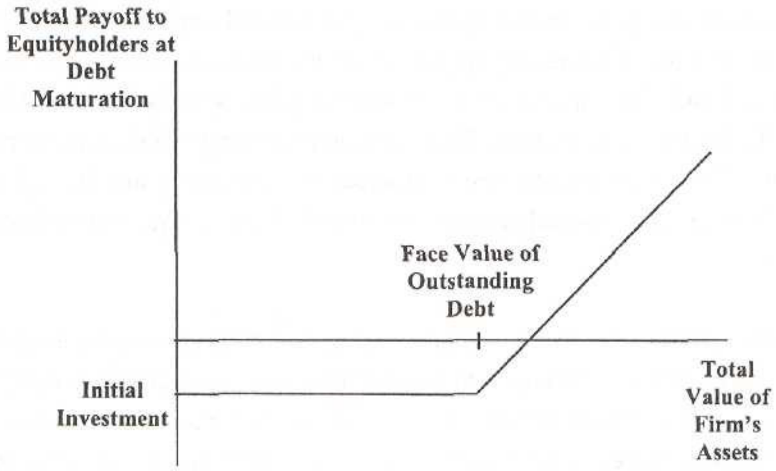
Fernandez (2001) seriously criticizes the employment of financial option formulas in real options valuation. He argues that using financial option formulas is completely inappropriate for valuing real options if the real options cannot be replicated, as all the formulas are based on the existence of a replicate portfolio. He claims further that the reasoning behind the option formula loses its entire basis when a replicate portfolio cannot be constructed.

4. Valuation of Equity in Distressed Firms

Damodaran (1994) indicates that equity will have value even if the value of the firm's total assets falls well below the face value of the outstanding debt. The equity in a firm is a residual claim in the sense that equity investors receive whatever is leftover in the firm after all outstanding debts are paid off. On the other hand, the notion of limited liability renders investors a downside protection so that investors cannot lose more than their investments if the value of the firm's total assets is less than the outstanding debt. Hence, the equity of a firm can be viewed as a call option with the underlying asset being the total assets of the firm. As depicted in Figure 2, the strike price of the call option is the face value of the debt and the option premium is the investment in equity.

Figure 2

Equity as a Call Option on Firm's Assets

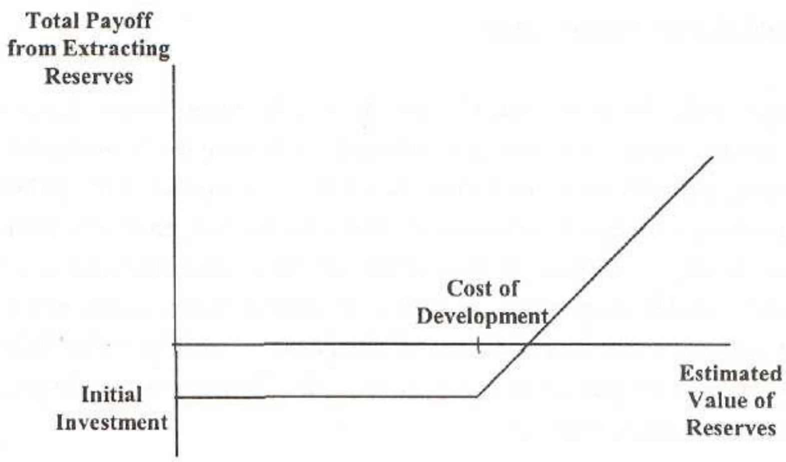


If the total value of the firm's assets is well above the face value of the outstanding debt, then equity may be viewed as a deep-in-the-money call option. For deep-in-the-money options, most of the option premium is comprised of intrinsic value and, hence, time value can be ignored for most practical purposes. Nevertheless, if the total value of the firm's assets is well below the face value of the outstanding debt, the equity is then a deep-out-of-the-money call option. The time value for such an option comprises 100% of the option premium. Thus, for distressed firms, valuation of equity via option valuation is natural as well as essential to obtain a fair valuation.

5. Valuation of Natural Resources

As Damodaran (1994) points out, firms that make natural resource investments have the option to leave the investments untouched if the price of the resource declines and to exploit them fully if the price rises. Therefore, it makes sense to extract the reserves if and only if the value of reserves exceeds the cost of development. Hence, a natural resource investment can be viewed as a call option where the underlying asset is the reserve and the value of the reserve depends on the quantity and price of the natural resource. As depicted in Figure 3, the strike price of the call option is the cost of development and the option premium is the initial investment.

Figure 3
Natural Resource as a Call Option on Estimated Reserves

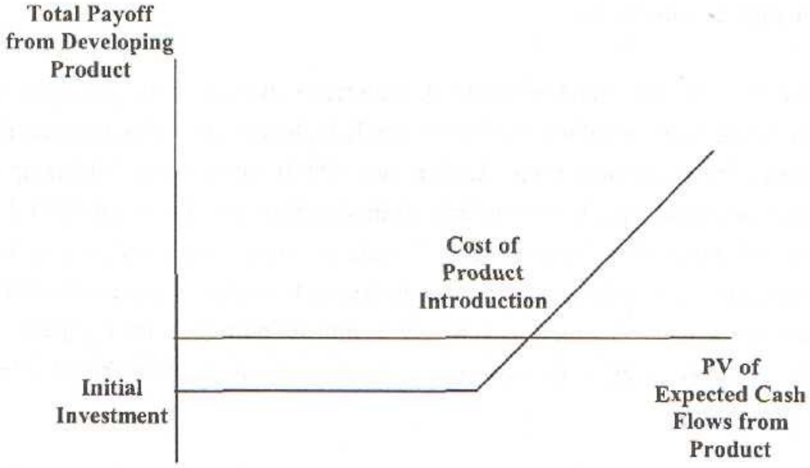


Moel and Tufano (1998) study the bidding for a copper mine that was offered for sale by the Peruvian government as part of the country's privatization program. The mine itself had a valuable real option component, in the form of the right to develop the mine after completing the exploration. The Peruvian government asked bidders to state both the premium that they would initially pay and pledged development expenditure that they would commit. Moel and Tufano conclude that the winning bidder clearly understood the option nature of the offering and followed a bidding strategy consistent with what should have been predicted. Moel and Tufano also add that the standard valuation technique of risk adjusted discounted cash flow (DCF) analysis fails to capture all sources of value associated with this type of investment since DCF assumes that the decision to invest is irreversible and inflexible. On the other hand, real options analysis incorporates managerial flexibility, which is, in this case, the option to abandon the project if the result of exploration turns out to be negative. In another study using a database that tracks the annual opening and closing decisions of 285 developed North American gold mines in the period between 1988 and 1997, Moel and Tufano (2001) find that the real options model is a useful descriptor of mines' opening and shutting decisions. On the other hand, they also conclude that real option models often fail to capture aspects of firm-level decision making while they are good stylized versions of plant-level decisions.

6. Valuation of Product Patents

Damodaran (1994) argues that a firm with valuable product patents that are unutilized currently but could produce significant cash flows in the future may be undervalued using traditional valuation techniques. Here, the product patent can be viewed as a call option where the underlying asset is the product itself. The value of the option largely stems from the variance in cash flows. Thus, the value of a product patent in a stable business will be less than the value of one in an environment where technology, competition, and markets all change rapidly. As depicted in Figure 4, the strike price of the call option is the cost of product introduction and the option premium is the initial investment.

Figure 4
Patent as a Call Option on Product



Kellogg and Charnes (2000) use the decision-tree and binomial-lattice methods to value a biotechnology company, Agouron Pharmaceuticals, as the sum of the values of its drug-development projects. Then, they compare their computed values of Agouron with actual market values at selected points in time during the development of Agouron's Viracept, a drug used to treat HIV positive patients. Their methods work best early in the life of the Viracept project, when the use of industry averages is more easily justified. Thus, they conclude that the real options approach can be used to value a biotechnology company, for which patents play an important role, provided that more specific assumptions are used for the later stages of project development.

7. Valuation of Highly Flexible High-Growth Companies

Even before the new economy frenzy of the late 1990s, it has been known among academic circles that managerial flexibility had an option value. Trigeorgis (1993) emphasizes the inadequacy of the net present value rule and other discounted cash flow approaches to capital budgeting as these methods cannot properly capture the management's flexibility to adapt and revise later decisions in response to unexpected market developments.

However, real options and relevant valuation techniques owe their popularity largely to the justification efforts for the stunningly high price multiples and market valuations of new economy firms. As Copeland (2000) points out, for emerging companies, which are small, high-growth businesses that have yet to establish a track record of profitability but are highly flexible and may have investment or growth opportunities that could greatly increase their cash flows, these opportunities have an option value that often represents a very significant portion of the company's total value. In these cases, it is more appropriate to use a real-options-based valuation technique.

Schwartz and Moon (2000) apply real options theory and capital budgeting techniques to the problem of valuing an Internet Company. They report that, depending on the parameters chosen, the value of an Internet stock may be rational if growth rates in revenues are high enough. Even with a real chance that a company may go bankrupt, if the initial growth rates are sufficiently high and if this growth rate contains enough volatility over time, then valuations can reach a level that would otherwise appear dramatically high.

Another important result from Schwartz and Moon (2000) is that the valuation is highly sensitive to initial conditions and exact specification of the parameters, which is consistent with observations that the returns of Internet stocks have been strikingly volatile.

Another justification for high market valuations of technology stocks comes from Boer (2000), who indicates that cash flow models for valuing technology are increasingly out of touch with marketplace valuations. According to Boer, while investor psychology and perceptions about the future may drive the marketplace, the theory of real options can go a long way toward closing the valuation gap. He illustrates how the hidden options in a new venture can contribute enormously to value, especially in fast growing industries and in markets exhibiting high volatility.

Angelis (2000), on the other hand, emphasizes that the value of flexibility in R&D projects lies in the fact that management always has the option to abandon the project if the results of the R&D are not promising, thus limiting losses to the amount invested in the R&D phase. On the other hand, traditional net present value analysis fails to recognize this flexibility and therefore tends to undervalue R&D opportunities.

8. New Developments in the Valuation Technologies of Real Options

After pointing out that a traditional net present value analysis misses the value of flexibility, Feinstein and Lander (2002) demonstrate how the discount rate can be adjusted to account for the impact of real options on risk. Their adjusted discount rate is a weighted average of the riskfree rate and the discount rate for the rigid project, which together replicate the flexible project. Further, it is also demonstrated that the adjusted discount rate can be computed iteratively.

The results obtained via this approach are mathematically equivalent to those obtained by classical option valuation methods. Hence, Feinstein and Lander show that some projects with real options can indeed be valued using simple and familiar tools without having to resort into mathematically complex models. Although their approach is practical for only simple real options, it is intuitively appealing and readily applicable for many capital budgeting problems.

9. Conclusions

Although the application of option pricing techniques to valuation of other assets is not a new perspective, it has been widely recognized in the golden era of Internet companies when market valuations of technology stocks have reached unprecedented levels. While such market valuations are simply inexplicable by conventional approaches, employment of real options has closed the gap between market prices and valuations.

Considering the fact that these valuations are also highly sensitive to initial conditions and exact specification of parameters, one may argue that the efforts for bridging stunningly high market prices and valuations via real options is merely an abuse of real option valuation. Nevertheless, regardless of the debate whether it is an abuse or not, real option valuation is a superior technology that can recognize managerial flexibility, which cannot otherwise be taken into account by static techniques such as the discounted cash flow analysis. Hence, real option valuation is indispensable for most capital budgeting problems, where managerial flexibility yields valuable options.

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