APPENDIX 7.1

Real Options versus Financial Options

Real options are not financial options; real options represent certain types of management decisions. The options models used to value real options are borrowed from financial options pricing models, but the underlying assumptions of these financial models do not strictly apply to real options.

A financial option is a derivative instrument whose value depends on the volatility of the underlying financial securities from which it is derived. Financial options are a right, but not an obligation, to buy or sell an underlying financial asset at a fixed price over a specified time period. For stock options, the underlying financial assets are equity securities; for currency options, the underlying asset is cash denominated in different currencies; and so on. For instance, a financial stock option (a put or a call) is traded on a regulated options exchange (e.g., the Chicago Board of Options Exchange). The traded option relates to a particular quoted equity security that is trading on a stock exchange, say the New York Stock Exchange or on the NASDAQ.

Behind real options are capital budget and resource allocation decisions. These managerial decisions are normally related to illiquid assets, such as research and development (R&D) projects, natural mineral resources, real estate, or investments in other types of *nonfinancial* tangible or intangible assets (e.g., plant and equipment or intellectual property). The underlying assets for real options do not normally trade on financial exchanges where market prices are observable. The assets underlying real options are illiquid and hard to trade. If they are being traded, they are usually being bought and sold in inefficient markets, such as in one-on-one negotiated transactions between companies or individuals, not on regulated market exchanges. Consequently, the assumptions behind the standard models used to value financial options do not strictly apply to the conditions of most real options. For instance, the Black-Scholes option pricing formula, published by Fischer Black and Myron Scholes in 1973, is designed to be used when there is a single source of uncertainty as measured by the volatility of the underlying asset (technically the standard deviation squared of the asset returns) and a single decision date (the time of exercising the option is fixed on a certain date).[1]

Real options are decision choices about real assets that a manager may exercise in the future.[2] Many real options are contingent on more than one source of uncertainty and so should be classified as compound real options or options on an option.[3] Real-life investment projects often include a collection of these compound real options whose values may interact.[4]

From Innovation to Cash Flows: Value Creation by Structuring High Technology Alliances

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For instance, compound real options are very common in many types of R&D project investment decisions, such as investing in an early-stage new product development project, which is followed by a sequence of prototype test rounds, expensive market research trials and quality tests, before being launched into the market.[5]

They also arise in various types of technology licensing agreements where patents are issued and the rights licensed to others for specific applications. For example in a research collaboration, the parties may agree to license back to each other the rights to use any codeveloped patents on technology discovered or enhanced through the collaboration. Such a clause seeks to ensure that each side has access to all the intellectual property rights resulting from the joint research. (This is one example of a "grant-back" contract clause, which is explained further in Chapter 14.)

Another example of a compound real option is when a pharmaceutical company provides equity financing and creates a joint venture to comarket a drug compound that is in late stages of clinical trials testing. In effect, the pharmaceutical firm's managers are betting on a promising drug compound that they hope will make it through Phase III clinical trials testing, receive government regulatory approval, and be launched successfully in the market, all in a linked three-stage process. By investing in Phase III trials, the manager is buying one option and paying to play. If the drug compound makes it through Phase III testing successfully, the manager will exercise his or her first real option and decide to invest more money in the initial market launch. Once launched, the drug may turn out to be a huge success, barely break even, or be a failure. If a market success, the manager can exercise the next real option (the compound real option) and invest heavily in clinical trials around the world to gain more government approvals and greater chances to reach a larger number of patients.[6]

More examples of compound real options may be found in opportunities to do joint ventures, strategic alliances, or mergers and acquisitions with other target technology companies that have promising R&D pipelines.

DISCOUNTED CASH FLOW VALUATIONS UNDERESTIMATE THE VALUE OF STRATEGIC REAL OPTIONS

Taking into account real options can *greatly* affect the valuation of a potential investment in an early-stage R&D project. Valuation methods such as the discounted cash flow (DCF) techniques, which we describe and discuss in Chapters 17 to 20, are *not* able to capture the value of real options. The DCF calculation ignores the benefits managers may attain from exercising their judgment and making decisions as future events unfold. Being unable to capture real options effects is a serious defect of DCF techniques. Real options is an attempt to extend the state of the art, but not even the most complex real options models are able to fully capture the competitive dynamics and interactions that occur for most compound real options.

Real options are on the frontiers of strategy and finance. We may be able to value the very simplest real options, but those that are more complicated, with competitive interactions, can be solved only by numerical techniques, and some are not solvable by today's known methods. Will the future bring newer real options techniques to value early-stage R&D alliances, licensing deals, and joint ventures? Many are working in this research area. As we gain a better understanding of the dynamics of these alliances and ventures, our modeling of the competitive interactions will improve, and the numerical techniques to solve the equations involved will be enhanced by advances in computer science and applied mathematics.

The key to any valuation is to take multiple perspectives, exercise judgment, and envision the future in creative ways. These are the skills of the artists and best scientists. Once the intuition is inspired, then the number crunching begins. Real options have a ways to go before they can be of practical use to managers faced with making complex decisions under uncertainty, conflict, and ambiguity, but they are a start.

NOTES

1. See Fischer Black and Myron Scholes, "The Pricing of Options and Corporate Liabilities," *Journal of Political Economy* 18 (1973): 637–659.
2. See Robert F. Bruner, *Applied Mergers & Acquisitions* (Hoboken, NJ: John Wiley & Sons, 2004), 423–454, for a succinct summary about real options and their impact on mergers and acquisitions. See also Luis E. Pereiro, *Valuation of Companies in Emerging Markets—A Practical Approach* (Hoboken, NJ: John Wiley & Sons, 2002), 222–246, for advice on how to apply real options in practice. For advanced readers, Lenos Trigeorgis, *Real Options—Managerial Flexibility and Strategy in Resource Allocation* (Cambridge, MA: MIT Press, 1996), provides an excellent treatment of real options theory and their complexities: On pp. 305–339, Trigerogis explains numerical methods used to solve the equations for certain types of real options; pp. 342–365 give numerous examples of real options applications in a variety of industries.
3. To estimate the value of a (simple) compound real option, you should not rely on the simple Black-Scholes formula but a more advanced equation (which only works under certain strict conditions) called the Geske formula; see Robert Geske, "The Valuation of Compound Options," *Journal of Financial Economics* 7, no. 1 (1979): 63–81. Also refer to Trigeorgis, *Real Options,* 213–215, for a brief explanation of valuing compound real options.
4. See Helen Weeds, "Real Options and Game Theory: When Should Real Options Valuation Be Applied?" Working paper, Cambridge University, 2002. In this working paper, Weeds discusses real options, game theory, and competitive strategic interactions.
5. For an interesting case study of Philips Electronics that applies real options thinking to new product development, refer to Onno Lint and Enrico Pennings, "An Option Approach to the New Product Development Process: A Case Study at Philips Electronics," *R&D Management* 31, no. 2 (2001): 163–172; DOI 10.1111/1467–9310.00206.
6. For examples of real options valuations in biopharmaceutical applications, refer to Richard L. Shockley Jr., Staci Curtis, Jonathan Jafari, and Kristopher Tibbs, "The Option Value of an Early Stage Biotechnology Investment," *Journal of Applied Corporate Finance* 15, no. 2 (2002): 44–55. See also David Kellogg and John M. Charnes, "Real-Options Valuation for a Biotechnology Company," *Financial Analysts Journal* (May-June 2002): 76–87.