The Real Options Approach to Investment Appraisal

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By the mid 1980s, people had begun to question traditional methods of evaluating investment projects. Early critics of the traditional capital budgeting techniques recognized that the standard discounted cash flow (DCF) analysis often undervalued investment opportunities, leading to under-investment because they failed to account for important strategic considerations. The Real Options theory emerged as an alternative route to evaluating the capital investment decisions of firms. This new approach attracted the interest of both academic researchers and practitioners, because it captures the strategic value of investment projects in an uncertain economic environment.

According to the traditional theory of investment analysis, an investment is undertaken if it has a positive net present value (NPV). However, this approach undervalues investments under conditions of uncertainty. Actually, most investments in innovative projects have a negative NPV when evaluated, due the fact that they are capital-intense and high-risk. At the same time, these investments are characterized by great uncertainty about future conditions and further give access to a range of future opportunities for the firm. Recognizing the operating flexibility that characterizes most projects, researchers proposed the use of simulation and decision tree analysis to capture its value. The main source of flexibility arises from the fact that good management reacts to changing conditions to capitalize on upside potential or to reduce downside risk by exploiting the options that are open to it. Typically, such options include delaying investment or abandoning the project if market conditions turn out to be unfavorable, changing the production rate of a factory, switching raw materials according to market prices etc. These options inherent in investment opportunities were called real options (Myers, 1977). The real options approach has shown that the traditional net present value rule can give very wrong answers in the presence of uncertainty and flexibility.

One might ask how firms acquire these investment opportunities, that is, options to invest, in the first place. Sometimes investment opportunities result from patents, ownership of land or natural resources. More generally, they arise from the resources of the firm, e.g. managerial resources, technological knowledge, and market position. Most important these options are valuable. Indeed, for most firms a substantial part of their market value is attributable to their options to invest and grow in the future (Kester, 1984).

Drivers of Option Value: Uncertainty and Flexibility

An option-based model of managerial decision making is especially appropriate when at least one of the following criteria is met: (a) uncertainty is high and (b) managerial flexibility is present. For financial options, an increase in the uncertainty of the underlying asset represented by the volatility of the asset on which the option contract is written leads to an increase in the value of the option. This occurs because the investment in the option is fixed at the price of the option, giving the investor access to a greater range of potential outcomes on the upside, while containing exposure on the downside. The real options analogue is that provided the downside loss an organization would sustain if it elects to stop further investment is contained, its investment increases in variance of results. Therefore, real option value generally increases as uncertainty increases.

An option-based model is also highly appropriate when there is managerial flexibility, that is, managers can make their decisions based on the information that arrives:

1. A defer option, which refers to the possibility of waiting before making an irreversible investment until more information has become available (e.g., McDonald and Siegel, 1986; Pindyck, 1991). In other words, management holds an investment opportunity and can wait to see whether market conditions (e.g., output or input prices) justify committing resources. The option to defer investment is analogous to an American call option on the present value of the expected cash flows of the project, with the exercise price being equal to the investment cost. Since early investment implies sacrificing the option to wait, this option value is an opportunity cost that should be included in the total investment cost. This type of flexibility is important whenever there is high uncertainty and long investment horizons, e.g. in natural resource investments and real estate development.
2. In some cases investment (e.g., in capacity) is at least partially reversible. If market conditions become unfavorable, management can abandon current operations and realize the salvage value of the project, i.e. resale value of capital equipment and other assets. Myers and Majd (1990) recognized this and valued the option to abandon a project for its salvage value. The abandonment option can be valued as an American put option on current project value with the salvage value being the exercise price. This type of flexibility is important in capital intensive industries such as airlines and energy as well as in new product development in uncertain markets.
3. Further, an abandonment option offers the possibility to make the investment in stages, deciding at each stage, based on the newest information, whether to proceed further or whether to stop and lose the initial investment. This is the value of a staged investment option (e.g., Carr, 1988; Majd and Pindyck, 1987).
4. The option to alter (contract or expand) operating scale represents the possibility to adjust the scale of the investment depending on whether market conditions turn out favorably or not (e.g., Pindyck, 1988; Trigeorgis and Mason, 1987).
5. A switching option allows changing the mode of operation of an asset, depending on factor prices, e.g. switching the energy source of a power plant or switching raw material suppliers (e.g., Kulatilaka, 1993; Triantis and Hodder, 1990).
6. Finally, there is a growing literature in the field of growth options, that is investments that enhance firm growth, e.g., by creating the opportunity to produce new products and even new businesses or enter new markets. The value of such investments may derive not so much from their expected cash flow, but rather from the future growth opportunities that they offer (e.g., Kester, 1984; Kulatilaka and Perotti, 1998).

Real Options Applications and Future Research Directions

Besides the theoretical work described earlier, which views and analyzes investment opportunities as options, real options applications have also received increased attention. Early applications of real options arose in the area of natural resources. Brennan and Schwartz (1985), recognizing the high degree of uncertainty attached to output prices of natural resource investments, applied option-pricing techniques to the evaluation of such investments. Soon after, Paddock, Siegel and Smith (1988) applied real options valuation to offshore petroleum leases. They provide the first empirical evidence that the values obtained with real options valuation are better than actual DCF-based bids in valuing such leases.

In real estate development, Titman (1985) and Capozza and Li (1994), among others, showed that the value of vacant land should reflect not only its value based on its best use according to current market conditions but also its option value if development is delayed and the land is converted into its best alternative use in the future. Furthermore, there is empirical evidence that option-based land values that incorporate the option to wait provide better approximations of actual market prices (Quigg, 1993).

In the area of manufacturing, Kulatilaka (1993) valued the flexibility provided by a dual-fuel industrial steam boiler that can switch between natural gas and oil as their relative prices fluctuate and finds that the value of this flexibility exceeds the incremental cost over a single-fuel alternative. There is also a great corpus of literature in real options that examines firms' R&D investment strategies. Secondly, there is both market and technical uncertainty. Due to the innovative nature of the product of an R&D process, there is high uncertainty as to the costs and revenues related to it but also over the physical completeness of the project that has to do with technical feasibility. Moreover, managers are open to many options during the R&D process. For example, they can wait until some of the market uncertainty has been resolved, or invest in stages so that at each stage they preserve the opportunity to abandon the investment based on the newest information. (e.g. Pennings and Lint, 1997; Huchzermeier and Loch, 2001; McGrath and Nerkar, 2004).

Early applications of the methodology of real options to investment analysis were based on a set of simplistic assumptions, e.g. about the market structure, the information set or the risk attitudes of decision makers. Recent developments include, among others, exploring competitive counteractions, market structure and strategic issues using game theoretic tools (e.g. Grenadier, 2002) as well as incorporating information asymmetries and extending the theory in an agency context (e.g. Grenadier and Wang, 2005).

Conclusion and Areas of Research and Development

Real options capture the value of managerial flexibility to adapt decisions in response to unexpected market conditions. Traditional capital budgeting assumes management is passively committed to project implementation. Thus, traditional methods (e.g. net present value) fail to accurately capture the value of the decision rights of managers to actively manage their investment opportunities in an environment of widespread uncertainty and rapid change. The real options method applies financial options theory to the evaluation of non-financial assets, in order to quantify the value of management flexibility in a world of uncertainty. It represents the new state-of-the-art technique for the valuation and management of strategic investments. This new approach to investment analysis enables corporate decision-makers to leverage uncertainty and limit downside risk. If used as a conceptual tool, it allows management to characterize and communicate the strategic value of an investment project. Real options bridge the gap between finance and strategic planning by providing a means to incorporate both the impact of uncertainty inherent in investment opportunities and how managerial actions can limit losses or capitalize on upside potential. This valuation process not only guides managers to focus on the different opportunities and strategic alternatives, but also provides a systematic methodology to measure the influence of contingent actions on project value.

Active research in the field of Real Options is being pursued within the Management Science Laboratory. The purpose of the research is to advance the existing methodology of Real Options by incorporating information asymmetries and examining the impact of variations in the level of information uncertainty. Specifically, using a Real Options approach, the research examines how the efficiency of corporate investment and decision making is influenced by problems of asymmetric information and agency. It is found that these issues may have a considerable impact on optimal decision making. Further, the implications of time-varying information uncertainty for real option decision-making are examined. The level of information uncertainty, widely known as volatility, is of special importance in real options given the longer time duration of real options relative to financial options. However, the correct specification of the volatility level remains largely untreated. Although a lot of research has been conducted along this line and a variety of tools have been developed in

economics and finance, adaptation in a real options context is required.

REFERENCES

- Brennan, M., and E. Schwartz, 1985, Evaluating Natural Resource Investments, *Journal of Business* 58, 135?157
- Capozza, D., and Y. Li, 1994, The Intensity and Timing of Investment: The Case of Land. *American Economic Review* 84, 889-904
- Carr, P., 1988, The Valuation of Sequential Exchange Opportunities, *Journal of Finance* 43, 1235-1256
- Grenadier, S. R, 2002, Option Exercise Games: An Application to the Equilibrium Investment Strategies of Firms, *Review of Financial Studies* 15, 691: 721
- Huchzermeier, A., and C.H. Loch, 2001, Project Management Under Risk: Using the Real Options Approach to Evaluate Flexibility in R&D. *Management Science* 47 1359-1377
- Kester, W. C., 1984, Today's Options for Tomorrow's Growth, Harvard *Business Review* 62, 153-160
- Kulatilaka, N., and E. C. Perotti, 1998, Strategic Growth Options, *Management Science* 44, 1021-1031
- Kulatilaka, N., 1993, The Value of Flexibility: The Case of a Dual-Fuel Industrial Steam Boiler, *Financial Management* 22, 271-279
- Majd, S., and R.S. Pindyck, 1987, Time to Build, Option Value, and Investment Decisions, *Journal of Financial Economics* 18, 7-27
- McDonald, R., and D. Siegel, 1986, The Value of Waiting to Invest. *The Quarterly Journal of Economics* 101, 707-728
- McGrath, R.G., and A. Nerkar, 2004, Real Options Reasoning and a new Look at the R&D investment Strategies of Pharmaceutical Firms, *Strategic Management Journal* 25, 1-21
- Myers, S. C., 1977, Determinants of Corporate Borrowing, *Journal of Financial Economics* 5 (2), 147-176
- Myers, S.C., and S. Majd, 1990, Abandonment Value and Project Life, *Advances in Futures and Options Research* (4), 1-21
- Paddock, J.L., D.R. Siegel and J.L. Smith, 1988, Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases, *Quarterly Journal of Economics* 103, 479-508
- Pennings, E., and O. Lint, 1997, The Option Value of Advanced R&D, European Journal of Operational Research 103, 83-94
- Pindyck, R., 1988, Irreversible Investment, Capacity Choice, and the Value of the Firm, *American Economic Review* 78, 969-985
- Pindyck, R.S., 1991, Irreversibility, Uncertainty, and Investment, *Journal of Economic Literature* 29, 1110-1148
- Quigg, L., 1993, Empirical Testing of Real Option-Pricing Models, Journal of Finance 48, 621-640
- Titman, S., 1985, Urban Land Prices Under Uncertainty, *American Economic Review* 75, 505-514
- Triantis, A.J., and J.E. Hodder, 1990, Valuing Flexibility as a Complex Option, *Journal of Finance* 45, 549-565
- Trigeorgis, L., and S. P. Mason, 1987, Valuing Managerial Flexibility, *Midland Corporate Finance Journal* 5, 14-21