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REAL OPTIONS

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Abstract

The *Real Options Valuation* (ROV) approach to *strategic investments* = “Creating Value Through Flexibility.” ROV values dynamic risk = danger (wei) + opportunity (ji).

With technologies changing, competition increasing and product cycles getting shorter, managers are faced with tough strategic choices whose outcomes will determine the success or failure of their enterprises. The strategically most valuable projects are also the most risky. Such strategic investments are made in the face of fundamental uncertainty. Consider a few recent examples, recently mentioned to me by Nalim Kulatilaka:

- How much should BP pay to Kazakhstan for the drilling rights to offshore oil reserves in the Caspian Sea?
- Should GM enter the Chinese market even if they expect to make losses in the first 10 years?
- How do you accurately value the film rights in Bollywood (= India's Bombay “Hollywood”)?
- How much should Verizon Wireless pay to secure spectrum to launch their 3G service?
- How much is the iPod worth for Apple Computer?
- How should Pfizer write a license with a small biotech firm for the development rights for a cholesterol-reducing drug that is in the early stages of development?
- What should be the value of XM and Sirius Satellite Radio?
- How should Intel manage their investments in the next microprocessor?
- How much should P&G pay to acquire the Gillette brand?

As a new valuation, project management, and strategic decision-making paradigm, ROV is revolutionizing the corporate world through its ability to deal with the unprecedented rate of economic change that has created a new, much higher, level of uncertainty about technologies and industries. ROV, which capitalizes on this uncertainty, provides the basis for a decision-making culture, which is conducive to adaptation, learning, risk taking and innovation. ROV captures both the value of managerial flexibility, which allows a firm to adapt to unexpected market developments, as well as the strategic value that results from proving a new technology, capitalizing on dynamic or cross-project synergies, and strategic or competitive positioning.

What will you learn in this Real Options course? You'll learn:

- How to make flexible step-by-step decisions and adapt to change to gain competitive advantage
- How to take advantage of uncertainty to capitalize on upside opportunities while limiting downside risk
- How to translate corporate strategic plans into forward-looking real option value that enhances shareholders' wealth and market price
- How to communicate the advantages of options thinking compared to conventional discounted cash flow (DCF) analysis
- How to structure your contracts to leave you valuable flexibility
- How to quantify the value of strategic investment opportunities
- How to value both high technology (bio-engineering, pharmaceuticals, telecoms, internet and media) and raw materials extraction (oil and gas and other energy) companies, in particular in new, emerging markets
- How to benefit from the experiences of leading corporations that are currently using ROV

ROV emphasizes that strategic investment is a multi-stage management process, involving problem structuring, evaluation, and implementation stages. It enables us to value a business taking account of its embedded strategic options that drive its potential for growth. Thus ROV is a useful approach for CEOs, CFOs, Heads of Strategy, Vice Presidents, Directors, Investment Bankers, Operating Managers and Analysts in:

- Corporate Finance
- Strategic Planning
- Portfolio Management
- Risk Management
- Market Valuation/Security Analysis
- Information Technology
- R&D
- Marketing

Faced with uncertain decisions, managers intuitively know they have the option to defer, stage, abandon or expand a project, or even switch funds to a more profitable financial opportunity, yet the traditional static DCF framework of capital budgeting fails to take such managerial flexibility into account. ROV is revolutionizing corporate strategy by bridging the existing gap between finance and strategic planning. Just as an option gives its owner the right - but not the obligation - to take a particular course of action at some time in the future, *flexibility* embedded in capital investment projects and company strategies allows managers to take a *staged approach* to strategy and react to changes in the business environment, so they can limit downside losses while fully capitalizing on upside potential opportunities. For example, the multi-stage process to go public in an IPO offering can significantly benefit from a proper ROV analysis. Other such multi-stage processes include the venture capital and M&A negotiations.

In such settings, multiple stochastic variables are identified to define a sufficient state space for decision-making. With the ROV framework one can analyze the impact of random competitive arrivals and simple game-theoretic competitive reactions. ROV assesses the value in *contingent, multistage*, evolving business *dynamics* with a *network*

of many *embedded options* under *uncertainty*. When analytic solutions are not available, numerical methods based on *simulation*, *finite-difference* or *lattice* methods are used to solve complex option problems with multiple *interacting options* and multiple underlying uncertainties.

Thus ROV provides a systematic methodology to measure the influence of contingent actions on the very nature of risk itself and its impact on the valuation of strategic investments and management. ROV imposes also financial discipline since it shows how a corporation can consistently evaluate and compare its alternatives, whether they are to invest in instruments traded in the financial markets or in non-traded physical assets.

Pre-requisites

A course on Corporate Finance and basic knowledge of option valuation

Readings

The theoretical foundation for the Real Options Valuation (ROV) of strategic investments goes back to the evaluation of natural resources by Michael Brennan and Eduardo Schwarz (*Journal of Business*, **58-2**, 1985, pages 135-157, updating the much earlier work of Houthakker on the same issue) and the development of a real option model to abandon by Robert McDonald and Daniel Siegel (*International Economic Review*, **26-2**, 1985, pages 331-349) that forms the basis for many current applications of ROV.

But it is only in the past decade that the theory rapidly expanded, i.a. by the efforts of Professors Trigeorgis, Amram and Kulatilaka, and became empirically enriched thanks to increased case research activity at top business schools. We will essentially read their two classic texts on ROV in parallel, since the Drucker MBA students have a variety of educational backgrounds. These two texts appeal to different groups of students. The first text is less technical and more managerial. The second text is more technical and less managerial. I advise you to read about a particular topic first in AK and then in T, both of which I recommend you to purchase:

[AK] Amram, Martha, and Nalin Kulatilaka (1999) *Real Options: Managing Strategic Investment in an Uncertain World*, Harvard Business School Press, Boston, MA (ISBN: 0-87584-845-1).

[T] Trigeorgis, Lenos (1998) *Managerial Flexibility and Strategy in Resource Allocation*, The MIT Press, Cambridge, MA (ISBN: 0-262-20102-X).

For those students who are familiar with the required Corporate Finance, but still unfamiliar with basic financial option theory, I'll refer to three chapters in Professor Hull's excellent book:

[H] Hull, John C. (2005) *Fundamentals of Futures and Options Markets*, Pearson/Prentice hall, Upper Saddle River, NJ, 5th ed. (ISBN: 0-13-144565-0).

For the technical measurement and analysis of the modern concept of "uncertainty," which is a much broader concept than the concepts of "randomness" and of "probability" (as Chicago economist Frank Knight already pointed out in 1921), I'll refer to the first chapter in my own book (hand-out):

[L] Los, Cornelis A. (2003) *Financial Market Risk: Measurement and analysis*, Routledge/Taylor & Francis Group, London (ISBN: 0-415-27866-X hbk; 0-415-77113-7 pbk).

There is a close and very interesting connection between real strategic investments (= networks of real options) and *differential games*, which is of great importance to innovating high technology firms. It emphasizes the connection between *complexity* and the broader concept of uncertainty. So we will spend some time on this issue by reading four chapters of the following book (hand-out):

[ST] Smit, Han T. J., and Lenos Trigeorgis (2004) *Strategic Investment: Real Options and Games*, Princeton University Press, Princeton, NJ (ISBN: 0-691-01039-0).

The most recent developments in ROV research are related to nontraditional sources of ROV uncertainty, e.g., incomplete markets and non-Gaussian, for example, multi-fractal noise. We'll discuss two such sources: first, scientific discoveries and intellectual innovation, only imperfectly protected by patents. To stimulate potential research interest, I refer first to a few chapters in the PhD dissertation by Dr. Philipp Baecker of the European Business School in Germany:

[B] Baecker, Philipp N. (2007) *Real Options and Intellectual Property: Capital Budgeting Under Imperfect Patent Protection*, Springer, Berlin, Germany (ISBN: 3-540-48263-5).

A second source of ROV uncertainty is non-constant interest rates and their various dynamic model specifications. I'll refer to a few chapters in the PhD dissertation by Dr. Schulmerich, VP of the Allianz Global Investors Group in München, also in Germany:

[S] Schulmerich, Marcus (2005) *Real Options Valuation: The Importance of Interest Rate Modelling in Theory and Practice*, Springer, Berlin (ISBN: 3-540-26191-5).

Both B and S are available in the Claremont Colleges Library. I'll also present some very recent results of the fractal modeling and wavelet multi-resolution analysis (MRA) of the US term structure by my PhD (2005) student in the MSFE program at Kent State University, Sutthisit Jamdee from Thailand.

A fine recapitulation and summary of the ROV approach is provided in the second chapter of the book by Alexander Vollert (hand-out):

[V] Vollert, Alexander (2003) *A Stochastic Control Framework for Real Options in Strategic Evaluation*, Birkhäuser, Boston (ISBN: 0-8176-4258-7).

Cases and Software

The two main texts of Amram, Kulatilaka and Trigeorgis contain many real world cases. In addition, we may want to read a few more specific case studies to read, to see the ROV framework applied in practice, in preparation for your projects. But that may be done according to your needs.

Jonathan Mun, the founder and CEO of Real Options valuation, Inc., a consulting, training, and software development firm specializing in real options, employee stock options, financial valuation, simulation, forecasting, and risk analysis, located in northern

California, has developed useful lattice solver, risk simulator and employee stock options valuation software, which is used at several top universities in the world:

Mun, Jonathan (2006) *Real Options Analysis: Tools and Techniques for Valuing Strategic Investments and Decisions*, 2nd ed., John Wiley & Sons, Hoboken, NJ (ISBN: 0-471-74748-3)

However, a lot of the valuation models can also be implemented by students themselves in EXCEL spreadsheets and by using MATLAB to produce fast C++ code (as Mun did when he worked as a financial economist for KPMG Consulting!):

Additional References

Copeland, Tom and Vladimir Antikarov (2001) *Real Options: A Practitioner's Guide*, Texere Publishing, New York (ISBN: 1-58799-028-8).

Neftci, Salih N. (2004) *Principles of Financial Engineering*, Elsevier Academic Press, Amsterdam, The Netherlands (ISBN: 0-12-515394-5).

Paxson, Dean A. (Ed.) (2003) *Real R&D Options*, Butterworth-Heinemann, Oxford, UK (ISBN: 0-7506-5332-9).

Project

A key component of this course is an ROV project, where you conduct a strategic analysis and valuation of growth options in a (public or non-public) company of your choice and write a 5-page original report (Plagiarism will be severely punished!). Using the tools of the course, your analysis will contain evaluation of the competitive environment (including uncertainty factors); analysis of the upcoming stages of development and their risks; and a valuation analysis benchmarked to pricing and norms in the financial markets. Since I'm scheduled to teach the Drucker Asset Management Practicum in the Spring semester, you may want to use this ROV project to explore already the valuations of lesser known, early stage growth (venture capital?) companies. This project will be something you can show potential or current employers, as a way of introducing your knowledge of advanced strategy and finance skills.

Grading

Grading will be based on a mid term exam (35%), a final exam (35%) and your project report (30%).

Websites with Extensive Bibliographies

<http://www.real-options.com>

Home page of the AK book by Martha Amram and Nalin Kulatilaka, with information, bibliography, case studies, FAQ, links, conferences, and more.

<http://www.realoptions.org/>

This site archives the large number of academic papers presented at the annual real options conferences, 1999 - 2006, organized by Lenos Trigeorgis, current President of the Real Options Group (ROG), an influential world-wide business consulting partnership, which has organized the Annual Real Options Conference since 1999. The

most recent, 11th Conference took place at the Haas Business School of the University of California at Berkeley, June 6 - 9, 2007 and focused on real options to grow!

<http://www.rhsmith.umd.edu/finance/atriantis/RealOptionsportal.html>

An excellent resource for real options. Professor Alex Triantis has organized over 500 articles and books about real options into a searchable database.

<http://www.puc-rio.br/marco.ind/main.html>

A rich site with downloadable tools, many links and references to research articles. Created and maintained by Marco Antonio Guimarães Dias, a petroleum engineer and technical consultant at Petrobras.

<http://www.real-options.de/index.html>

A website devoted to real options, based in Germany. Created and maintained by Prof. Ulrich Hommel of the European Business School in Vallendar, Germany.

CLASSES MONDAY EVENINGS 7:00- 10:00PM	TOPICS	READINGS & ASSIGNMENT
Sept 10	Real Options potential; Valuation principles and capital budgeting (review); When does DCF fail? What is uncertainty? What is complexity? How do we measure risk? Stochastic processes; Risk = Opportunity + Danger	AK: Chapters 1, 2 T: Chapter 1, 2 L: Chapter 1 (hand-out) [A general financial engineering reference is Neftci]
Sept 17	Real vs. financial options; Black-Scholes option valuation model; ROV four-step solution process	AK: Chapters 3, 4, 7 T: Chapter 3 (cf. H: Chapter 9, 12)
Sept 24	Binomial option valuation model; capital budgeting with options; Pharmaceutical R&D and other sequential investments	AK: Chapters 8, 9, 13 T: Chapter 4 (cf. H: Chapter 11), and Section 11. 1 [For more on Real R&D Options, cf. Paxson]
Oct 1	Valuing oil & gas exploration, mining, vacant land, and infrastructure projects	AK: Chapters 12,15 T: Sections 11.3 and 11.5 ST: Sections 3.4, 3.5
Oct 8	Valuing real and financial flexibility; Oil or gas boilers? What is the optimal operating strategy for an oil refinery? Dynamic programming	AK: Chapters 16, 17 T: Chapters 5, 6
Oct 15	Valuing information technology investments; Valuing pioneer ventures and early stage growth companies; Present your industry choices	AK: Chapter 14 T: Section 11.2 ST: Chapter 1

Oct 22	MIDTERM EXAM	
Oct 29	Real options and multi-stage games; interactions and irreversibility; joint R&D	T: Chapters 7, 8 ST: Chapter 2, 5
Nov 5	Strategic planning, flexibility, commitment, irreversibility; Nash price competition, monopoly, Stackelberg price leadership; tobacco advertising games	T: Chapter 9 ST: Chapter 6
Nov 12	Investing to preempt competition	AK: Chapter 18 T: Chapter 9
Nov 19	Valuing start-ups; IPO's and post-IPO management of real options	AK: Chapters 10, 11
Nov 26	Valuing intellectual property; patents as investment opportunities; patent risk as an option to litigate; patent protection in the pharmaceutical industry	B: Chapters 2, 4, 6, 11 (Don't go too deep in the mathematical intricacies! This is meant to be a show case)
Dec 3	Real options and non-constant interest rates; one-, two-, and multi-factor term structure models; Schwartz-Moon, Ingersoll-Ross, Cox-Ross-Rubinstein and Trigeorgis models	S: Chapters 3, 4
Dec 10	Review and recap; real options to invest, to defer, to stage (time-to-build), to alter operating scale, to abandon, to switch, to grow; multiple interacting options; Hand in your ROV Project	V: Chapter 2 (hand-out)
Dec 17	FINAL EXAM	