Economics 659: Real Options and Investment Under Uncertainty
Course Outline, Winter 2008

**Professor:** Margaret Insley
**Office:** HH211 (Ext. 32422). E-mail: minsley@uwaterloo.ca
**Office Hours:** 9:30-11, Tuesday and Thursday or by appointment
**Class time and location:** Tues & Thurs, 1:00-2:20 pm, ML, Room 315.
**Class Number:** 2146

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**COURSE DESCRIPTION**
This course considers the application of option concepts from finance to valuing real assets and investment opportunities. The focus is on using real options theory and methodology to value investments characterized by uncertainty, irreversibility, and flexibility in the timing of irreversible expenditures. The course begins with an introduction to stochastic processes, Ito’s Lemma, the Black-Scholes equation, contingent claims analysis and dynamic programming. Methods to solve simple option value problems will be presented, such as binomial trees and Monte Carlo simulation. Applications will focus on problems in natural resource and environmental economics, such as valuing the option to drill for oil or install pollution control equipment and, time permitting, other applications in economics.

**BACKGROUND REQUIRED**
In addition to standard economic theory, basic calculus and linear algebra are required. No knowledge of stochastic calculus or advanced finance is assumed. Students are expected to become proficient in Matlab.

**EVALUATION**

<table>
<thead>
<tr>
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<th>Weighting in final grade</th>
<th>Due date</th>
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<tbody>
<tr>
<td>Assignment 1</td>
<td>10%</td>
<td>Feb 5</td>
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<td>Assignment 2</td>
<td>10%</td>
<td>March 6</td>
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<td>Assignment 3</td>
<td>10%</td>
<td>Ap 3</td>
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<tr>
<td>Project</td>
<td>25%</td>
<td>Topic due: Feb 27</td>
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<td>Project due: April 7</td>
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<td>Final exam</td>
<td>45%</td>
<td>TBA</td>
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**Project Details:**
The project will consist of a written review (up to 15 pages in length) of one or two journal articles and an in-class presentation. The article(s) are to be an application of real options theory/methodology to an economics problem. Paper selections must be
approved by the instructor by Wed. February 27. The project will be marked out of 100, with up to 20 marks awarded for the presentation. The written review and presentation will identify the problem being examined, clearly describe the model and discuss its results in the context of course material and relevant literature. Although the focus will be on 1-2 papers, you will also need to discuss other relevant papers so that the contribution of the paper(s) to the relevant literature is clearly explained. The oral presentations will be scheduled sometime in March or April. The written review is due on April 7. More instructions regarding the project will be handed out during the term.

REFERENCES
(Where possible I will place these on reserve in the Porter library.)


Schwartz, Eduardo and Lenos Trigeorgis (2001) Real Options and Investment under Uncertainty, MIT.


TENTATIVE LIST OF TOPICS
This list of topics may be adjusted during the term depending on interest and timing. Readings will be assigned throughout the term.

I. Introduction
   1. Traditional investment theory versus the options approach
   2. Financial options
   3. A two period example of valuing an investment under uncertainty
   4. Extending the example to more periods
   5. Other types of real options
II. Review of traditional capital budgeting
   1. Financial objective of the firm
   2. Net present value under certainty
   3. Net present value under uncertainty
      a. Certainty equivalent
      b. Risk adjusted discount rate
   4. Mean variance portfolio optimization and the capital asset pricing model

III. Stochastic processes and Ito’s lemma
   1. Introduction to stochastic processes
   2. The Wiener process
   3. The generalized Wiener process.
   4. Random walk representation of Brownian motion
   5. Ito processes
   6. Ito’s Lemma

IV. Dynamic optimization under uncertainty
   1. Dynamic programming and the Bellman equation
   2. Contingent claims approach to valuing a risky asset, Black Scholes equation
   3. Risk neutral valuation

V. Simple models of investment valuation and optimal investment timing
   1. A basic investment problem when the value of the project follows GBM
   2. A more realistic problem – profits depend on an uncertain price and costs are known
   3. Other examples

VI. Models of investment that require numerical solution
   1. Binomial trees
   2. Monte Carlo approach

VI. Applications: A consideration of real options applications that have appeared in the literature

The following is a list of papers that apply real options theory.


2. Jon Conrad and Koji Kotani, When to Drill? Trigger Prices for the Arctic National Wildlife Refuge, Resource and Energy Economics, vol 27, no. 4, 273-86, November 2005. Also see the comment and erratum on this article:


**Avoidance of academic offenses**

All students registered in the courses of the Faculty of Arts are expected to know what constitutes an academic offense, to avoid committing academic offenses, and to take responsibility for their academic actions. When the commission of an offense is established, disciplinary penalties will be imposed in accord with Policy #71, Student Academic Discipline. For information on categories of offenses and types of penalties, students are directed to consult the summary of Policy #71, Student Academic Discipline [http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm](http://www.adm.uwaterloo.ca/infosec/Policies/policy71.htm)

If you need help in learning how to avoid offenses such as plagiarism, cheating, and double submission, or if you need clarification of aspects of the discipline policy, ask your course instructor for guidance. Other resources regarding the discipline policy are the graduate advisor and the Associate Dean of Graduate Affairs. Students who believe that they have been
wrongfully or unjustly penalized have the right to grieve; refer to Policy #70, Student Grievance
http://www.adm.uwaterloo.ca/infosec/Policies/policy70.htm

**Note for students with disabilities**: The Office for Persons with Disabilities (OPD), located in Needles Hall, Room 1132, collaborates with all academic departments to arrange appropriate accommodations for students with disabilities without compromising the academic integrity of the curriculum. If you require academic accommodations to lessen the impact of your disability, please register with the OPD at the beginning of each academic term.