COLORADOSCHOOLOFMINES

Subject: Finance/Capital Budgeting/Valuation/Real Options/Optimal Timing

Number: EBGN575

Course Title: Advanced Mining and Energy Asset Valuation©

Section: A

Semester/year: Spring 2017

Instructor: Graham A. Davis

Contact information (Office/Phone/Email): EH325/303 273-3550/gdavis@mines.edu

Office hours: Wednesdays 11:00 AM to 4:00 PM, or by appointment.

Class meeting days/times: Tuesdays and Thursdays 5:00 PM – 6:15 PM

Class meeting location: EH211

Instructional activity: _3_ hours lecture _0_ hours lab _3_ semester hours

Course designation: ___ Common Core ___ Distributed Science or Engineering

___ Major requirement _X_ Elective ___ Other (please describe _____)

Course description from Bulletin: The use of stochastic and option pricing techniques in mineral and energy asset valuation. The Hotelling Valuation Principle. The measurement of political risk and its impact on project value. Extensive use of real cases. Prerequisites: Principles of Microeconomics, MATH111, EBGN504, EBGN505, EBGN509, EBGN510, EBGN511; or permission of instructor.

Textbook and/or other requirement materials:

Required text: Guthrie, Graeme, Real Options in Theory and Practice, Oxford: Oxford University Press, 2009.

Other required supplemental information: will be provided on Blackboard

Student learning outcomes: At the conclusion of the class students will…

1. Produce the financial valuation component of mineral and energy venture scoping, pre-feasibility and feasibility studies
2. Incorporate uncertainty into mineral and energy asset valuation
3. Describe the classical literature on real asset valuation
4. Incorporate option-pricing theory into mineral and energy asset valuation and management
5. Read advances in real options techniques as they are discovered and reported in the literature

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6. Implement these advances when conducting asset valuations
7. Be employable and make big $$$

Brief list of topics covered:

1. Cost Approach to Valuation
2. Comparable Sales Approach to Valuation
3. The Income Approach to Valuation
4. The Need for Simulation
5. Evaluating Flexibility in Project Management and Design
6. Modern Valuation Techniques/Real Option Valuation

Policy on disability support:

The Colorado School of Mines is committed to ensuring the full participation of all students in its programs, including students with disabilities. If you are registered with Disability Support Services (DSS) and I have received your letter of accommodations, please contact me at your earliest convenience so we can discuss your needs in this course. For questions or other inquiries regarding disabilities, I encourage you to visit disabilities.mines.edu for more information.

Policy on academic integrity/misconduct: The Colorado School of Mines affirms the principle that all individuals associated with the Mines academic community have a responsibility for establishing, maintaining and fostering an understanding and appreciation for academic integrity. In broad terms, this implies protecting the environment of mutual trust within which scholarly exchange occurs, supporting the ability of the faculty to fairly and effectively evaluate every student's academic achievements, and giving credence to the university's educational mission, its scholarly objectives and the substance of the degrees it awards. The protection of academic integrity requires there to be clear and consistent standards, as well as confrontation and sanctions when individuals violate those standards. The Colorado School of Mines desires an environment free of any and all forms of academic misconduct and expects students to act with integrity at all times.

Academic misconduct is the intentional act of fraud, in which an individual seeks to claim credit for the work and efforts of another without authorization, or uses unauthorized materials or fabricated information in any academic exercise. Student Academic Misconduct arises when a student violates the principle of academic integrity. Such behavior erodes mutual trust, distorts the fair evaluation of academic achievements, violates the ethical code of behavior upon which education and scholarship rest, and undermines the credibility of the university. Because of the serious institutional and individual ramifications, student misconduct arising from violations of academic integrity is not tolerated at Mines. If a student is found to have engaged in such misconduct sanctions such as change of a grade, loss of institutional privileges, or academic suspension or dismissal may be imposed.

The complete policy is online.

Since there are no exams, and since I am to give you a grade that signals to the broader community your competence in this area, I must insist that the weekly projects or question sets that I am grading be done individually unless I have approved group work. Some discussion among yourselves is of course healthy and valuable, and I encourage this. I also encourage you to share data downloaded from public sources, and to learn from each other on the weeks that the assignments are not handed in. But complete the hand-in assignments individually. I do not want to see joint production. I cannot emphasize this enough. If I find that students are working together or copying from past years' assignments, all parties involved will be awarded an F for the assignment and possibly the course.

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Grading Procedures: Individual assignments and projects that have a quality acceptable for graduate credit will be awarded a grade of A (4.0), A- (3.7), B+ (3.3), or B (3.0), with the grade reflecting the proficiency of the work. Work that is below par but may be acceptable for graduate credit if sufficient acceptable work is done in this class and in other classes such that a 3.0 GPA can be maintained will be awarded grades of B- (2.7), C+ (2.3), C (2.0), or C- (1.7), with the grade reflecting the proficiency of the work. Work that is unacceptable for graduate credit is awarded a grade of D+ (1.3), D (1.0), D- (0.7), or F (0.0), with the grade reflecting the proficiency of the work. The final grade for the course will be a weighted average of the grades on the individual assignments and the final project, calculated just as a grade point average is calculated. The receipt of an **×** for a weekly assignment (see below) will lower your grade by one letter division (e.g. B+ to B).

Coursework Return Policy: I will endeavor to return assignments, with comments and a grade, within 7 days of receiving them, and in all cases within 14 days of receiving them.

Absence Policy: I have no attendance policy – I assume graduate students are mature enough to optimally allocate their time given their budget and time constraints. There is no class participation grade. However, in some cases your presence will be required, as in cases where there is a presentation or group presentation. If you miss handing in or presenting an assignment because of an event that CSM classifies as an "excused absence" (see http://inside.mines.edu/Student-Absences), I will allow you to present or hand in a substitute assignment at a later date.

Homework: Due to the fact that we cover answers in class, homework and assignments must be turned in by the time they are due. For this reason I suggest you do not plan to hand assignments in at the very last minute.

Detailed Course Description and Schedule:

This course, which follows on from Professor Stermole's Engineering Economics course (EBGN504), mainly explores advanced discounted cash flow techniques and the emerging use of option pricing theory in the valuation and management of mineral and energy firms and properties. It will also fill in a gap in our micro courses by providing theory and insights into irreversible capital investments. We first review two other approaches to valuation, the cost approach and the comparison sales approach, that are prevalent in industry regulation. We then review traditional discounted cash flow (DCF) and Monte Carlo DCF valuation techniques. Monte Carlo techniques are an attempt to more rigorously deal with the uncertainty in capital budgeting. Following this, the third section of the course delves into the more difficult use of option pricing theory in valuation and property operation. This "real options" section takes up a good portion of the course. The course ends with a capstone valuation case. The presentation of this case will take place during the scheduled final exam period.

Textbooks

There is no one textbook that neatly covers all of the material in the course. For the real options component of the course we will be using Graeme Guthrie's Real Options in Theory and Practice (2009, Oxford University Press). I like John C. Hull's book, Options, Futures, and Other Derivative Securities, any edition, for the financial theory behind derivative asset valuation and will most likely provide you with some scans of chapters from there. I will supplement the Guthrie book by individual articles that I will either provide you with on Blackboard or in hardcopy. I also recommend Avinash Dixit and Robert Pindyck, Investment Under Uncertainty (1994, Princeton University Press) as a more advanced text on real options, though we will not be using it in this class. For those who would like an NPV refresher text, I recommend Professor Stermole's book, which also deals nicely with the rules for taxing mineral rents in the United States.

To keep up with the latest in real options articles and ideas, visit the well-maintained real options web site http://www.realoptions.org/. The site also has electronic copies of papers delivered at the past annual real options conferences. Two other sites, http://www.real-options.com/resources_links.htm, and

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http://marcoagd.usuarios.rdc.puc-rio.br/, have some resources on them, but they are no longer maintained and updated.

Course Tools

Blackboard is the point of reference for all materials each week. I will also use Blackboard to post messages and certain additional items and papers. We will also be using Oracle's Crystal Ball Monte Carlo software, which is installed on the EB server and available in our computer labs. Finally, we may use Hull's Derivagem option pricing software, available on the EB server.

Course Design and Requirements

Research has shown that lecturing is a poor method of instruction. Students typically "tune out" for about 50% of a lecture, and retain very little: three months after a course, students that have taken the course know only 8% more on the course topic than students that have not taken the course. I have therefore structured this course in a way that will improve learning and retention. Most weeks a project or question set will be assigned along with some suggested readings and several optional readings. I will always give you more work than is humanly possible to complete: always look carefully at the required readings, and then in the remaining optional readings continue with what interests you and fulfills your own particular needs. In the Thursday lecture, I will lead a discussion of the week's readings, bringing out the important points and clarifying any problem areas. In most Tuesday lectures a designated student or group of students will present the results of the assignment and field any questions. An anonymous student will perform and publish a peer review of the presentation. My job will be to help the presenting students out if they get stuck, and to moderate if necessary. This will not only give you good practice at presenting financial analyses and leading discussions, but will also generate a true "seminar" environment. Since the class is small, you will each have at least one opportunity to present.

Each project or question set must be completed by the students not presenting. Assignments tend to build on the previous week's assignment. Every third week or so I will ask you to hand in an assignment for grading. Since the assignments build on one another, you should have plenty of incentive to do the assignments each week even though you are not handing them in. Even so, to provide you with more incentive I will randomly ask a few individuals not presenting each week to hand in their work to show me that they have done it. This will be graded either as a ✓ or ×. The presenters for the week will be graded on their classroom presentation, and are not required to hand anything in. The graded assignments and presentations will each be weighted equally, totaling 70% of the grade. The capstone case, in week 15, will be worth the remaining 30% of the grade.

I assign a healthy amount of work for each week based on the premise that 3 courses is a full time load at the graduate level. Note, however, that only a modest amount of work is required for a passing grade, and that students have done well without spending long hours on the assignments. What I am looking for in these assignments is clear presentation of the results, not necessarily fancy presentations and pages and pages of text. Handwritten work is fine (do not waste hours using MSWord's Equation Editor or making your Powerpoint presentation fancy!). Another key to staying on top of things is to do some of the work each day and make use of my office hours. Do not attempt to do the entire assignment or read all of the required readings the night before it is due.

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Weekly Outline

I. Cost Approach, Comparable Sales Approach

Week 1 Definition of Value, Cost Approach, Comparable Sales Approach

Definition of Value (oil): H3070-2 Economic Evaluation of Oil and Gas Properties Handbook, US Bureau of Land Management (circa 1992).

Definition of Value and Valuation Standards (mining): Standards and Guidelines for Valuation of Mineral Properties, Special Committee of the Canadian Institute of Mining, Metallurgy and Petroleum on Valuation of Mineral Properties, February 2003.

Definition of Value and Valuation Standards (mining and oil): Code for the Technical Assessment and Valuation of Mineral and Petroleum Assets and Securities for Independent Expert Reports (The Valmin Code, 2005 edition).

On Defining Resources (mining): CIM Definition Standards 2014.

Cost Approach: William E. Roscoe, "Valuation of Mineral Exploration Properties Using the Cost Approach," in Mineral Resources/Reserves and Valuation Standards, CIM Special Volume 56 (Montreal: The Canadian Institute of Mining, Metallurgy and Petroleum, 2009), pp. 605-15.

Comparison Sales Approach: William E. Roscoe, "Metal Transaction Ratio Analysis – A Market Approach for Valuation of Non-Producing Properties with Mineral Resources," in Valmin Seminar Series 2011-2012, Proceedings,The Australasian Institute of Mining and Metallurgym Publication Series No 3/2012, 2012, pp. 85-91.

Comparison Sales Approach: Graham A. Davis, "Some Thoughts on Mineral and Energy Property Valuation," mimeo, Colorado School of Mines, latest version January 2017.

II. Traditional DCF Valuation Techniques (Income Approach)

Week 2 Review of Basic DCF Concepts

Graham A. Davis and Robert D. Cairns, "The Odd Notion of Reversible Investment," (2017), Forthcoming, Journal of Banking and Finance.

Alexander A. Robichek and Stewart C. Myers, "Conceptual problems in the use of risk-adjusted discount rates," Journal of Finance, (December 1966): 727-730.

Optional: Richard S. Ruback, "Capital Cash Flows: A Simple Approach to Valuing Risky Cash Flows," Financial Management (Summer 2002): 85-103.

Optional: Richard Stanton and Mark. S. Seasholes, "The assumptions and math behind WACC and APV calculations," unpublished working paper, University of California Berkeley (2005).

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Week 3 Incorporating Monte Carlo and Strategy/Project Optimization into DCF Analysis

Monte Carlo:

Wilbur G. Lewellen and Michael S. Long, "Simulation versus Single-Value Estimates in Capital Expenditure Analysis," Decision Sciences Vol. 3 (1972): 19-33.

Optional: G. P. Walduck, "Decision Making Under Risk in the Mining Industry: A Risk Appraisal Case Study," in Case Histories and Methods in Mineral Resource Evaluation, ed. Alwyn E. Annels, London: The Geological Society (1992), pp. 25-32.

Optional: Jasper Bertisen and Graham A. Davis, "Bias and Error in Mine Project Capital Cost Estimation," Engineering Economist Vol. 53 (2008): 118-39.

Optional: James A. Murtha, "Monte Carlo Simulation: Its Status and Future," Journal of Petroleum Technology (April 1997): 361-70, and articles in Hart's E & P (August 2000).

Optional: Robert E. Megill. An Introduction to Risk Analysis, 2nd edition. Tulsa, PennWell Books, 1984. See pp. 43-46, 114-23, 135-37 for more on appropriate frequency distributions for energy project analysis.

Optional: Graham A. Davis, "(Mis)Use of Monte Carlo Simulations in NPV Analysis," Mining Engineering (January 1995): 75-79.

Strategy/Optimization:

Stewart C. Myers, "Finance Theory and Financial Strategy," Interfaces Vol. 14, No. 1 (January-February 1984): 126-37.

W. Carl Kester, "Today's Options for Tomorrow's Growth," Harvard Business Review Vol. 62, No. 2 (March-April 1984): 153-60.

Week 4 Stochastic Processes and Monte Carlo Simulation

John Norstad, "Random Walks," unpublished manuscript, Northwestern University (2011).

Michael. R. Samis, Graham A. Davis, and David G. Laughton, "Using stochastic discounted cash flow and Monte Carlo simulation to analyze the impacts of contingent taxes on mining projects," in Project Evaluation 2007, AusIMM, Carlton, Australia (2007), pp. 127-37.

Optional: Graham A. Davis, "Technical Note: Simulating the Two-factor Schwartz and Smith Model of Commodity Prices," Engineering Economist Vol. 57 (2012): 130-40.

Week 5 Modeling Forward-looking Strategy Using Binomial Lattices: Flexible Investment Timing and Flexible Project Management

Guthrie, Chapters 1 and 2

Typos in book: 1) p. 195, line 16 from the top: insert "and" after V_1 in "binomial trees for V_1 for V_2"; (2) p. 288, line 9 from the end of Table 12.6: replace "becomes" with "become" in "while up moves becomes"

Graham A. Davis, "A Primer on Real Options Analysis," unpublished manuscript (2007).

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Avinash K. Dixit and Robert S. Pindyck, "The Options Approach to Capital Investment," Harvard Business Review (May-June 1995): 105-15.

Daniel R. Siegel, James L. Smith, and James L. Paddock, "Valuing Offshore Oil Properties with Option Pricing Models," Midland Corporate Finance Journal Vol. 5, No. 1 (1987): 22-30. (NB: there is no Appendix A and B with this paper, even though the text refers to these)

Optional: Alberto Moel and Peter Tufano, "When Are Real Options Exercised? An Empirical Study of Mine Closings," Review of Financial Studies Vol. 15, No. 1 (2002): 35-64.

Optional: John C. Cox, Stephen A. Ross, and Mark Rubinstein, "Option pricing: A simplified approach," Journal of Financial Economics Vol. 7 (1979): 229-63.

III. Modern Valuation Techniques (Income Approach)

Weeks 6 and 7 State Pricing (a.k.a. risk-adjusted discounting, risk-neutral discounting, contingent claims analysis, modern asset pricing)

Guthrie, Chapters 3 and 4 (ignore Ch. 4 appendices)

Hull, Ch. 1 (Introduction - Forward Contracts, Futures Contracts, Summary), Ch. 2 (Mechanics of Futures Markets - everything up to Delivery), Ch. 5 (Determination of Forward and Futures Prices - ignore Known Income, Futures prices of Stock Indices, Forward and Futures Contracts on Currencies, Delivery Options, Appendix).

Graham A. Davis and Michael R. Samis, "An Overview of Modern Financial Methods for Mine Project Valuation," unpublished manuscript (2011).

Michael Samis, Graham A. Davis, David Laughton, and Richard Poulin, "Valuing Uncertain Asset Cash Flows When There are No Options: A Real Options Approach," Resources Policy 30 (2006): 285-98.

Week 8 Combining Valuation and Strategic Decision Making

Guthrie, Chapter 5

Michael J. Brennan and Eduardo S. Schwartz, "A New Approach to Evaluating Natural Resource Investments," Midland Corporate Finance Journal Vol. 3, No. 1 (1985): 37-47.

Michael Samis and Graham A. Davis, "Using Dynamic DCF and Real Options Methods to Value and Assess Flexible Mine Project Design," in Mineral Resources/Reserves and Valuation Standards, CIM Special Volume 56, Montreal: Canadian Institute of Mining, Metallurgy and Petroleum (2009): 632-50.

Week 9 Model Calibration

Guthrie, Chapters 12 and 14

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Week 10 Simple Operating Options

Guthrie, Chapter 6

Michael Hsu, “Spark spreads options are hot!,” Electricity Journal 11.2 (1998): 28-39.

Week 11 Simple Timing Options

Guthrie, Chapter 7

Eric Pickles and James L. Smith, “Petroleum Property Valuation: A Binomial Lattice Implementation of Option Pricing Theory,” Energy Journal 14.2 (1993): 1-26.

Week 12 Compound Timing Options

Guthrie, Chapter 8

Michael J. Brennan and Eduardo S. Schwartz, “Evaluating Natural Resource Investments,” Journal of Business Vol. 58, No. 2 (1985): 135-57.

Week 13 Developing a Gas Field

Guthrie, Chapter 16

Optional: Han T. J. Smit, “Investment analysis of offshore concessions in the Netherlands,” Financial Management Vol. 26, No. 2 (1997): 5-17.

Optional: James L. Paddock, Daniel R. Siegel, and James L. Smith, “Option Valuation of Claims on Real Assets: The Case of Offshore Petroleum Leases,” Quarterly Journal of Economics Vol. 103, No. 3 (August 1988): 479-508.

Optional: Petter Bjerksund and Steiner Ekern, “Managing Investment Opportunities Under Price Uncertainty: From 'Last Chance' to 'Wait and See' Strategies,” Financial Management (Autumn 1990): 65-83.

Week 14 Mothballing an Ethanol Plant, Next Steps

Guthrie, Chapters 17 and 18

Todd M. Schmit, Jianchuan Luo, and Loren W. Tauer, “Ethanol plant investment using net present value and real options analysis,” Biomass and Bioenergy Vol. 33 (2009): 1442-51.

T. M. Schmit, J. Luo, and J. M. Conrad, “Estimating the influence of U.S. ethanol policy on plant investment decisions: A real options analysis with two stochastic variables,” Energy Economics Vol. 33 (2011): 1194-1205.

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IV. Capstone Case

Week 15 Final Case Study TBA

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