GOLDEN GATE UNIVERSITY
SCHOOL OF BUSINESS

FI 346 DERIVATIVE MARKETS

Summer 1999

Instructor: David Hua, Ph.D., Russell T. Sharpe Professor of Finance
Office GGU Los Altos Campus, 5050 El Camino Real
Phone/Fax (650) 961-3000 x 237, (408) 749-1699 x 237. Fax (415) 961-3749
e-mail Address dhua@ggu.edu
Office Hours Tuesday, 4:00-6:00, at Los Altos or by Appointment
Classes Saturday, 9:30 am – 1:30 pm, Los Altos
Credits 3 units.
Prerequisite FI 340 Investments

Course Description Theoretical and practical applications in the futures, options and other derivative markets. Topics included: forwards; futures; swaps; options; hedging strategies; the random walk (Brownian motion) model of stock prices; the Black-Scholes analytical model and the binomial models. Risk management techniques and computer applications are discussed.

Course Objective To develop a sound knowledge of the valuation methods of options and understanding the functions of various derivatives in financial risk management.

Software OptionLab, Mantic Software Corporation. Loveland, CO.

Futures & Options Strategy Guide. Chicago Mercantile Exchange®

The Wall Street Journal


If the subject of futures and options was never covered in your investment class, you may have some catch-up to do. Make a copy of my FI340 handout: “Introduction to Derivatives” and study it before you attend the class. It is available at GGU Los Altos library reference desk upon request.

Student subscriptions to The Wall Street Journal are available. Check with your instructor.
Class Administration And Assignments

1. Attendance is required. Please contact the instructor if a conflict should prevent you from attending the class.
2. The class schedule gives the reading assignments. Students must read the chapters before they are covered in class. Students are encouraged to study some of the math concepts necessary to understand the valuation formulae.
3. Assigned homework should be turned in at the beginning of next meeting. No late work would be accepted without the instructor’s prior consent. We will review some of the assignments in class, if time permits.
4. Beside the homework assignments, please study all the quiz questions at the end of each chapter.
5. Always bring the Friday’s The Wall Street Journal to the class.
6. Work on the OptionLab at the lab.
7. A complementary copy of computer software DerivaGem comes with the textbook. All your homework should be done by hand. However, you can use the software to check your answers to the questions, calculate the implied volatility and explore ideas of your own.
8. Please download or order the freeware The Options Toolbox/The Index Toolbox from CBOE’s web site.
9. For the latest information on various derivative securities and development in the industry, visit the following web sites:

   http://www.cbot.com           Chicago Board of Trade
   http://www.cme.com            Chicago Mercantile Exchange
   http://www.cboe.com           Chicago Board Option Exchange
   http://www.margrabe.com       William Margrabe’s Derivative ‘Zine
   http://www.in-the-money.com   Mark Rubinstein’s web site
   http://www.ipmorgan.com       JP Morgan’s RiskMetrics can be found here
   http://pw2.netcom.com/~bschacht/var/wps.html   Value-at-Risk Resources
   http://www.cob.ohio-state.edu/dept/fin/overview.htm OSU Visual Finance Library

Exam
Exams will be open-book. Please bring your calculator with you. No computer software is allowed. Students should consult the current Golden Gate University Bulletin for university policies regarding incomplete and withdrawals. In addition, students should refer to the Bulletin for University policies regarding academic integrity.

Grading

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<th>Percentage</th>
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<tr>
<td>Assignments</td>
<td>30%</td>
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<td>Midterm</td>
<td>30%</td>
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<td>Final Exam</td>
<td>40%</td>
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3 Review materials on probability and basic calculus can be found at GGU Los Altos library reserve desk.
# Class Schedule and Assignments

<table>
<thead>
<tr>
<th>Week</th>
<th>Date</th>
<th>Topics and Readings</th>
<th>Assignments</th>
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<tbody>
<tr>
<td>1</td>
<td>5/22</td>
<td><strong>I. Overview</strong>&lt;br&gt;&quot;Derivatives&quot; CBS 60 Minutes Documentary&lt;br&gt;Ch. 1 Introduction&lt;br&gt;Ch. 2 Mechanics of Futures and Forward Markets&lt;br&gt;Ch. 7 Mechanics of Options Markets</td>
<td>&quot;Calculus of Risk&quot;&lt;br&gt;(<a href="http://www.sciam.com/1998/0598issue/0598stix.html">http://www.sciam.com/1998/0598issue/0598stix.html</a>)&lt;br&gt;1.2, 1.16;&lt;br&gt;2.10, 2.16;&lt;br&gt;7.1, 7.2, 7.6.</td>
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<td>2</td>
<td>6/5</td>
<td><strong>II. Forward and Futures</strong>&lt;br&gt;Ch. 3 The Determination of Forward &amp; Futures Prices&lt;br&gt;Ch. 4 Hedging Strategies Using Futures</td>
<td>3.4, 3.8, 3.10, 3.11;&lt;br&gt;4.9, 4.11, 4.12.</td>
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<tr>
<td>3</td>
<td>6/12</td>
<td><strong>III. Swaps and Structured Notes</strong>&lt;br&gt;Ch. 6 Swaps</td>
<td>6.1, 6.2, 6.13, 6.14.</td>
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<td>4</td>
<td>6/19</td>
<td><strong>IV. Options</strong>&lt;br&gt;Ch. 8: Basic Properties of Stock Options&lt;br&gt;Ch. 9 Trading Strategies Involving Options&lt;br&gt;CME: <em>Strategy Guide</em></td>
<td>Computer Lab: <em>OptionLab</em>&lt;br&gt;8.3, 8.4, 8.6, 8.7, 8.12;&lt;br&gt;9.1, 9.3, 9.7, 9.13, 9.14.</td>
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<td>⊗ <em>Midterm Exam</em> (due 6/19)</td>
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<td>6</td>
<td>7/3</td>
<td>Ch.12 Options on Stock Indices and Currencies&lt;br&gt;Ch.13 Options on Futures</td>
<td>12.4, 12.5, 12.9, 12.10;&lt;br&gt;13.1, 13.8, 13.9, 13.10.</td>
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<td>7</td>
<td>7/10</td>
<td>Ch.10 An Introduction to Binomial Tree&lt;br&gt;Ch.16 Valuing Options Using Binomial Trees&lt;br&gt;Handout: Exotic Options</td>
<td>10.5, 10.6;&lt;br&gt;16.1, 16.2;&lt;br&gt;Exercises on Exotics.</td>
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<td>8</td>
<td>7/17</td>
<td><strong>V. Financial Risk Management</strong>&lt;br&gt;Ch.14 Hedging Positions in Options and the Creation of Options Synthetically&lt;br&gt;Ch. 17 Biases in the Black-Scholes Model</td>
<td>14.4, 14.9, 14.10, 14.16;&lt;br&gt;17.6.</td>
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<tr>
<td>9</td>
<td>7/24</td>
<td>Ch. 15 Value at Risk&lt;br&gt;Harvard Business School Case (9-297-069)</td>
<td>15.1, 15.4, 15.8, 15.11.&lt;br&gt;<a href="http://www.gsm.uci.edu/~jorion/oc/case.html">http://www.gsm.uci.edu/~jorion/oc/case.html</a></td>
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<tr>
<td>10</td>
<td>7/31</td>
<td>⊗ <em>Final Exam</em></td>
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*The above schedule and assignments are for guidance only and may change in the event of extenuating circumstances.*
Annotated Bibliography


The first mathematical description of a continuous-time continuous-state stochastic process (arithmetic Brownian motion), amazingly with the goal of valuing options (French rents); although that goal was only partially realized, the paper - a thesis submitted to the Academy of Paris - anticipated Einstein's work on Brownian motion by six years as well as the mathematical basis for Black-Scholes formula (which is based on geometric Brownian motion) by 73 years; forgotten, but rediscovered by financial economists in the 1960's. [Black-Scholes Formula]


Origin of the theory of purchasing power parity to explain differences in international interest rates. [Introduction]


One of classic works in economics written in the twentieth century; among its many contributions to economic thought is the Fisher equation relating the nominal interest rate to the real interest rate and the rate of inflation. [Introduction]


Assuming that hedgers are naturally net short so that speculators are naturally net long, Keynes argues that hedgers will pay a risk premium to speculators resulting in what he called "normal backwardation": futures prices which are downward biased estimates of expected future spot prices. [Forwards and Futures]


Develops the "Hotelling Principle" which states that, under certainty and perfect competition, the net price (price minus extraction cost) of an exhaustible resource should rise at the riskless return over time as long as it pays to extract some of the resource and leave some unextracted; this condition arises from the requirement that each producer be indifferent between current and future production. [Forwards and Futures]


Origin of the concept of convenience yield to explain backwardation. [Forwards and Futures]


Best known for its invention of the concept of state-contingent claims, this article also contains the first published occurrence of the idea that an incomplete forward market can be effectively completed by opportunities for portfolio revision over time - the key idea behind modern option pricing theory. Valuable extensions of these ideas are contained in Dreze, J.H., "Market Allocation Under Uncertainty," European Economic Review 2 (Winter 1970), pp. 133-165; in particular, it is shown there that the prices of state-contingent claims can be regarded as products of subjective probabilities and risk aversion adjustments, that the present value of an asset can be viewed as its (discounted) expected value where the state-contingent prices equal the subjective probabilities that would adhere in an economy with risk-neutral preferences, and that option-like securities can substitute for state-contingent claims in completing the market. [Introduction, Binomial Option Pricing Model]


Empirical examination of whether or not futures prices are greater or less than expected future spot prices; concludes that for wheat, cotton and corn during 1937-1957, the futures prices were typically less than corresponding future spot prices, suggesting that long positions in futures was profitable, although the expected profit may have been just compensation for risk. [Forwards and Futures]


Explains how risk aversion determines the exact location of the forward price between the arbitrage bounds caused by convenience yield. [Forwards and Futures]


Contradicts Houthakker (May 1957) and finds that futures prices are unbiased predictors of future spot prices; examines cotton from 1926-1950 and wheat from 1927-1954. [Forwards and Futures]


Proposes that stock prices follow a random walk, and the first paper to advocate lognormal (as opposed to normal) distributions for security returns; apparently written without knowledge of Bachelier's much earlier related paper; also anticipates much later work which justifies lognormal distributions as the outcome of an equilibrium in which investors have logarithmic utility functions. [Black-Scholes Formula]

Derives what was later to be called the Black-Scholes formula by integrating the option payoff assuming a lognormal distribution for the underlying asset price; formula contains the expected asset return and a risk-adjusted discount rate; did not realize that arbitrage arguments could be used to justify replacing both of these with the riskless return. [Black-Scholes Formula]

Specializes Sprenkle's formula for the case when investors are assumed to have risk-neutral preferences and obtains the what later became known as the Black-Scholes formula (see equation (4), page 170); did not realize that arbitrage arguments could be used to justify using the riskless return. [Black-Scholes Formula]

Uses payoff diagrams and a payoff algebra to analyze individual options and portfolios of options. [Introduction to Options]

An early application of primitive option pricing techniques and payoff diagrams to the pricing of warrants, including the use of "zeroprofit lines" partially anticipating the Black-Scholes delta hedging argument; see, in particular pages 81-83. [Introduction to Options]

An early regression approach to option pricing; state-of-the-art in 1967 but now obsolete. [Introduction to Options]

Proof of the put-call parity relation for otherwise identical European options. [Introduction to Options]

The first paper to examine the joint implications of the resolution of uncertainty over time and the irreversibility of physical investments: explains the demand for liquidity as arising from the coexistence of uncertainty that is partially dispelled over time, the ability to defer commitments, and the partial irreversibility of longer-term physical investments. [Corporate Securities and Credit Derivatives]

Perhaps the first paper to propose a stochastic volatility model of stock prices; first a random change in the prior local volatility is drawn; this determines the volatility of the new lognormal distribution from which the next return is drawn: capable of explaining excess kurtosis of realized frequency distributions. [Alternative Option Pricing Models]

The observation that the put-call parity relation holds only for European options since it may pay, particularly for American puts, to exercise options early. [Introduction to Options]

The classic paper on derivatives pricing based on the idea that a self-financing dynamic strategy in an option and its underlying asset is riskless, leading to the Black-Scholes formula; in addition, shows that the theory can be applied to corporate securities (stocks and bonds) since they can be interpreted as options; an early working paper with almost the same results was written under the title "A Theoretical Valuation Formula for Options, Warrants, and Other Securities" dated October 1, 1970. [Black-Scholes Formula]

A complementary paper to Black-Scholes developing the general arbitrage relations and extending the new option pricing theory in a number of ways including to payouts and uncertain interest rates. [Introduction to Options, Black-Scholes Formula]

Extended development of Black-Scholes methodology to the pricing of non-callable and non-convertible zero-coupon corporate debt without safety covenants; shows how the default premium is a function of underlying firm volatility and bond maturity. [Corporate Securities and Credit Derivatives]

The binomial model for pricing options where one move (up or down) is a small change with very high risk-neutral probability, and the other move is a large change in the other direction with very small risk-neutral probability; as the number of moves in the tree is increased over a fixed total time interval, the small change gets smaller, the large change remains fixed but its probability approaches zero. [Binomial Option Pricing Model]


Probably the most widely used procedure for estimating the term structure of riskless returns from the concurrent prices of coupon bonds, dealing in particular with the problem that different bonds have different timing to their coupon payments; applies the interpolation method of cubic splines. (Forwards and Futures, Fixed Income Options).


Sound advice about how to use the Black-Scholes formula in practice. [Black-Scholes Formula]


Five page unpublished typewritten notes providing the original derivation of the constant elasticity of variance diffusion model - a generalization of Black-Scholes formula which builds in a negative correlation between the underlying asset price and its local volatility. A version of the working paper was published as "The Constant Elasticity of Variance Option Pricing Model," in Journal of Portfolio Management (Special Issue: A Tribute to Fischer Black, December 1996), pp. 15-17. [Alternative Option Pricing Models]


Derives the Black-Scholes type formula for options on futures, known in practice as the "Black formula". [Black-Scholes Formula]


Provides the "Cox-Ross" shortcut to valuing options: whenever it is known that an option can be replicated by a dynamic self-financing trading strategy utilizing only its underlying asset and cash, then it can be valued relatively to its current underlying asset price as if it were traded in a risk-neutral economy where the option, its underlying asset and cash all have the same expected return. (Binomial Option Pricing Model, Black-Scholes Formula)


Generalization of the Black-Scholes formula for possible (Poisson) jumps in the underlying asset price; uses risk-neutral arguments permitted by the assumption that jump movements (but not necessarily continuous movements) n the underlying asset price are uncorrelated with aggregate wealth: concludes that the option value is a weighted average of Black-Scholes values, one value for each possible number of jumps over the life of the option. [Alternative Option Pricing Models]


Shows that in place of state-contingent aims, a full set of standard calls can also complete the market; and shows how to identify their single underlying portfolio. [Portfolio Optimization and Performance Measurement]


Extension of the Black-Scholes methodology (and Merton's May 1994 article) to the valuation of corporate securities to include a protective covenant whereby the firm must declare bankruptcy even before it defaults if its value falls below a certain level; similar to a down-and-out barrier option. [Corporate Securities and Credit Derivatives]


The first article to use implied volatilities to compare related option prices. [Volatility]


Early unpublished generalized equilibrium model based on no riskless arbitrage and multivariate diffusion processes for security prices, allowing among other things for purely stochastic volatility. [Alternative Option Pricing Models]


Early discussion of the empirical behavior of the local volatility of an underlying asset, which contrary to the Black-Scholes assumptions, moves like random variable; in particular, about how this volatility varies inversely with its underlying asset price. [Volatility, Alternative Option Pricing Models]

The Black-Scholes formula is derived from an equilibrium capital asset pricing model in which the market consensus preferences have the property of constant proportional risk aversion and underlying asset returns are subjectively lognormal; unlike the Black-Scholes derivation, continuous trading opportunities are not required. (Black-Scholes Formula)


Develops static replication in which a piecewise-linear payoff line is replicated by a portfolio of options, and shows that the general arbitrage relations are sufficient as well as necessary for there to be no buy-and-hold riskless arbitrage opportunities among a portfolio of options on the same underlying asset. (Introduction to Options, Dynamic Strategies)


The first application of finite difference numerical methods for solving differential equations to the numerical valuation of options. (Numerical Methods)


The first application of Monte-Carlo numerical techniques to the valuation of European options, sped up by use of control variates. (Numerical Methods)


The original Black-Scholes argument is couched in terms of replicating cash with a position in the asset and the option: article suggests it is better to think in terms of replicating the option with a position in the asset and cash. (Introduction to Options)


The first paper to interpret corporate investments as options; in particular, current investments have embedded options which are the opportunities they open to make profitable subsequent investments. (Corporate Securities and Credit Derivatives).


First published model of bond pricing built on a diffusion process imposed directly on the shortest-term spot interest rate; has the feature that on a given date, the ratio of the local expected excess return of any bond divided by its local volatility (the market price of risk) is the same, irrespective of the maturity of the bond; a special case combining a constant market price of risk with an Ornstein-Uhlenbeck process - a single factor (current shortest-term riskless return) constant volatility mean reverting process - results in a closed-form formula for the current value of a zero-coupon bond. (Fixed Income Options)


Extension of the Black-Scholes pricing methodology (and Merton's May 1974 article) to the pricing of corporate debt which is both convertible by the investor into the underlying asset and callable by the firm issuing the bond. An extension of this to uncertain interest rates can be found in Brennan, M.J. and E.S. Schwartz, "Analyzing Convertible Bonds," *Journal of Financial and Quantitative Analysis* 15, No. 4 (November 1980), pp. 907-929. (Corporate Securities and Credit Derivatives)


Early exotic option article, extending the Black-Scholes formula to random strike prices, which are (in risk-neutral terms) jointly lognormal with the underlying asset price. (Exotic Options and Real Options)


Investigates implications from assuming that the only source of disagreement among investors being the subjective probabilities attached to outcomes of the market portfolio. Since investors' conditional subjective probabilities regarding individual security returns are the same, then state-contingent claims on the market portfolio would be the only securities needed by the market. - [Portfolio Optimization and Performance Measurement]

Rules for calculating the present values of payoffs, generally received at several dates over time, which are linear functions of other variables, assuming no riskless arbitrage opportunities. [Forwards and Futures]

Clear review of explicit and implicit finite difference numerical techniques for pricing options. [Numerical Methods]

Shows how to recover the risk-neutral probability distribution from the current prices of standard European options on the same underlying asset with the same time-to-expiration, when there exist a continuum of options spanning all strike prices; individual risk neutral probabilities are similar to the prices of butterfly spreads with arbitrarily short distances between the constituent strike prices. [implied Binomial Trees]

Shows that consensus constant proportional risk aversion is not only sufficient but also necessary to produce the Black-Scholes formula without continuous trading opportunities in a market where the underlying asset returns are subjectively lognormally distributed; extension of Rubinstein's Autumn 1976 article. [Fixed Income Options]

A model of bond pricing built on a two-factor diffusion process, using the shortest-term and longest-term spot interest rates; although no closed-form solution is forthcoming and numerical methods must be used to solve the differential equation for bond prices, the model allows for a much more complex evolution in the term structure than is possible with single-factor models. [Fixed Income Options]

Original derivation of a Black-Scholes type formula for pricing compound options - exotic options whose underlying asset is itself interpreted as an option. (Exotic Options and Real Options, Corporate Securities and Credit Derivatives)

The first paper to analyze natural resources as an option; paradox of why they are recovered is circumvented by assuming that extraction costs grow faster than the rate of interest. [Corporate Securities and Credit Derivatives]

Formal mathematical development of the relation between risk-neutral probabilities and no riskless arbitrage opportunities; formalizes the notion of self-financing strategies. [Binomial Option Pricing Model, Black-Scholes Formula]

The classic article developing the binomial option pricing model, showing that in the continuous-time limit it can converge to the Black-Scholes formula, and emphasizing the advantage of the binomial model in valuing American options. [Binomial Option Pricing Model]

A less popular, but simultaneously and independently developed treatment of the binomial option pricing model. [Binomial Option Pricing Model]

One of the first papers to apply Black-Scholes logic to nonstandard or exotic options; formula derived for the valuation of what are now known as lookback options. [Exotic Options and Real Options]

First binomial model for bond options: assumes that the shortest-term spot return follows a recombining binomial process and that the unbiased expectations hypothesis holds: bonds of different maturities all have the same expected return over the next binomial period. [Binomial Option Pricing Model. Fixed Income Options]

Why some investors should prefer convex payoff lines, while others should prefer concave payoff lines? Emphasizes hedging motives: the rate an investor’s risk aversion changes as his wealth changes relative to the rate of change for the market as a whole. [Dynamic Strategies]


1981 Cox, J.C., J.E. Ingersoll and S.A. Ross, "The Relation Between Forward Prices and Futures Prices," *Journal of Financial Economics* 9, No. 4 (December 1981), pp. 321-346. Shows that under no riskless arbitrage opportunities, perfect markets and certainty of future spot rates, otherwise identical forwards and futures contracts will have forward prices and futures prices which are equal. [Forwards and Futures]


1982 Baldwin, C., "Optimal Sequential Investment When Capital is Not Readily Reversible," *Journal of Finance* 37, No. 3 (July 1982), pp. 763-782. Argues that firms with market power should demand a premium over ordinarily calculated net present value as compensation for the loss of future flexibility from undertaking irreversible investments. [Corporate Securities and Credit Derivatives]

1982 Engle, R.K., "Autoregressive Conditional Heteroskedasticity with Estimates of the Variance of United Kingdom Inflation," *Econometrica* 50, No. 4 (July 1982), pp. 987-1008. Initiates a new and now quite popular approach to forecasting variance; proposes the linear ARCH(Q) model of time-series variance; states that the current local variance equals the sum of two terms: a constant plus a weighted average of the q past squared returns; explicitly takes account of volatility clustering over time. [Volatility, Alternative Option Pricing Models]

1983 Rubinstein, M., "Displaced-Diffusion Option Pricing," *Journal of Finance* 38, No. 1 (March 1983), pp. 213-217. Extension of the Black-Scholes formula to allow for underlying assets which have a future price which equals a positive constant plus a risk-neutral lognormal random variable. [Alternative Option Pricing Models]

1983 Garman, M. and S. Kohlhagen, "Foreign Currency Option Values," *Journal of International Money and Finance* 2, No. 3 (December 1983), pp. 231-237. Original derivation of a Black-Scholes type formula for foreign currency options, showing that the key feature that the payout return in the formula should be replaced the foreign riskless return. [Binomial Option Pricing Model]

1983 Ball, C.A. and W.N. Torous, "Bond Price Dynamics and Options," *Journal of Financial and Quantitative Analysis* 18, No. 4 (December 1983), pp. 517-531. Pricing model for options on bonds assuming that the price of the underlying bond starts and ends at known levels, and in between meanders randomly but with a force drawing it toward the known terminal bond value, growing, like a magnet, more powerful as the maturity approaches. [Fixed Income Options]

1983 Cox, J.C. and H.E. Leland, "On Dynamic Investment Strategies," Massachusetts Institute of Technology and University of California at Berkeley, unpublished working paper (December 1983). In most other work, optimal self-financing dynamic strategies are derived from prespecified risk preferences: in this unpublished paper, the inverse problem is solved; given a proposed dynamic strategy, how can we tell if it will be self-financing, has path-independent outcomes, and is consistent with expected utility maximization? the paper concentrates on a situation involving a choice between a single risky asset (market portfolio) following geometric Brownian motion, and cash with an exogenously specified constant riskless return; a key result is that path-independent dynamic strategies are a necessary condition for expected utility maximization. [Dynamic Strategies]
Proof that assuming the Black-Scholes formula and subjectively lognormal underlying asset prices, the expected payoff of a standard European option over a finite horizon shorter or equal to its life is the Black-Scholes value of the option with slightly altered inputs. [Black-Scholes Formula]

Derivation of the closed-form Cox-Ingersoll-Ross formula for the pricing of options on fixed income securities from within a general equilibrium model: based on a single-factor (current shortest-term riskless return) diffusion with mean reversion and local volatility which varies positively with the square root of the logarithm of the factor. [Fixed Income Options]

Classic text on options markets, containing the most detailed exposition of the binomial option pricing model; although superseded by newer texts in dealing with more recent developments in derivatives markets, continues to remain the best discussion of the economic theory behind option pricing. [general source]

Detailed and extremely careful transaction by transaction test of the Black-Scholes formula applied to individual stocks in the late 1970's: test compares the implied volatilities of otherwise identical calls that differ only either by strike price or by time-to-expiration using relatively weak Nonparametric statistics; despite this, documents statistically significant biases from the Black-Scholes formula, but which may not be economically significant. [Empirical Tests]

Compares alternative ways of implementing a floor in a payoff function, in particular stop-loss orders, rolling over short-term options, and Black-Scholes type dynamic strategies. [Dynamic Strategies]

Incorporates proportional trading costs into the cost and discrete-time replicating strategy of a payoff function which is either everywhere convex or everywhere concave: for convex payoffs, trading costs are equivalent to an increase in the volatility; for a concave payoffs, trading costs are equivalent to a reduction in the volatility. [Dynamic Strategies]

Shows that stock volatility is much higher per hour (1 to 100 times) when exchanges are open than when they are closed; for example three-day weekend variance is only slightly higher than single trading day variance; affects the timing adjustments that should be made when translating historical observations into estimates of volatility. [Volatility]

Proposes the linear GARCH(q,p) model of time-series variance - the most popular extension of the Engle's ARCH(q) model; states that the current local variance equals the sum of three terms: a constant plus a weighted average of the q past squared returns plus a second weighted average of the p past local variances; explicitly takes account of volatility clustering over time even when p = q 1. [Volatility, Alternative Option Pricing Models]

First model for pricing options on bonds which is calibrated to be consistent with the current price of bonds of different maturities; takes the form of a no riskless arbitrage binomial model of the short-term riskless return; resulting binomial tree can be used to value a large variety of contingent claims including bond options and callable bonds. [Binomial Option Pricing Model, Fixed Income Options]


One of the first analytic models for valuing options with a random local volatility which is uncorrelated with the underlying asset price; uses risk-neutral arguments permitted by the assumption that volatility is uncorrelated with aggregate wealth; concludes that the option value is a weighted average of Black-Scholes values, one value for each possible level of the average realized volatility over the life of the option. An extension of this article to local volatility correlated with the asset price can be found in Hull, J. and A. White, 'An Analysis of the Bias in Option Pricing Caused by Stochastic Volatility,' *Advances in Futures and Options Research* 3 (1988), pp. 29-61. [Alternative Options Pricing Models]


Computationally fast, reasonably accurate (for short-maturity options), and non-recursive algorithm for approximating the values of standard American calls and puts. This article is an extension of earlier work found in Macmillan, L.W., "Analytic Approximation for the American Put Option," *Advances in Futures and Options Research* 1, Part A:Options (1986), pp. 119-139. (Numerical Methods)


Single-factor diffusion model of bond prices in which the local variance is proportional to bond duration. (Fixed Income Options)


Shows how the stop-loss, start-gain dynamic strategy comes short of replicating the payoff of a call; and uses this difference to provide an alternative proof and interpretation of the multiperiod binomial option pricing formula. (Binomial Option Pricing Model)


Binomial calculation of the risk-neutral expected life of an American option. [Binomial Option Pricing Model]


Extends Vasicek (1977) to closed-form formula for the values of European options on zero-coupon bonds; shows that an option on a portfolio of zero-coupon bonds is equivalent to a portfolio of options each on a single discount bond, thereby extending Vasicek even further to options on coupon bonds. (Fixed Income Options)


The best text exclusively devoted to forwards and futures covering both institutional and theoretical aspects of futures markets. [Forwards and Futures]


Develops single-factor (shortest-term spot rate) binomial model for fixed income derivatives where the tree is calibrated to be consistent with the current term structure of spot returns and its exogenously estimated volatilities. [Fixed Income Options]


Considers the "paradox" that anyone mines gold, when gold is held almost exclusively for investment purposes, the cost of mining increases more slowly than the rate of interest and the mine cannot be expropriated; gold should then be similar to a perpetual payout protected standard American option which it would therefore never pay to exercise. [Forwards and Futures]


Shows how path-independent binomial trees which are not recombining can, by adjusting the move sizes, be transformed into a recombining tree which has the same continuous-time limit. [implied Binomial Trees]

Shows that the single-factor models of Vasicek (1977) and Cox-Ingersoll-Ross (1985) can be extended in the spirit of Ho and Lee (1986) to be consistent with the concurrent term structure of interest returns and either exogenously estimated current volatilities of all spot returns, or exogenously estimated current volatilities of all forward returns. [Fixed Income Options]


Proposes the linear EGARCH(p, q) model of time-series variance - an extension of the Bollersiev's GARCH(p, q) model; states that the current local variance equals the sum of 3 terms: a constant plus a weighted average of functions of the q past squared returns plus a second weighted average of the p past local variances; the functions of the q past squared returns explicitly take account of an asymmetric response of current local volatility to the direction of past returns. [Volatility, Alternative Option Pricing Models]


Generalization of the binomial option pricing model to options on more than one underlying asset, while preserving its dynamic arbitrage properties and its convergence to a multivariate lognormal risk-neutral return distribution. [Exotic Options and Real Options]


Develops a multiple factor fixed income continuous-time derivatives model which includes several earlier models developed by others as special cases; in the spirit of Ho and Lee (1986), their model is consistent with the current prices of all zero-coupon bonds by imposing exogenous stochastic properties directly on the evolution of forward rates. [Fixed Income Options]


Current acceptance of a real investment project and its delayed acceptance are mutually exclusive; as result, the project should not be currently accepted just because its present value is positive; in addition to the effect of the current term structure on this tradeoff, the article considers also the influence of uncertainty of future spot rates; shows that this uncertainty can substantially enhance the option value of waiting and should affect the aggregate level of investment in the economy. [Corporate Securities and Credit Derivatives]


A popularly written history, primarily of the contribution of academics to financial practice from Bachelier in 1900 to the 1990 Nobel Prize awarded for research in financial economics; provides bibliographical accounts of Louis Bachelier, Fischer Black, Alfred Cowles, Charles Dow, Eugene Fama, Hayne Leland, John McQuown, Harry Markowitz, Robert Merton, Merton Miller, Franco Modigliani, M.F.M Osborne, Harry Roberts, Barr Rosenberg, A.D. Roy, Mark Rubinstein, Paul Samuelson, Myron Scholes, William Sharpe, James Tobin, Jack Treynor, James Vertin, John Burr Williams, and Holbrook Working, many of the living drawn from personal interviews: includes chapters on the Black-Scholes formula and portfolio insurance. [general source]


Two factor general equilibrium model of the term-structure, where the shortest-term interest rate and its volatility are the two factors: leads to closed-form solutions for bond prices and options. [Fixed Income Options]


Generalization of the Hull-White stochastic volatility model (June 1987) to permit arbitrary correlation between the price and volatility of the underlying asset as well as stochastic interest rates; a measure of risk preference toward volatility (price of volatility risk) enters as a parameter, the same for all options with the same time-to-expiration on the same underlying asset. [Alternative Option Pricing Models]

Derives necessary and sufficient conditions (in the form of a partial differential equation) governing the relation between consensus risk preferences and the stochastic process of the market portfolio that must hold in equilibrium; assumes an economy with cash and a single risky asset (market portfolio), the risky asset return conforms to a diffusion process, a constant riskless return that is exogenously specified, and investors maximize a state-independent utility function of wealth at some future date. [Implied Binomial Trees]

A highly mathematical text, emphasizing differential equations and finite difference methods, covering both standard and exotic options.
[general source]

Discuss a differential equation, a sort of dual to the Black-Scholes differential equation - but under circumstances in which the local volatility can be an arbitrary continuous function of time and the concurrent level of the underlying asset price - which relates the local volatility to the second derivative of option value with respect to its strike price (the price of a state-contingent claim) and to the first derivative of the option value with respect to its time-to-expiration. [Implied Binomial Trees]

Recovering the unique recombining binomial tree which simultaneously fits all the prices of standard European options on the same underlying asset, where available options span all strike prices and times-to-expiration corresponding to nodes in the tree. [Implied Binomial Trees]

Generalization of the binomial option pricing model for arbitrarily specified expiration-date risk-neutral probability distributions; and new methods for recovering the expiration-date risk-neutral probability distribution from the prices of otherwise identical standard European options with different strike prices. [Binomial Option Pricing Model, Implied Binomial Trees]

Text integrating much of the work on real options with an emphasis on its roots in the economics literature. [Exotic Options and Real Options, Corporate Securities and Credit Derivatives]

Shows how to use trinomial trees to implement the pricing of several one-factor fixed income option pricing models designed to be consistent with the initial term structure, including Ho and Lee (December 1986) and Hull and White (Winter 1990). A companion paper to this for two-state variable models is in *Journal of Derivatives* 2, No. 2 (Winter 1994), pp. 37-48. A more recent paper containing yet further results for one-factor models is in *Journal of Derivatives* 3, No. 3 (Spring 1996), pp. 25-36. [Fixed Income Options]

Extension of the Black and Cox (May 1976) article to the closed-form pricing of corporate debt with protective covenants, differential taxation, and bankruptcy costs; uses the trick of assuming debt is perpetual and allowing for endogenous determination of bankruptcy or continuously rolling-over very short-term debt with bankruptcy only triggered when the firm's net worth becomes negative. In H.E. Leland, "Bond Prices, Yield Spreads and Optimal Capital Structure with Default Risk" University of California at Berkeley, working paper (November 1994), this is extended to the case of continuously rolled-over debt of arbitrary maturity permitting a comparative statics analysis of debt maturity. [Corporate Securities and Credit Derivatives]

One of the best of many recent papers on credit derivatives. [Corporate Securities and Credit Derivatives]

The Hotelling Principle (Hotelling April 1931) cannot explain the typically observed backwardation in commodities futures markets without relying on unrealistically quickly rising extraction costs; paper builds a model under uncertainty where because of the option value of delayed extraction, backwardation is necessary for current production; as a corollary, the higher the volatility of the underlying commodity, the greater the option value of postponed extraction and the greater the backwardation required for current production to occur. (Forwards and Futures, Exotic Options and Real Options)

1996 Jarrow, R.A., Modeling Fixed Income Securities and Interest Rate Options (McGraw-Hill 1996). Text on fixed income options relying primarily on binomial trees as a pedagogic device. [Fixed Income Options]

1996 Trigeorgis, L., Real Options: Managerial Flexibility and Strategy in Resource Allocation (MIT Press 1996). Text integrating much of the work on real options with an emphasis on its roots in the finance literature. [Exotic Options and Real Options]

Given a constant riskless return and a univariate diffusion process for the underlying asset price (a continuous-time continuous state process where the local volatility is a continuous function only of the concurrent underlying asset price and time), the paper shows that any European derivative (with an arbitrary continuous payoff function, not just calls and puts) at all times in its life inherits the key features of its payoff function: upper and lower delta bounds, monotonicity, convexity or concavity. [Introduction to Options]

State-contingent prices are explained by consensus risk-aversion and consensus subjective probabilities; paper shows how option prices (which imply the state-contingent prices) and realized return frequencies (which proxy for subjective probabilities) can be used to recover consensus risk-aversion; in particular, this is done in a way which is insensitive to the problem of the presence of infrequently observed but significant return events. [Implied Binomial Trees]

In a Black-Scholes setting, the traditional mean-variance analysis applied to the performance measurement of portfolios containing significant derivatives positions or using dynamic investment strategies is inadequate because it assumes normal rather than lognormal distributions and takes no account of investor preference toward skewness and higher-order moments; paper shows that option positions priced according to the Black-Scholes formula will be expected to exhibit apparent risk-adjusted over- or under-performance of the market; paper shows how to modify the traditional mean-variance approach to correct for these errors. [Portfolio Optimization and Performance Measurement]

Using the S&P 500 Index as an example, article argues that at least since the stock market crash of 1987, the Black-Scholes lognormality assumption is not supported by either observed underlying asset returns or distributions implied in exchange-traded European option prices; article compares alternative means of recovering these distributions from option prices; extension of Rubinstein's July 1994 article. [Implied Binomial Trees]

An empirical comparison of alternative option pricing approaches - Black-Scholes, CEV, jump-diffusion, stochastic volatility, implied binomial trees, and two naive trader models - using the metric of prediction of future implied volatility smiles from current information. [Empirical Tests]

Why should some investors buy and others sell options? Why should investors buy or sell exotic path-dependent options? As a complement to the author's earlier article (May 1980) which primarily looked at hedging motives (based on differences in risk aversion from the market consensus), this article examines speculative motives (based on differences in beliefs from the market consensus). [Dynamic Strategies, Exotic Options and Real Options]

In the binomial option pricing model where the underlying asset is interpreted as the portfolio of risky assets held by an investor, and given that at each node he chooses his optimal allocation of wealth between this portfolio and cash, observing only his allocations along the single realized path through the tree permits inference of what his allocations would have been at all other nodes (that were not realized) in the tree. [Dynamic Strategies]


Excellent discussion of "value at risk" (VaR), the new popular risk measure for derivatives portfolios discusses alternative means of estimation and sensitivity to distributional assumptions. [Portfolio Optimization and Performance Measurement]


The most well-rounded standard derivatives text currently available. [general source] 1997 Miller, M., Merton Miller on Derivatives, (Wiley 1997). A discussion of recent allegations against derivatives arising from publicized corporate and public fund loses and lawsuits. [general source]


Compares empirically the two basic ways to value plain-vanilla interest rate swaps - as a portfolio of a long and a short bond, and as a sequence of short-term forward contracts spanning the life of the swap, showing that price differences may relate to differences in the default risk between these two replicating strategies. [Forwards and Futures]


Derives a model for pricing forward contracts on commodities used for consumption or production purposes. As in Litzenberger and Rabinowitz's December 1995 article, the authors solve for an endogenously determined stochastic process for convenience yield. While Litzenberger and Rabinowitz base their approach on the value of the commodity for its use in production, this paper considers the option created from holding the commodity in non-negative inventory. In particular, they derive endogenously a correlation between the underlying commodity spot price and its convenience yield. [Forwards and Futures]


A virtually complete survey of exotic options focusing on closed-form solution methods and explaining their uses and history. (Exotic Options and Real Options]


Derives an option pricing formula for Leland's (September 1994) model of levered corporate equity; as predicted, explains part of the smile biases of the Black-Scholes formula by the amount of corporate leverage and the average time-to-maturity of the debt; the greater the leverage and the shorter debt maturity, the more pronounced the smile bias; extension of Geske's March 1979 article. [Corporate Securities and Credit Derivatives]


In response to the demand for derivatives whose value depends on several random variables, a considerable literature has developed applying enhanced Monte Carlo techniques. This literature is surveyed in this paper. [Numerical Methods]


Extension of methods for implied binomial trees to allow volatility to depend on a second random variable, possibly in addition to the underlying asset price. [Impplied Binomial Trees]

Derives upper and lower bounds on standard European option prices in the presence of proportional transactions costs and plausible limits on investor risk aversion; shows that these bounds, considering realistic trading costs, cannot by themselves explain the volatility smile for S&P 500 Index options. [Implied Binomial Trees]

Uses tree models to price options on underlying assets which have uncertain volatility conforming to generalized discrete-time GARCH processes. Several bivariate diffusion models previously used to price options are shown to be limiting cases of these discrete-time processes, including the models of Hull and White (June 1987) and Heston (Summer 1993). [Alternative Option Pricing Models]

One way to distinguish between a jump process and stochastic volatility (both of which ran explain excess kurtosis) is to compare the way their higher-order moments depend on the sampling interval; paper derives algebraic expressions for these moments for both types of processes as functions of the sampling interval. [Volatility, Alternative Option Pricing Models]

Provides a simple way to incorporate opinions about the skewness and kurtosis (as well as volatility) of the risk-neutral expiration date distribution into option pricing, and with the help of the method of implied binomial trees, into calculating hedging parameters and valuing American options. [implied Binomial Trees]

1998 McDonald, R.L. and Schroder, M.D., "A Parity Result for American Options," _Journal of Computational Finance_ 1, No. 3 (Spring 1998), pp. 5-13,
Shows that when the underlying asset price is governed by geometric Brownian motion (as assumed by Black-Scholes) or by a discrete binomial process (where $ud = 1$), then a standard American put has the same value as an otherwise identical standard American put, but where the underlying asset price and strike price have been transposed and the riskless and payout returns have also been transposed. [Binomial Option Pricing Model]

Separates the components of option dollar profit into profits from directional changes in the underlying asset price from profit due to option mispricing relative to the underlying asset. The key is to define the "true relative value" of the option by using the future value of a self-financing dynamic option replication strategy as a Monte-Carlo control variate. Also shows that if the benchmark formula used to assess attribution is a good guess of the formula used by the market to price options, then the second source of profit may itself be subdivided into profit from superior volatility forecasting and profit from using a superior option valuation formula. [Portfolio Optimization and Performance Measurement]

Possibly the best popular description of the emerging significance of the modern derivatives markets, together with a brief but accurate discussion of modern option pricing theory - the kind of article you might politely suggest a curious relative read to find out what you are up to. [general source]

A detailed development of the history of the use of derivatives and their institutional and regulatory environment, emphasizing the important and positive role of derivatives in shaping modern financial global markets. Also provides brief sketches of the dark side of the role of derivatives as represented by the 1987 market crash, the 1992-93 European Monetary System crisis, Metalgesellschaft, Barings, Bankers Trust/Proctor Gamble, Orange Country, and the 1994 Mexican peso devaluation. [general source]
The trading hours for products on our derivatives market including equity index futures and options, stock futures and options, commodities and foreign exchange products. Sign up to receive company announcements or website updates by email. Market Data Services. Vendors can sign up to purchase wholesale market data from HKEX’s Market Data Services department. Products. Securities.