

Financial Engineering I Spring, 2008

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In the past three decades, both theories and applications in finance have been rapidly developed and innovated. These innovations create a new field called "Financial Engineering". Since "Financial Engineering" is developed in a very short period, there is no well-defined contents for it. In general, however, "Financial Engineering" should include the following contents: Problem Definitions, Products Design, Techniques of Bundling and Unbundling, Pricing and Hedging, Promotion Activities, and Distribution Channels.

This course will explore any financial engineering case following the above mentioned doctrine. Since this is a Ph.D. course, however, the course will mainly focus on Pricing and Hedging. Therefore, the course provides an introduction to continuous time stochastic processes, stochastic integration and differential calculus, martingales methods and stochastic optimization methods. Emphasis is placed on applications to finance and economics problem.

The following is a tentative list of topics, lectures and associated readings. It is a subjective and elective list of references and applications in continuous-time finance that may be used to supplement and advance your study; it does not pretend to be complete. Students will be only responsible for the assigned readings (in bold) because the comprehensive examination will cover them.

Books:

For carefully reading:

1. Mikosch, T., 1998, "**Elementary Stochastic Calculus** with Finance in View," Advanced Series on Statistical Science & Applied Probability, Vol. 6, World Scientific Publishing Co.
2. Oksendal, B., 1998, "**Stochastic Differential Equations**: An Introduction with Applications," 5th edition, Springer-Verlag, New York.
3. Bjork, T., 1998, "**Arbitrage Theory in Continuous Time**," Oxford University Press.
4. Musiela, M. and M. Rutkowski, 1998, "**Martingale Methods in Financial Modelling**," Applications of Mathematics: Stochastic Modelling and Applied Probability, 36, Springer-Verlag, New York.
5. Neftci, Salih N., 1996, "**An Introduction to The Mathematics of Financial Derivatives**," 1th edition, Academic Press, New York.
6. Hull, J.C., 2000, "**Options, Futures, & Other Derivatives**," 4th edition, Prentice-Hall, Inc., Upper Saddle River, N.J. 07458.

For reference only:

1. Malliaris, A.G. and W.A. Brock, 1982, "Stochastic Methods in Economics and Finance", North-Holland.
2. Karatzas, I. and S.E. Shreve, 1987, "Brownian Motion and Stochastic Calculus", Springer-Verlag, New York.

3. Merton, Robert C., 1990, " Continuous-Time Finance ", BlackWell Publisher.
4. Protter, P., 1990, " Stochastic Integration and Differential Equations ", Springer-Verlag, Berlin.
5. Revuz, D. and M. Yor, 1991, " Continuous Martingales and Brownian Motion ", Springer-Verlag, Berlin.

Reading List :

I) Portfolio-Consumption Decisions under Uncertainty: The Multiperiod Discrete Time Problem

(Should be covered in Capital Theory II)

II) Introduction to Stochastic Processes, Stochastic Differential Equations and Control

Brock and Malliaris; Karatzas and Shreve; Protter; Revuz and Yor.

(Should be covered in Stochastic Process and Stochastic Calculus)

III) Option Pricing Theory

(Depending upon Students' Background, Some lectures may be needed)

Applications:

- Duan, Jin-Chuan, 1995, "The GARCH Option Pricing Model", *Mathematical Finance*, 5(1), 13-32
- Johnson, Shane. and Yison S. Tian, 2000, "Indexed Executive Stock Options", *Journal of Financial Economics*, 57(1), 36-64
- Johnson, Shane. and Yison S. Tian, 2000, "The Value and Incentive Effects of Nontraditional Executive Stock Option Plans", *Journal of Financial Economics*, 57(1), 3-34
- Duan, Jin-Chuan and Jason Wei, 2002, "Executive Stock Options and Incentive Effects due to Systematic Risk", Working Paper, University of Toronto
- Meulbroek, Lisa K., 2001a, "The Efficiency of Equity-Linked Compensation: Understanding the Full Cost of Awarding Executive Stock Options", *Financial Management*, 30(2), 5-30
- Meulbroek, Lisa K., 2001b, "Executive Compensation Using Relative-Performance-Based Options: Evaluating the Structure and Costs of Indexed Options", *Working Paper*, Harvard Business School
- Mehra, Rajnish and Edward C. Prescott, 1985, "The Equity Premium Puzzle", *Journal of Monetary Economics*, 15, 145-161

IV) Optimal Consumption-Portfolio Rules: The Continuous-Time Problem

Merton, R. C., 1969, " Lifetime Portfolio Selection Under Uncertainty: The Continuous Time Case", *Review of Economic Studies* 51.

Merton, R. C, 1971, " Optimal Consumption and Portfolio Rules in a Continuous-Time Model ", *Journal of Economic Theory* 3.

Application:

Ingersoll, Jr. Jonathan E., 2002, "The Subjective and Objective Evaluation of Incentive Stock Options," Working Paper, Yale University.

V) Asset Pricing: Partial Equilibrium Models

Bergman, Y.Z., 1985, " Time Preference and Capital Asset Pricing Models ", Journal of Financial Economics 14, p.145- 159 .

Breeden, D. T., 1979, " An Intertemporal Asset Pricing Model with Stochastic Consumption and Investment Opportunities ", Journal of Financial Economics 7.

Cornell, B., 1981, " The Consumption Based Asset Pricing Model: A Note on Potential Tests and Applications ", Journal of Financial Economics 9.

Merton, R.C., 1973, " An Intertemporal Capital Asset Pricing Model ", Econometrica 41

VI) Asset Pricing: General Equilibrium Models- Theory

Brock, W.A., 1982, " Asset Prices in a Production Economy ", in Economics of Information, Ed., John McCall, University of Chicago Press.

Cox, J.C., J.E. Ingersoll, and S.A., Ross, 1985, " An Intertemporal General Equilibrium Model of Asset Prices ", Econometrica 53.

VII) Asset Pricing: General Equilibrium Approach and No Arbitrage Approach - Applications***(A) The Term Structure of Interest Rates***

Amin, K.I. and R.A. Jarrow, 1992, " Pricing Options on Risky Assets in a Stochastic Interest Rate Economy ", Mathematical Finance, Vol. 2, No. 4, p. 217-237.

Baxter, Martin W, 1997, " General Interest-Rate Models and the Universality of HJM ", In: Mathematics of Derivatives Securities, M.A.H.Dempster, S.R.Pliska, eds. Cambridge University Press, Cambridge, pp. 315-335.

Bhar, R. and C. Chiarella, 1995, " Transformation of Heath-Jarrow-Motorn Models to Markovian Systems ", Working Paper, University of Technology, Sydney.

Black, F. and M. Scholes, 1973 (July - August), " Bond and Option Pricing When Short Rates Are Lognormal ", Financial Analysts Journal, Vol. 47, p.52-59.

Black F., E. Derman, and W. Toy., 1990 ~ January - February), " A One -Factor Model of Interest Rates an Its Application to Treasury Bond Options ", Financial Analyst Journal, p.33-39.

- Black, F. and P. Karasinski, 1991, " Bond and Option Pricing When Short Rates Are Lognormal ", Financial Analyst Journal, 52-59.**
- Brace, A., Gatarek, D., and Musiela, M., 1997, "The Market Model of Interest Rate Dynamics", Mathematical Finance 7, 127-154.**
- Brennan, M. and E. Schwartz, 1979, " A Continuous Time Approach to the Pricing of Bonds " Journal of Banking and Finance 3, p. 133-155.**
- Carverhill A., 1995, " A Simplified Exposition of the Heath, Jarrow and Morton Model " Stochastic and Stochastic Reports, Vol. 53, p. 227-240.**
- Chen, R. and L. Scott, 1992, " Pricing Interest Rate Options in a Two-Factor Cox-Ingersoll-Ross Model of the Term Structure ", Review of Financial Studies 5, p.613-636.**
- Chen, R., 1995 (April), " Two Factor, Preference Free Formulas for Interest Rate Sensitive Claims ", Journal of Futures Markets.**
- Constantinides, G., 1992, " A Theory of the Nominal Term Structure of Interest Rates ", Review of Financial Studies, Vol. 5 . No. 4, p.53 1-552.**
- Cox, J.E., J.E. Ingersoll, S.A. Ross, 1981, " A Reexamination of Traditional Hypotheses about the Term Structure of Interest Rates ", Journal of Finance 36, No. 4 .**
- Cox, J.E., J.E. Ingersoll, S.A. Ross, 1985 (March), " A Theory of the Term Structure of Interest Rates ", Econometrica 53, No. 2, p.385-407.**
- Duffie D. and Rui Kan, 1996, " A Yield-Factor Model of Interest Rates ", Mathematical Finance 6, pp. 379-406.**
- Gibbons, M. and K. Ramaswamy, 1993, " A Test of the Cox, Ingersoll, and Ross Model of the Term Structure ", Review of Financial and Quantitative Analysis, V12, p.541-552.**
- Heath, D., R. Jarrow, and A. Morton, 1992 ~ February ~ " Bond Pricing and the Term Structure of Interest Rates: A New Methodology ", Econometrica 60, p.77-105.**
- Ho, T. and S. Lee, 1986 (December), " Term Structure Movements and Pricing Interest Rate Contingent Claims ", Journal of Finance, Vol.3. No. 4. p.573-592.**
- Hull, J. and A. White, 1990a, " Pricing Interest Rate Derivative Securities ", Review of Financial Studies 3, 4, p.573-592.**
- Hull, J. and A. White, 1990b, " Valuing Derivative Securities Using the Explicit Finite Difference Method ", Journal of Financial and Quantitative Analysis, Vol. 25, No. 1, p.87-100.**
- Hull, J. and A. White, 1994a, " Numerical Procedures for Implementing Term Structure Models I: Single-Factor Models ", Journal of Derivatives 2, 1, p.7-16.**
- Hull, J. and A. White, 1994b, " Numerical Procedures for Implementing Term Structure Models II: Two-Factor Models ", Journal of Derivatives 2, 2, p.37-48.**

- Hull, J. and A. White, 1996, " Using Hull-White Interest Rate Trees ", Journal of Derivatives 4, 1, p. 26-36.**
- Jamshidian, F., 1989, " An Exact Bond Option Formula ", Journal of Finance 44, p. 205-209.**
- Jamshidian, F., 1991, " Forward Induction and Construction of Yield Curve Diffusion Models ", Journal of Fixed Income, p. 62-74.
- Jamshidian, F., 1997, " Libor and Swap Market Models and Measures ", Finance Stochast. 1, pp. 293-330.**
- Jarrow, R.A., 1995, " Modeling Fixed Income Securities and Interest Rate Options ", McGraw-Hill: New York.
- Li, A., Ritchken, P. and Sankarasubramanian, L., 1995, "Lattice Models for Pricing American Interest Rate Claims", Journal of Finance 50, pp. 719-737.**
- Longstaff, F. and E. Schwartz, 1992 (December), " Interest Rate Volatility and the Term Structure: A two Factor General Equilibrium Model ", Journal of Finance, V.47, No.4. p.1259-82.**
- Longstaff, F. and E. Schwartz, 1993 (September), " Implementation of the Longstaff-Schwartz Interest Rate Model ", Journal of Fixed Income, p.7-14.
- Longstaff, F. and E. Schwartz, 1995, " A Simple Approach to Valuing Risky Fixed and Floating Rate Debt ", Journal of Finance.**
- Maghsoodi, Y., 1996, " Solution of the Extended CIR Term Structure and Bond Option Valuation", Mathematical Finance 6, p.89-109.
- Miltersen, K.R., Sandmann K., and D. Sondermann, 1997, " Closed Form Solutions for Term Structure Derivatives with Log-Normal Interest Rates ", Journal of Finance 52, pp. 409-430.**
- Pearson and Sun, 1994, " Exploiting the Conditional Density in Estimating the Term Structure: An Application to the CIR Model ", Journal of Finance, 4, p.1279-1304.
- Rebonato, R., 1996, "Interest Rate Option Models: Understanding, Analyzing and Using Models for Exotic Interest-Rate Options ", John Wiley & Sons.
- Richard, S.F., 1978, " An Arbitrage Model of the Term Structure of Interest Rates ", Journal of Financial Economics 6, p. 33-57.
- Ritchken, P., 1995, " On Pricing Barrier Options ", Journal of Derivatives 3, 2, p. 19-28.**
- Ritchken, P. and L. Sankarasubramanian, 1995a, "Volatility Structures of Forward Rates and the Dynamics of the Term Structure ", Mathematical Finance 5, p.55-72.**
- Ritchken, P. and L. Sankarasubramanian, 1995b, "Lattice Models for Pricing American Interest Rate Claims" , Journal of Finance, Vol. L, No 2, June, 721-37.**
- Ritchken, P. and Chuang, I., 1999, "Interest Rate Option Pricing with Volatility**

Humps”, Working Paper, Case Western Reserve University.

Rogers, L.C.G., 1995, " Which Model for the Term Structure of Interest Rates Should One Use? ", in M. Davis, D. Duffie, W. Fleming, and S. Shreve, eds., *Mathematical Finance*, IMA Volumes in Mathematics and its Applications, Springer-Verlag, p. 93-115.

Sundaresan, S.M., 1983 (March), " Constant Absolute Risk Aversion Preferences and Constant Equilibrium Interest Rates ", *Journal of Finance*.

Vasicek, O., 1977, " An Equilibrium Characterization of the Term Structure ", *Journal of Financial Economics*, 5, p.177-188.

(B) The Pricing of Forward, Futures and Option on Futures Contracts

Black, F., 1976, " The Pricing of Commodity Contracts ", *Journal of Financial Economics* 3 .

Breeden, D.T., 1984, " Futures Markets and Commodity Options: Hedging and Optimality in Incomplete Markets ", *Journal of Economics Theory*.

Cox, J.C., Ingersoll, J.E., and Ross, S.A., 1981 (December), " The Relation Between Forward Prices and Futures Prices ", *Journal of Financial Economics*.

Richard, S.F. and Sundaresan, M., 1981 (December), " A Continuous Time Equilibrium Model of Forward Prices and Futures Prices in a Multigood Economy ", *Journal of Financial Economics*. 6,p.33-57

VIII) Arbitrage Pricing, Consistency With General Equilibrium, Incomplete Markets.

Duffie, D. and Huang, C., 1985 (November), " Implementing Arrow-Debreu Equilibria by Continuous Trading of Few Long-Lived Securities ", *Econometrica* 53, p. 1337-1356.

Harrison, J.M., and Kreps, D.M., 1979, " Martingales and Arbitrage in Multiperiod Securities Markets," *Journal of Economic Theory* 20, p.381-408.

Harrison, J.M., and Pliska, S. R., 1981," Martingales and Stochastic Integrals in the Theory of Continuous Trading ", *Stochastic Processes and their Applications*, Vol. 11.

Huang, C., 1985, " Information Structure and Equilibrium Asset Prices ", *Journal of Economic Theory* 35, p.33-71.

Kreps, D. M., " Three Essays on Capital Markets Institute for Mathematical Studies in Social Sciences ", Technical Report No. 261, Stanford University.

IX) Credit Market and Credit Derivatives

Abel Elizalde, December 2005, “Credit Risk Models I: Default Correlation in Intensity

Models,” CEMFI and UPNA.

Abel Elizalde, November 2005, “Credit Risk Models II: Structural Models,” CEMFI and UPNA.

Abel Elizalde, November 2005, “Credit Risk Models III: Reconciliation Reduced – Structural Models,” CEMFI and UPNA.

Abel Elizalde, December 2005, “Credit Risk Models IV: Understanding and pricing CDOs,” CEMFI and UPNA.

Burtschell, X., Gregory, J. and J.-P. Laurent, April 2005, “A Comparative Analysis of CDO Pricing Models,” BNP-Paribas.

Ferrarese, C., September 2006, ”A Comparative Analysis of Correlation Skew Modeling Techniques for CDO Index Tranches,” Munich Personal RePEc Archive.

Greenberg, A., O’Kane, D. and L. Schloegl, June 2004, “[LH+: A Fast Analytical Model for CDO Hedging and Risk Management](#),” Lehman Brothers | Quantitative Credit Research Quarterly.

Hull, J. and A. White, Fall 1998 “Value at Risk when Daily Changes Are Not Normally Distributed” Journal of Derivatives, Vol. 6, No. 1, pp. 5-19.

Hull, J. and A. White, Fall 2000 “Valuing Credit Default Swaps: No Counterparty Default Risk,” Journal of Derivatives, Vol. 8, No. 1, pp. 29-40.

Hull, J. and A. White, Spring 2003, “Valuing Credit Default Swap Options,” Journal of Derivatives, Vol. 10, No. 3, pp. 40-50.

Hull, J., & A. White, 2004, “Valuation of a CDO and an nth to Default CDS without Monte Carlo Simulation,” Journal of Derivatives, 2, 8-23.

J.P. Morgan, March 2004,”Credit Correlation: A Guide,” Credit Derivatives Strategy, London.

J.P. Morgan, March 2004,”Introducing Base Correlations,” Credit Derivatives Strategy, London.

J.P. Morgan, May 2004,”A Model for Base Correlation Calculation,” Credit Derivatives Strategy, London.

Kakodkar, A., Martin, B., and S. Galiani, November 2003, “Correlation Trading: A New Asset Class Emerges,” Merrill Lynch Global Securities Research & Economics Group Fixed Income Strategy

Li, D. X., 1999, “On Default Correlation: A Copula Function Approach,” The Journal of Fixed Income; Mar 2000; 9, 4; ABI/INFORM Global pg. 43

Li, D. X., 1998, “Constructing a Credit Curve,” Credit Risk Special Report, Risk November

Merton, R.C., 1974, “On the Pricing of Corporate Debt: The Risk Structure of Interest

- Rates,” Journal of Finance, Vol. 29, pp. 449-70.**
- O’Kane, D. and M. Livesey, November 2004,”Base Correlation Explained,” Fixed Income Quantitative Credit Research.**
- O’Kane, D. and L. Schloegl, 2005, “A note on the large homogeneous portfolio approximation with the Student-t copula,” Finance and Stochastics, 9, 577–584**
- Peretyatkin, V., July 2006, “HPM-Plus: A Fast Analytical Model to Price Synthetic CDOs,” Imperial College and Rabobank International. This draft version: 9 July 2006.**
- Vasicek, O., 1987, “Probability of Loss on Loan Portfolio” , KMV Corporation.**

Suggesting Readings:

Ait-Sahalia, Yacine, 1996, "Nonparametric Pricing of Interest Rate Derivative Securities", *Econometrica*, Vol. 64, No.3, 527-560.

Aiyagari, S. R. and M. Gertler, 1991, "Asset Returns with Transaction Costs and Uninsured Individual Risk", *Journal of Monetary Economics* 27, 311-331.

Baz J. and S. R. Das, 1996, "Analytical Approximations of the Term Structure for Jump-Diffusion Processes: A Numerical Analysis", *The Journal of Fixed Income*, Vol. 6, No. 1.

Bievwag G. O., 1996, "The Ho-Lee Binomial Stochastic Process and Duration", *The Journal of Fixed Income*, Vol. 6, No. 2.

Bjerkstrand P. and G. Stensland, 1996, "Implementation of the Black-Derman-Toy Interest Rate Model", *The Journal of Fixed Income*, Vol. 6, No. 2.

Blake D. and J. M. Orszag, 1996, "A Closed-Form Formula for Calculating Bond Convexity", *The Journal of Fixed Income*, Vol. 6, No. 1.

Chance D. M. and J. V. Jordan, 1996, "Duration, Convexity, and Times as Components of Bond Returns", *The Journal of Fixed Income*, Vol. 6, No. 2.

Falkenstein E. and J. Hanweck, 1996, "Minimizing Basis Risk from Non-Parallel Shifts in the Yield Curve", *The Journal of Fixed Income*, Vol. 6, No. 1.

Frishling V. and J. Yamamura, 1996, "Fitting a Smooth Forward Rate Curve to Coupon Instruments", *The Journal of Fixed Income*, Vol. 6, No. 2.

Goncalves F. O. and J. V. Issler, 1996, "Estimating the Term Structure of Volatility and Fixed-Income Derivative Pricing", *The Journal of Fixed Income*, Vol. 6, No. 1.

Heath, D. and R. Jarrow, 1987, "Arbitrage, Continuous Trading, and Margin Requirements", *Journal of Finance* 42' 1 129-1 142.

Jonsson J. G. and M. S. Fridson, 1996, "Forecasting Default Rates on High-Yield Bonds", *The Journal of Fixed Income*, Vol. 6, No. 1.

Luttmer, Erzo G. J., November 1996, "Asset Pricing in Economies with Frictions", *Econometrica*, Vol. 64, No. 6, 1439-1467.

Ram Willner, 1996, "A New Tool for Portfolio Managers: Level, Slope, and Curvature Durations" *The Journal of Fixed Income*, Vol. 6, No. 1.

Ritchken, P. and Trevor, R., 2000, "Pricing Options under Generalized GARCH and Stochastic Volatility Processes", *Journal of Finance*.

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Shiller, 1981, "Do Stock Prices Move Too Much to Be Justified by Subsequent Changes in Dividends ?", *American Economic Review*.

- Telmer, 1993, "Asset-Pricing Puzzles and Incomplete Markets", *Journal of Finance*.
- Wang J., 1994, "A Model of Competitive Stock Trading Volume", *Journal of Political Economy*.
- Weli, 1989, "The Equity Premium Puzzle and the Risk-Free Rate Puzzle", *Journal of Monetary Economics*.
- West, 1988, "Dividend Innovations and Stock Price Volatility", *Econometrica*.
- Zame, 1993, "Efficiency and the Role of Default When Security Markets Are Incomplete", *American Economic Review*.

The Latest Interesting Articles:

Issues on the Option Pricing Model: Leptokurtic Feature, Volatility Smile, and Analytical Tractability

1. GARCH Option Pricing Models

- Duan, J., 1995, "The GARCH Option Pricing Model", *Mathematical Finance*, 5, 13-32.
- Duan, J., 1997, "Augmented GARCH(p,q) Process and Its Diffusion Limit", *Journal of Econometrics*, 79, 97-127.
- Duan, J., E. Dudley, G. Gauthier, and J. Simonato, 1999, "Pricing Discretely Monitored Barrier Options by a Markov Chain", Working Paper.
- Duan, J., G. Gauthier, and J. Simonato, 1990, "An Analytical Approximation for the GARCH Option Pricing Model", *Journal of Computational Finance*, 2, 75-116.
- Duan, J., and J. Simonato, 1999, "American Option Pricing under GARCH by a Markov Chain Approximation", to appear in *Journal of Economic Dynamics and Control*.
- Duan, J., and H. Zhang, 2000, "Pricing Hang Seng Index Options around the Asian Financial Crisis—A GARCH Approach", to appear in *Journal of Banking and Finance*.
- Engle, R., and C. Mustafa, 1982, "Implied ARCH Models from Option Prices", *Journal of Econometrics*, 52, 289-311.
- Heston, S., and S. Nandi, 2000, "A Closed-Form GARCH Option Valuation Model", *The Review of Financial Studies*, 13, 585-625.
- Ritchken, P., and R. Trevor, 1999, "Pricing Options Under Generalized GARCH and Stochastic Volatility Process", *Journal of Finance*, 54, 377-402.

2. *Models with Closed Form Solutions*

- Kou, S. G., 2000, "A Jump Diffusion Model for Option Pricing with Three Properties: Leptokurtic Feature, Volatility Smile, and Analytical Tractability", Working Paper, Columbia University.
- Kou, S. G., 2001, "On Pricing of Discrete Barrier Options", Working Paper, Columbia University.
- Kou, S. G. and H. Wang, 2001, "First Passage Times of a Jump Diffusion Process", Working Paper, Columbia University and Brown University.

3. *Others*

- Donaldson and Kamstra, 2001, "Volatility Forecasts, Trading Volume, and the ARCH vs Option-Implied Volatility Tradeoff ", Working Paper, University of British Columbia.
- Jiang, G. J. and Pieter J. van der Sluis, 2000, "Index Option Pricing Models with Stochastic Volatility and Stochastic Interest Rates ", Working Paper, Center for Economic Research at Tilburg University.