Course Name: Financial Modelling

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Introduction: This is a hands-on course aimed at exposing students to cutting edge financial tools and techniques used by both buy-side and sell-side teams in global investment and commercial banks, quantitative hedge funds, fund of funds, mutual funds and asset management companies to analyze and do transactions in financial markets. Students will make extensive use of various tools including financial databases (both paid like Bloomberg and free data sources like yahoo finance etc.), analytical tools like Octave and MS Excel. Some assignments will require writing snippets of code (10-50 lines).

Course Topics:

This course will expose students to fairly complex financial modelling across asset classes including equity, FX, fixed income and commodities for both delta1 and derivatives products. Areas taught in this course will cover a gamut of cutting-edge financial engineering and modelling applications including:

1. Construction of optimal stock portfolios under varying utility regimes
2. Modelling risk of large equity portfolios using economic and statistical techniques
3. Time-series modelling and forecasting volatility (applicable for FX, Commodities & Equities) – GARCH family models & their extensions
4. Monte-Carlo Simulation to price European equity options under various volatility assumptions – Black Scholes and Stochastic Volatility models
5. Modelling interest rate derivatives (bond options, caps and floors) using 1-factor models – Merton, Vasicek, CIR. Also, 2-factor models like extensions of dual-Vasicek
6. Modelling interest rate derivatives using no-arbitrage models – Hull-White, BDT model
7. Modelling interest rate derivatives (Swaptions and Exotics) using whole curve approach – Libor Market Model

Following table maps the course content, tools used and potential employment opportunities:

SrNo	Topic & (Techniques)	Tools Used	Useful in following Industry Segments
1	Stock Portfolio Construction & Optimization (Constrained optimization)	Octave (Financial and Optimum Package)	Mutual Funds, Hedge Funds, Index Creators
2	Forecasting Volatility (GARCH and its variations - both univariate and multivariate)	Octave (Econometrics Package), Excel/VBA	Investment Banks, Hedge Funds, Option Trading Companies
3	Modelling short rate and pricing IRDs (Building Trees like BDT, Whole curve approach for exotic derivatives)	Octave(Financial Package), Excel/VBA	Derivatives Desks in Investment Banks, Hedge Funds
4	Pricing and Hedging a Vanilla Options Trading Book (Monte Carlo Simulation)	Octave(Financial Package), Excel/VBA	Investment Banks, Hedge Funds, Option Trading Cos

Prerequisites:

1) Previous programming experience is NOT required. First 2-3 hours of the course will get you to speed on Octave environment and will cover all the required programming concepts using simple examples.
2) All students who take this course must bring laptops to the classroom. You need to have Octave installed on your laptop. Following packages are required: Financial, Optimum & Econometrics.

Software:

More than 80% implementation will be done in Octave, which is free open source software, which allows very similar functionality to MATLAB. Rest of the implementation will be done in Excel/VBA. You must have Octave installed on your laptop before the first class begins.

1) Download Octave from here and Install it: https://ftp.gnu.org/gnu/octave/windows/
2) Install Econometrics, Financial & optim packages: Read wiki and especially first section on Installers for Microsoft Windows to correctly install packages. http://wiki.octave.org/Octave_for_Microsoft_Windows
3) Read the wiki before first class: http://wiki.octave.org/FAQ

I will prepare an installation manual and send it around a week before class starts. It will help you in correctly installing Octave and all the required packages. In case, you still have questions, you can email me or take help from institute's systems team.

Evaluation & Grading:

Financial modelling and empirical work will be needed both in classroom and in form of assignments. Assignments will be designed to give you an opportunity to implement models studied in the class.

Since this is an industry focused hands-on modelling course, there will be no mid-term and end-term exams. Rather, there will be a group project involving substantial empirical work. Ideal group size is 2 students, however if you want to have 3 members in your team, it is OK. Grading will be on following criteria:

1) Five Assignments of 10% each for – 50%
2) In-Class Performance – 10%
3) Empirical Project – 30%
4) Quiz (Mini-Exam)– 10%

To get an A+ in the project, your project needs to be good enough to get published in a student finance journal.

Recommended Course Text Book:

There is no textbook that fits this course. Selected Handouts and presentations will be provided.

Reference Text Book:

If you want to read a particular topic in depth, following textbooks are good books for reference:

1) Options, Futures and Other Derivatives – John C. Hull
2) Interest Rate Models – Riccardo Rebonato
3) Active Portfolio Management: A Quantitative Approach for Producing Superior Returns and Controlling Risk – Grinold and Kahn
4) The Econometrics of Financial Markets – Campbell, Lo and MacKinlay

Session plan

Session		Topic		Total
1		Introduction to Octave		75 min
	a	Course Introduction - Aims, Evaluation Criteria & Project	15 min	
	b	Octave Desktop Environment, Command Window etc.	15 min	
	c	Creating Matrices, basic operations on matrices in Octave	15 min	
	d	Arrays Vs Matrices, Octave Operators	15 min	
	e	Useful Octave Functions	15 min	
2		Programming with Octave		75 min
	a	Graphs & Plots in Octave	15 min	
	b	Flow Control - if, for, while, continue, break	15 min	
	c	User Defined Functions	15 min	
	d	Multi-dimensional Arrays & Custom Data Structures	15 min	
	e	E.g. Pricing option using binomial trees/Solving linear equations	15 min	
3		Portfolios & Mean-variance Optimization - I		75 min
	a	Markowitz Mean-Variance Stock portfolios	75 min	
4		Portfolios & Mean-variance Optimization - I		75 min
	a	Why Sharpe Ratio	15 min	
	b	Constrained Quadratic Optimization	15 min	
	c	Implementation - Markowitz Mean-Variance Stock portfolios	15 min	
	d	Black-Litterman Approach	30 min	

5	Portfolios & Mean-variance Optimization - I			75 min
	a	Multi-country Stock portfolios	15 min	
	b	Portfolio Construction in Indian MFs - Theory Vs Reality	30 min	
	c	Preferences, Utility, Indifference Curves & Optimal Portfolios	30 min	
6	Portfolios & Mean-variance Optimization - II			75 min
	a	Portfolios - Active Risk-Active Return Framework	75 min	
7	Portfolios & Mean-variance Optimization - II			75 min
	a	Portfolios - Active Risk-Active Return Framework	15 min	
	b	Modelling Large Portfolio Risk – Factor Models	60 min	
8	Basic Fixed Income			75 min
	a	Forward/Zero/Par Rates	15 min	
	b	Bonds, FRAs, Swaps, Eurodollar future, Bond Futures	15 min	
	c	Issues in Bootstrapping & Interpolation	30 min	
	d	Duration and Convexity	15 min	
9	Hedging a Fixed Income "Swaps" Portfolio			75 min
	a	Hedging for parallel Shifts	15 min	
	b	Bucketing - Hedging for non-parallel Shifts	15 min	
	c	Hedging using Principal Components Analysis (PCA)	30 min	
	d	Motivation for interest rate models	15 min	
10	Modelling Fixed Income Derivatives – I			75 min
	a	Merton Model of interest rates	20 min	
	v	Vasicek Model of interest rates	20 min	
	c	CIR Model of interest rates	20 min	
	d	2-factor models of interest rates	15 min	
11	Modelling Fixed Income Derivatives – II			75 min
	a	Hull-White, BDT Tree, HJM Model	75 min	
12	Modelling Fixed Income Derivatives – II			75 min
	a	Implementing BDT Model in Octave	40 min	
	b	Implementing HJM Model in Octave	35 min	
13	Modelling Fixed Income Derivatives – III			75 min
	a	Whole Curve Models, LMM Model	30 min	
	b	Implementing LMM Model in Octave	45 min	
14	Equity Options and Cross-Sectional Volatility			75 min
	a	Black-Scholes	30 min	

	b	Greeks - Risk Management under Black Scholes	30 min	
	c	Volatility Smile, Skew and Volatility Surface	15 min	
15	Models of Volatility			75 min
	a	Volatility Smile, Skew and Volatility Surface	30 min	
	b	Local Volatility Vs Stochastic Volatility	45 min	
16	Equity Options Pricing/Hedging			75 min
	a	Writing a Monte Carlo Simulation	30 min	
	b	Using MC to price vanilla European options using Stoc Vol	15 min	
	c	Calculating and Hedging Greeks	30 min	
17	Equity Options Pricing/Hedging & Exotics			75 min
	a	Hedging Greeks with Transaction Costs	15 min	
	b	Exotic Options – Asians, KI/KO, Barriers	45 min	
	c	EWMA and ARCH models	15 min	
18	Time-varying Volatility & Correlations			75 min
	a	GARCH(1,1)	30 min	
	b	Variations of GARCH	30 min	
	c	Correlations	15 min	
19 & 20	Project Presentations			1.5 hr

Suggestions for Project Topics – Must use empirical data

1) Real-world multi-currency portfolio construction – E.g. USA, UK, German, Indian Stocks in a portfolio. Use empirical data to gauge effectiveness of various Hedging approaches over the years.
2) GARCH family techniques – What empirical data tells us on volatility forecasting of multiple asset classes over the last decade (E.g. Take crude oil, equities indices, gold, bonds, currencies).
3) Forecasting model for cheapest to deliver bonds (formulate model on at least 2 countries like US, Japan etc. and do a comparison).
4) Cross-sectional variation of best GARCH Volatility models for any one country's stocks against various factors like different sectors, different market capitalization, percentage of free float etc.
5) Empirical analysis of strategy of selling premium (at least 2 markets e.g. India, US) for various categories of stocks and indices
6) Effect of corporate actions on stocks volatility and future excess returns (at least 2 countries e.g. US, India)
7) Devise a systematic hedging strategy for a portfolio of vanilla options across strikes (portfolio must have at least 50 options on at least 8 underlyings, all from same country) and backtest your hedging strategy over last 5 years using daily data. Must hedge all major Greeks.
8) Compare and Contrast the effectiveness of different class of short rate models to price and hedge portfolio of caps, floors and swaptions for any one country
9) Design an exotic interest rate derivative and use an appropriate model to price and hedge it using market traded contracts
10) Design an exotic hybrid IR-FX derivative and use an appropriate model to price and hedge it using market traded contracts
11) Are there significant difference between cap vol and swaption vol – An empirical Investigation
12) Compare and contrast modelling, pricing and hedging differences between cap, floor and/or swaptions markets on USD/EUR/JPY rates