BEM 111 Quantitative Risk Management
Spring 2018 Prof. Kenneth Winston

Casino operators have no idea what the next turn of the roulette wheel or the next roll of the dice will bring. (If they do know these things, they tend to get sent to jail by the local gaming authority.) Nonetheless it is very profitable to be in the casino business. This is of course because while casino operators don't know particular outcomes, they do know probabilities and are able to set the payoffs accordingly.

Financial markets exist in order to match up owners of capital with users of capital. Ideally, financial markets harness the wisdom of crowds (of investors) to deploy capital appropriately, so that good uses of capital are encouraged and bad uses of capital are discouraged. To the chagrin of many, the process of finding good uses of capital and avoiding bad uses of capital is fraught with uncertainty.

Are financial markets casinos? This question can be parsed in two ways. In one sense, the question could be: are financial markets useless? Is all the activity in financial markets doing nothing to help the real economy, but rather is simply a form of entertainment like casinos?

A second sense of the question is: Can we understand the distributions of outcomes of financial markets in the way that casinos understand the distributions of outcomes of their games? Not to keep the suspense up too long, the answer is resoundingly "No!" But it is equally clear that the answer to the question in the previous paragraph is also no. Markets are not all chaos; there are patterns that can be observed and exploited to the benefit of the capital allocation process.

Quantitative investment management is the study and use of patterns in financial markets that may help predict characteristics of the distribution of financial outcomes. Predicting the next outcome – will an investment be up or down tomorrow – is nearly impossible. Even predicting the mean of outcomes is very hard. But decisions still have to be made, even though we lack full information about the future.

In fact, that is how we define risk: it is *lack of information about the future*. Quantitative investment risk management focuses on understanding how much information we lack about the financial future, and understanding how we might proceed despite this lack of information.

The class is aimed at advanced undergraduates or grad students. Freshmen have taken it and have done well, but I wouldn't generally recommend that. Prerequisites are a solid undergraduate mathematics education, knowledge of calculus, probability and statistics. If you have taken one or more of BEM 105, Ma 112, or ACM/ESE 118, you probably have the right background.

- Lectures will be as follows, subject to change:
    - Lecture 1 (April 4): Risk, Uncertainty and Profit (Frank Knight, 1921). Basic concepts of risk as uncertainty about the future. Basic economics. Utility theory.
    - Lecture 2 (April 11): Interest rate risk. Yield curves and yield curve dynamics. Principal components. Litterman-Scheinkman. Short rate models.

- Lecture 3 (April 18) Coherent risk measures (Artzner, Delbain, Eber and Heath), Bayes Theorem. Markowitz efficient frontier; portfolio selection. Michaud – resampled efficient frontier. Black-Litterman.
- Lecture 4 (April 25): Portfolio volatility models: APT, Factor, PCA. Normality & non-normality. Generating portfolio distributions: Historical, Delta-normal,
- Lecture 5 (May 2): Generating portfolio distributions, cont'd: Delta-gamma, Monte-Carlo. Scenario analysis and stress testing. Fat tails. Regime switching. Extreme value theory.
- Lecture 6 (May 9): Time-series volatility modeling. Heston's model. GARCH and variants. Practical methods to predict volatility.
- Lecture 7 (May 16): Correlation measures. Copula functions. Anticipating correlations. MacGyver method (Engel).
- Lecture 8 (May 23): Credit risk: Capital Structure. Structural models. Merton and KMV models. Credit convexity.
- Lecture 9 (May 30): Credit: Reduced form models, credit default swaps, Li copula. Hedge fund risk management

There is no textbook for the class. I have written lecture notes in PowerPoint that essentially comprise the textbook. I generally post the next week's notes on Moodle on Sunday nights. I co-edited a book, The Oxford Handbook of Quantitative Asset Management. It's not required for this class – everything you will need for this class is in the lecture notes – but I can't resist giving it a plug. If you're interested in quantitative asset management, visit http://www.amazon.com/Handbook-Quantitative-Management-Handbooks-Finance/dp/0199685053/ref=tmm_pap_title_0?_encoding=UTF8&sr=8-4&qid=1323963013

Homework assignments are at the end of each lecture except Lecture 5 and Lecture 9. Responses should be uploaded to Moodle before the beginning of the next class at 7PM. Original electronic documents are preferred (PDF, Word) but if you need to, you can write on paper, scan to PDF or JPG; and upload. Since we may discuss the homework at the next class, no credit will be given for homework received after the start of the next class. The two worst homeworks will be thrown out; the remaining ones will be averaged to form 30% of the grade.

This class requires a fair amount of time. You should plan to spend at least nine hours a week on the class between lectures, homework, tests, and general studying.

If you take the class pass/fail, you must attend the entire lecture and participate in the class for seven out of the nine lectures to pass.

If you take the class for a grade, you do not have to attend the lectures. However the maximum you can get without attending the lectures is A-.

A grade will be formed from: 30% homework, 30% midterm, 40% final. If you are taking the class pass/fail, you must attend seven out of nine lectures and you must get 66% or higher on the final.