BEM 111 Quantitative Risk Management
Winter 2019 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. (The local gaming authority insists on that.) 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. But 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 distributions 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 104, BEM 105, Ma 112, or ACM 116, you probably have the right background.

- Lectures will be as follows, subject to change. The first lecture will be on January 8, 2019.
    - Lectures 1&2: Risk, Uncertainty and Profit (Frank Knight, 1921). Basic concepts of risk as uncertainty about the future. Basic economics. Utility theory.
    - Lectures 3&4: Interest rate risk. Yield curves and yield curve dynamics. Principal components. Litterman-Scheinkman. Short rate models.
    - Lectures 5&6: Coherent risk measures (Artzner, Delbain, Eber and Heath), Bayes Rule. Markowitz efficient frontier; portfolio selection. Michaud – resampled efficient frontier. Risk Parity. Black-Litterman.

- Lectures 7&8: Portfolio volatility models: APT, Factor, PCA. Normality & non-normality. Generating portfolio distributions: Historical, Delta-normal,
- Lectures 9&10: Generating portfolio distributions, cont'd: Delta-gamma, Monte-Carlo. Scenario analysis and stress testing. Fat tails. Regime switching. Extreme value theory.
- Lectures 11&12: Time-series volatility modeling. Heston's model. GARCH and variants. Practical methods to predict volatility.
- Lectures 13&14: Correlation measures. Copula functions. Anticipating correlations. MacGyver method (Engel).
- Lectures 15&16: Credit risk: Capital Structure. Structural models. Merton and KMV models. Credit convexity.
- Lectures 17&18: Credit: Reduced form models, credit default swaps, Li copula.
- Lectures 19&20: Hedging techniques. Hedge fund risk management.

The textbook for this class is a combination of Jupyter Notebooks and PowerPoint slides. I generally post the next week's material on Moodle on Sunday nights.

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.

A detailed description of the requirements of the class (participation, homeworks, tests) is given in the slides for Lecture 1, which are available on Moodle.

If you have questions about the class or your ability to take it, feel free to drop by my office in Baxter 236 or email kwinston@caltech.edu.