Kay Giesecke
Management Science and Engineering
Stanford University
giesecke@stanford.edu
www.stanford.edu/~giesecke
General

- Admissions form due Thu 1:30pm in the box outside Terman 418
- We will review the forms and get back by the end of the week
- Office hours: Tuesday 3-4:30pm and by appointment
- Ben’s office hours: Monday 4-6:30
- Contact at EvA: Lisa Borland, lecture April 11
- Data: WRDS database (access details after teams have formed)
- Background material: course website
Project 1

Modeling and predicting the arrival of buy and sell orders

• Goal: forecast the conditional distribution of future trades and volumes given past trade arrivals and other co-variates

• Important stylized fact: trade times, price changes are clustered

• Model arrival times \( T^k \) as a **self-affecting point process**

\[
N_t = \sum_{k} 1\{T^k \leq t\}
\]

• Examples: intensity \( \lambda \) of \( N \) responds to arrivals
  
  – Birth process: \( d\lambda_t = \delta dN_t \)
  
  – Hawkes process: \( d\lambda_t = \kappa(\lambda_\infty - \lambda_t)dt + \delta dN_t \)
  
  – Generalized process: \( d\lambda_t = \kappa(\lambda_\infty - \lambda_t)dt + \sigma \sqrt{\lambda_t} dW_t + \delta dN_t \)
Frequency of trades

IBM 10:30am Aug 2, 2006

# trades

60s increment
Simulated Hawkes process with $\lambda_\infty = 0.7$, $\delta = 1$, $\kappa = 5$ and jump size uniform on $\{0.4, 0.6, 0.8, 1\}$
Arrivals of Poisson and Hawkes processes with $\lambda_\infty = 1$, $\delta = 2$, $\kappa = 1.5$ and jump size uniform on $\{0.4, 0.6, 0.8, 1\}$
Simulated general process with $\lambda_\infty = 0.7$, $\delta = 1$, $\kappa = 5$, $\sigma = 0.2$ and jump size uniform on $\{0.4, 0.6, 0.8, 1\}$
Project 1

Modeling and predicting the arrival of buy and sell orders

- Estimate parametric intensity model from observed arrivals using maximum likelihood, for example
- Obtain forecast conditional distribution by inverting the characteristic function $E[e^{i \nu (N_s - N_t)} | F_t]$, which we know for a broad class of self-affecting intensity models
  - Used in portfolio credit risk
- Develop and test program trading strategy
- Develop optimal execution strategy, see Hewlett (2006)
  - Trader’s dilemma: market impact vs. adverse price movements
Project 2

Modeling and predicting volatility

- Volatility is a measure of the degree of fluctuation of a security price around its mean; it is the main driver of option prices.

- Goal: Forecast the conditional distribution of future security price volatility given past prices and other co-variates.

- Well known stylized facts of empirical asset returns:
  - Fat tails relative to the Gaussian distribution: power law.
  - Volatility clustering: long range memory in volatility; auto correlation follows power law.
  - Leverage effect: vol is correlated with price changes.
Daily S&P 500 log-returns October ’82 to November ’04: skewed and leptokurtic
Daily log-returns simulated from
\( N(0.00038, 0.0107^2) \)
Empirical daily S&P 500 return distribution
Empirical Nasdaq return distribution

10 NASDAQ stocks, 1 min, 2001

Probability Density

Normalized Return

$q = 1.43$
Mean excess
\[
\sum_{i=1}^{n} \frac{1}{1_{\{r_i \leq q\}}} \sum_{i=1}^{n} (q - r_i)^+ \]
as a function of \(-q\) for the daily S& P 500 returns

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Power laws

- The empirical mean excess return grows with the negative value of the threshold
- Intuitively, the more infrequent an event, the higher is the loss: the data shows that there very few but extreme return fluctuations
- A much better model for the daily return is thus a power law
- A random variable $X$ with distribution function $F_X$ follows a power law with exponent $\alpha$ if

$$ (1 - F_X(x)) \sim x^{-\alpha} $$

That is, the survival probability $P[X > x]$ is asymptotically proportional to $x^{-\alpha}$: the tail of the distribution decays like $x^{-\alpha}$
Densities of the Normal and the Power law with $\alpha = 1$
IBM price changes

IBM 10:30am August 2, 2006

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IBM price changes

last price change $

next price change $

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Project 2

• A price event arrives when the price change exceeds some threshold $\alpha$

• The sequence of price events forms a point process that is self-affecting if the volatility clusters

• The intensity or conditional event arrival rate of this process measures the volatility

• How good is this measure? Relate it to realized volatility

• What are the properties of this volatility measure?
  – Clustering
  – Distribution of future volatility roughly log-normal
  – Higher moments exhibit multi-fractal scaling: $E[r(\ell)^n] = c_n \ell^{b_n}$
  – Volatility shock decays like a power law
  – Leverage effect
Project 3

Capital structure arbitrage

- Goal: design and test a trading strategy that exploits relative mis-pricing in credit and equity markets
- EvA has developed an option pricing model that incorporates the stylized facts of empirical asset returns discussed above
- Can calibrate this model to market option prices of a given name
- What does the calibrated model imply for the price of a credit swap referenced on that name?
- Need to model default of the firm along with an equity option: domain of structural credit models, in which a firm defaults when its assets hit a lower barrier and the equity of a firm is an option on firm value
Project 4

Effect of earnings announcements

- Realized volatility of stock prices rises significantly on the day that a company reports its earnings.

- Option prices (implied volatility) anticipate this increase prior to the announcement, and then fall as soon as the stock price absorbs the new information.

- Can we validate this pattern statistically based on past earnings announcements and the corresponding option implied volatilities?

- If so, we can exploit the pattern with a trading strategy.
Project 4

Effect of earnings announcements

- Suppose a hedge fund manager has insider information about negative news
- The manager would leverage this information by taking positions in out of the money options
- Can we infer the presence of insider information from the distribution of the underlying implied by the listed option prices?
- Can compare the shape of the tail of the distribution with subsequent realized performance
Project 5

Detecting takeovers and mergers

- Goal: detect likely candidates from typical patterns in market prices
- Related to Mike Lipkin’s talk last December in the Financial Math Seminar: corporate insiders choose a certain strategy to leverage their information, and we can link that strategy to patterns in the implied volatility surface
- Of interest are general signatures that dominate the noise