QUANTS AT WORK
Testing prototypes via Monte Carlo simulation

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1. Statistical Arbitrage
Statistical Arbitrage

- Principle 1
  - There are identifiable patterns in the financial markets

- That means:
  - We can find exploitable trading strategies

- Example:
  - Price trends
  - Volatility trends
  - Volume trends
  - Macro events
  - News
Statistical Arbitrage

- Principle 2
  - Some identified patterns are statistically robust

- That means:
  - Some patterns are stable under small changes on their input and their parameters

- Example:
  - Parametric models:
    - Model is stable
  - Non-parametric models:
    - Distribution is stable
  - Recurrent behaviour:
    - Volumes and volatility spikes
Statistical Arbitrage

- Principle 3
  - For some patterns, past behaviour can on average predict future behaviour

- That means:
  - Some patterns are stable in time
  - At least in the short term
  - Potential need of “periodic recalibration”

- Example:
  - Volume curves
  - Volatility curves
  - Correlations
Statistical Arbitrage

- Principle 4
  - A strategy exploiting a robust pattern is profitable on average

- That means:
  - Do not expect to win all the time
  - But you can win in the long run:
    - Law of Large Numbers
    - Central Limit Theorem

- Example:
  - Insurance premium
  - Option pricing
  - Market-making
Statistical Arbitrage

• Principle 5
  • A pattern normally changes after some time

• That means:
  • Even if patterns are stable in time, they do not last forever
  • Some patterns can disappear if the market changes
  • Frequent recalibration to determine when a strategy is no longer profitable

• Example:
  • Correlation strategies:
    • Pair trading
    • Index arb
2. Backtesting
Backtesting

- Stage 1
  - Build prototype of the trading strategy

- What to do:
  - Code the rules of the algorithm
  - Simulate time series:
    - Monte Carlo
  - Use simulations to test:
    - Code
    - Rules
    - Dependence on parameters
  - Get a first glimpse of the distribution
Backtesting

- Stage 2
  - Define the parameters and the “utility function”

- What to do:
  - Define the space of parameters
    - Potentially reduce dimensions
  - Define the optimisation function
    - Utility function
      - Maximise
    - Cost function
      - Minimise
Backtesting

- Stage 3
  - Define your “In Sample” and “Out of Sample”

- What to do:
  - Get time series of real data:
    - Data needs to be cleaned
  - Divide the sample set in two:
    - In Sample:
      - Find optimal parameters
    - Out of Sample:
      - Test statistical robustness of the optimal parameters found in In Sample

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Backtesting

- Stage 4
  - Find the optimal parameters for the utility function

- What to do:
  - Find the best parameters In Sample:
    - By “brute force” if 1 or 2 parameters:
      - Plot the whole utility function
      - Find the global maximum
    - By numerical methods:
      - Gradient methods

graphics.ethz.ch/~achapiro
Backtesting

• Stage 5
  • Test the stability of the In-Sample best parameters in the Out of Sample

• What to do:
  • If the pattern is still profitable, keep the strategy

http://aostrading.cz/
Backtesting

- Stage 5
  - Test the stability of the In-Sample best parameters in the Out of Sample

- What to do:
  - If the pattern is still profitable, keep the strategy
  - Otherwise, discard the strategy and restart from Stage 1

http://aostrading.cz/
3. Pairs Trading: Definition
Pairs Trading

- Market neutral strategy
  - Buy one stock, sell another
  - Their correlation needs to be strong:
    - Same sector, country, market cap, etc

- Assumptions:
  - Correlation will continue to be strong
  - Any break in correlation is temporary

- The spread is mean reverting
  - Sell spread if it is large:
    - Sell outperforming stock
    - Buy underperforming stock
  - Buy spread if it is small
Pairs Trading

- We will use only 2 parameters:
  - The threshold of the entry signal:
    - \( \mu(t) \pm a\sigma(t) \)
  - The threshold of the stop-loss signal:
    - \( \mu(t) \pm b\sigma(t), \ b > a \)
Pairs Trading

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3. Pairs Trading: Example
Example

- Build the algorithm:
  - Create a price simulator
    - Use it to simulate the spread
    - Intraday prices every 5 minutes
    - One day of data
  - Compute the entry and exit levels
    - Rolling mean and volatility
  - Check rules
    - We buy (sell) when we have to buy (sell)
    - We enter (exit) the position when we hit the thresholds
Example

- Monte Carlo Simulation:
  - Run the algorithm for 252 days
  - Compute:
    - PNL (profit and loss) per transaction
    - Cumulative PNL
Example

- Monte Carlo Simulation:
  - Build the distribution of PNL
    - Histogram
  - Spread was modelled as a Normal random variable
    - Shall we expect a normal distribution of PNL?
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Not very “normal”!
Or rather, my favourite books on Algorithmic Trading:


And Microstructure

Thank you for your attention

KEEP CALM
PRESENTATION IS OVER
ANY QUESTIONS?