Machine Learning and Financial Applications

Lecture 2
Quantitative Trading Strategies

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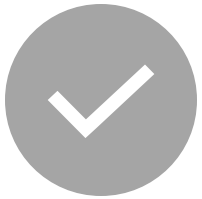
Learning outcomes

Get to know common trading strategies



Able to implement and evaluate a trading strategy

Know the challenges and pitfalls in building a good trading strategy

Introducing Quant Trading Strategies

- Also called algorithmic trading, refers to automated trading activities that buy or sell particular instruments based on specific algorithms/models
- A good trading strategy could be as simple as buying low and selling high (i.e., long a security) or selling high and buying low (i.e., short a security).
- The quality of a trading decision relies on the sufficiency of the input data and the model's suitability and robustness.
- Proper backtesting is often required to validate a strategy

Common Types of Financial Data

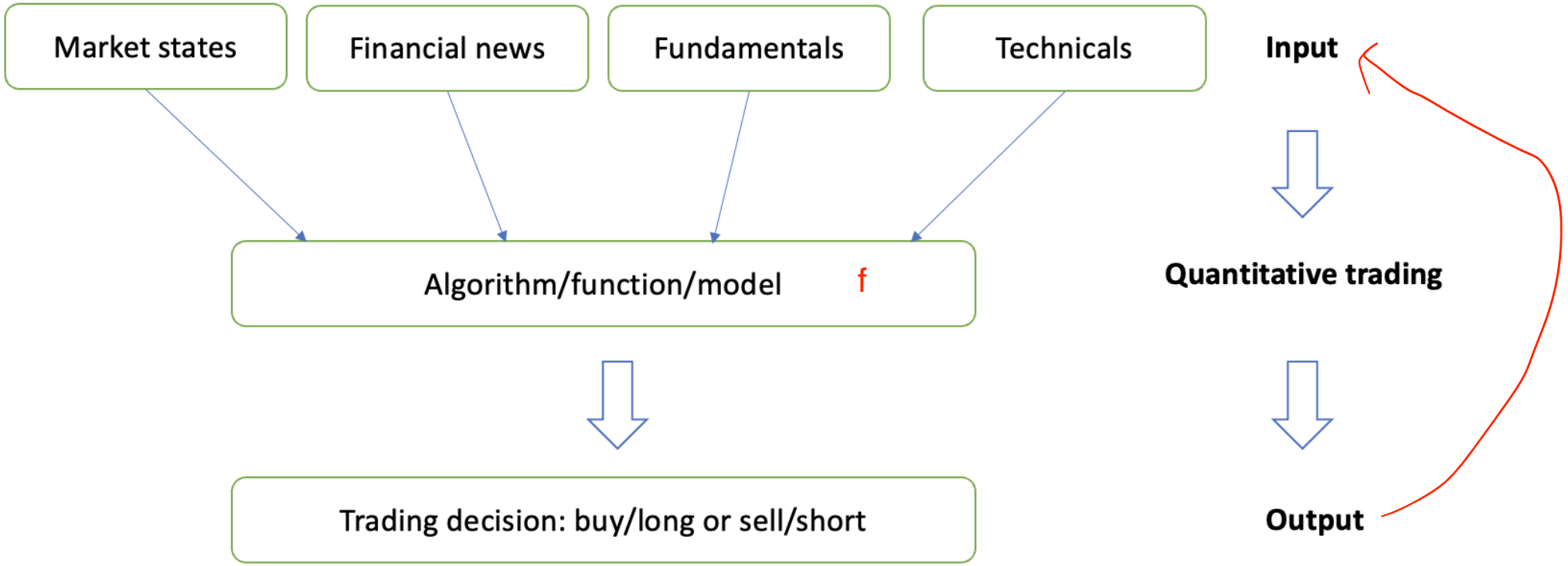
Market states: security-specific price movements such as tick data that measures the minimum upward or downward movement in the price of a security, or market-specific factors such as bid-ask spread in limit-order books (LOB) in high-frequency trading.

Financial news: macroeconomic news, analyst reports, earnings conference call transcripts, etc.

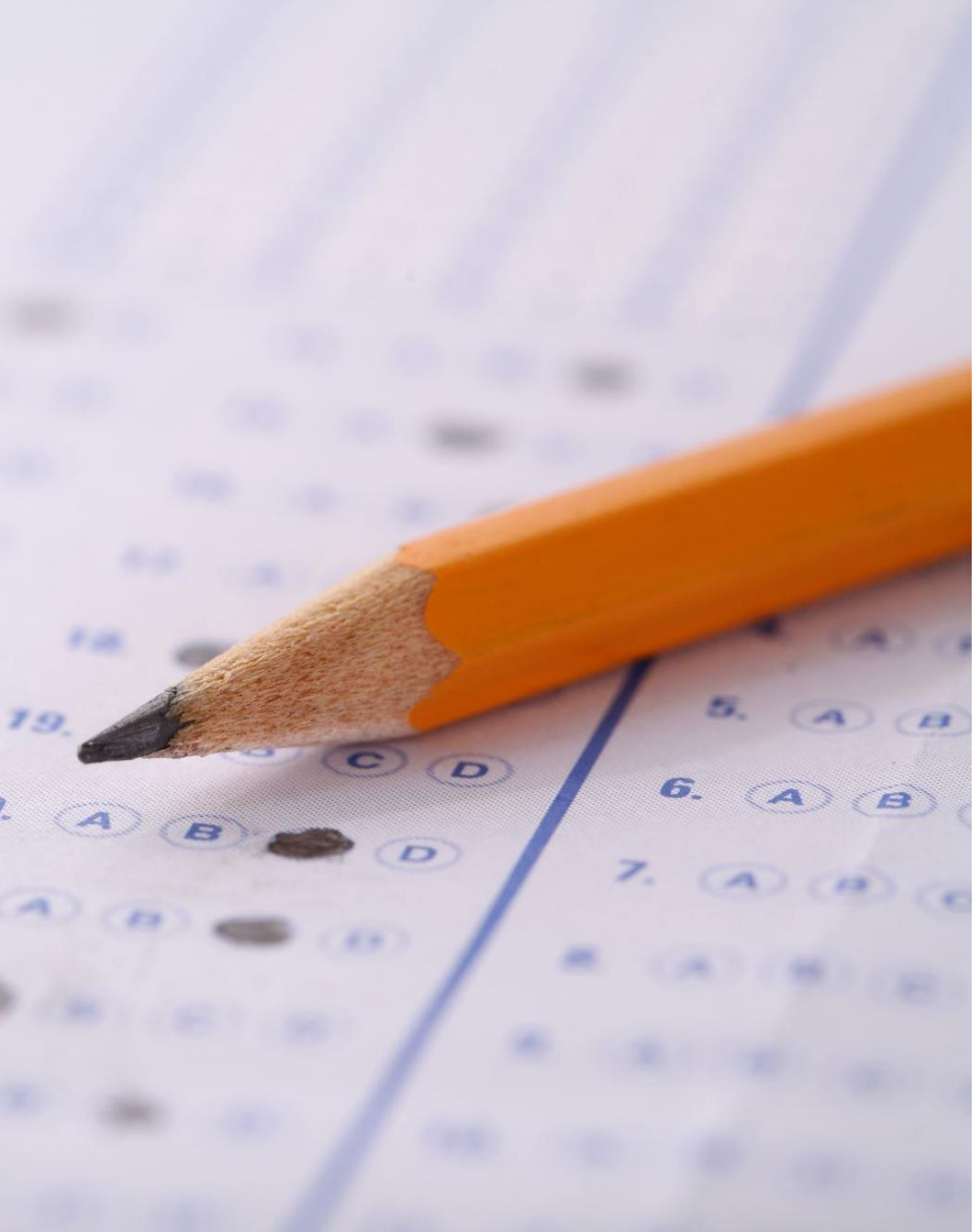
Fundamentals: overall economic or sector-specific conditions and firm-specific metrics such as revenue, cash flow, earnings per share (EPS), etc.

Technicals: derived technical indicators based on the raw price series, including moving averages, stochastic indicators, etc.

A High-Level View



Data-Driven Decision Making



In-class quiz

- Q1-4

Common Types of Trading Strategies

Momentum Strategies

- Based on the assumption that securities with recent strong performance will continue to perform well in the near future.
- Typically involves buying assets that are trending upward and selling those trending downward.
- Example indicators include Relative Strength Index (RSI), Moving Average Convergence Divergence (MACD), and price breakouts.

Mean Reversion Strategies

- Assumes asset prices will revert to historical averages after significant deviations.
- Involves buying undervalued securities (below historical mean) and selling overvalued securities (above historical mean).
- Common methods include statistical arbitrage, Bollinger Bands, and pairs trading.

Fundamental Strategies

- Relies on economic indicators, financial statements, and valuation metrics to identify mispriced assets.
- Emphasizes intrinsic value calculations (e.g., Discounted Cash Flow analysis, Price-Earnings ratios).
- Primarily used for longer-term positions and investment portfolios rather than frequent trading.

Trend Following using Moving Averages

- Moving average, also called rolling average, is the mean or average of the specified data field (e.g. daily closing price) for a given set of consecutive periods.
- As new data becomes available, the mean of the data is computed by dropping the oldest value and adding the latest one. It is rolling along with the data, hence the name “Moving Average”.
- When working with time series data such as daily stock price, the averaging effect can also be considered as smoothening the time series, reducing short-term fluctuations and temporary variations in the data.

Simple moving average (SMA)

- The simple moving average SMA_t at time t is defined as follows:

$$\mathrm{SMA}_t = \frac{S_{t-(M-1)} + \cdots + S_{t-1} + S_t}{M}$$

Q: why not including S_t?

- In other words, to calculate SMA_t, we would take M historical price points and then take the average of these M price points.

- The simple moving average (SMA) is the mean of the previous M price points. Here, M is a user-defined input. It depends on the amount of smoothing desired, since increasing the value of M leads to a smoother curve, while a smaller M reduces the smoothness.

- Need to shift to the past by one day to avoid lookahead bias

Q: What is the role of M in the context of ML model? A parameter? A hyperparameter?

Calculating SMA

Calculating the simple moving average

$$\mathrm{SMA}_t = \frac{S_{t-(M-1)} + \cdots + S_{t-1} + S_t}{M}$$

Created using .rolling(window_size).mean()

Date	Adj Close	SMA-3
2022-01-03 00:00:00-05:00	180.959747	NaN
2022-01-04 00:00:00-05:00	178.663086	NaN
2022-01-05 00:00:00-05:00	173.910645	177.844493
2022-01-06 00:00:00-05:00	171.007523	174.527084
2022-01-07 00:00:00-05:00	171.176529	172.031565

Empty due to incomplete values in the rolling window

$177.844493=\frac{180.959747+178.663086+173.910645}{3}$

Exponential Moving Averages (EMA)

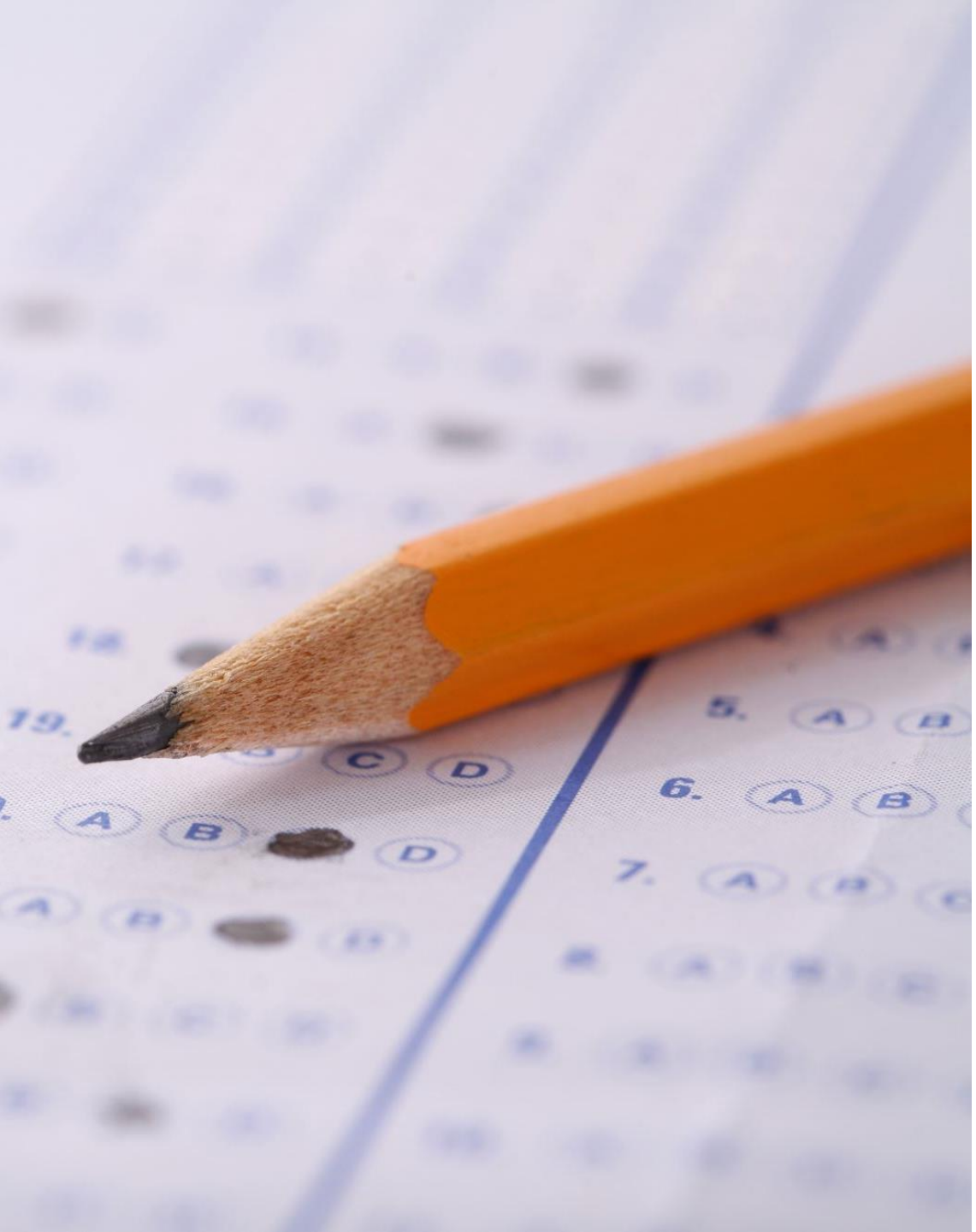
- The exponential moving average (EMA) is a widely used method to reduce the noise in the data and identify long-term trends.
- EMA assumes that recent data is more relevant than old data. Such an assumption has its merit, since EMA can react faster to changes and is thus more sensitive to recent movements as compared to the simple moving average.
- This also means that there is no window size to be specified by the function, since all historical data points are in use.
- $\mathrm{EWMA}_t = \begin{cases} S_0, \ t = 0 \\ \alpha \mathrm{S}_t + (1-\alpha) EWMA_{t-1}, \ t > 0 \end{cases}$

Visualizing Moving Averages

Crossover-based Trading

- We can now generate a short-term moving average and a long-term moving average.
- When the short-term moving average *crosses above* the long-term moving average, it signals a *buy action*, and the trend trader enters a *long position* on the asset.
- When the short-term moving average *crosses below* the long-term moving average, it signals a *sell action*, and the trend trader enters a *short position* on the asset.
- Thus, the strategy is based on the intersection of two moving averages: one short term (quick) and one long term (slow).
- The *crossover* between two technical indicators generates the trading signal.

Q: How to determine position size?



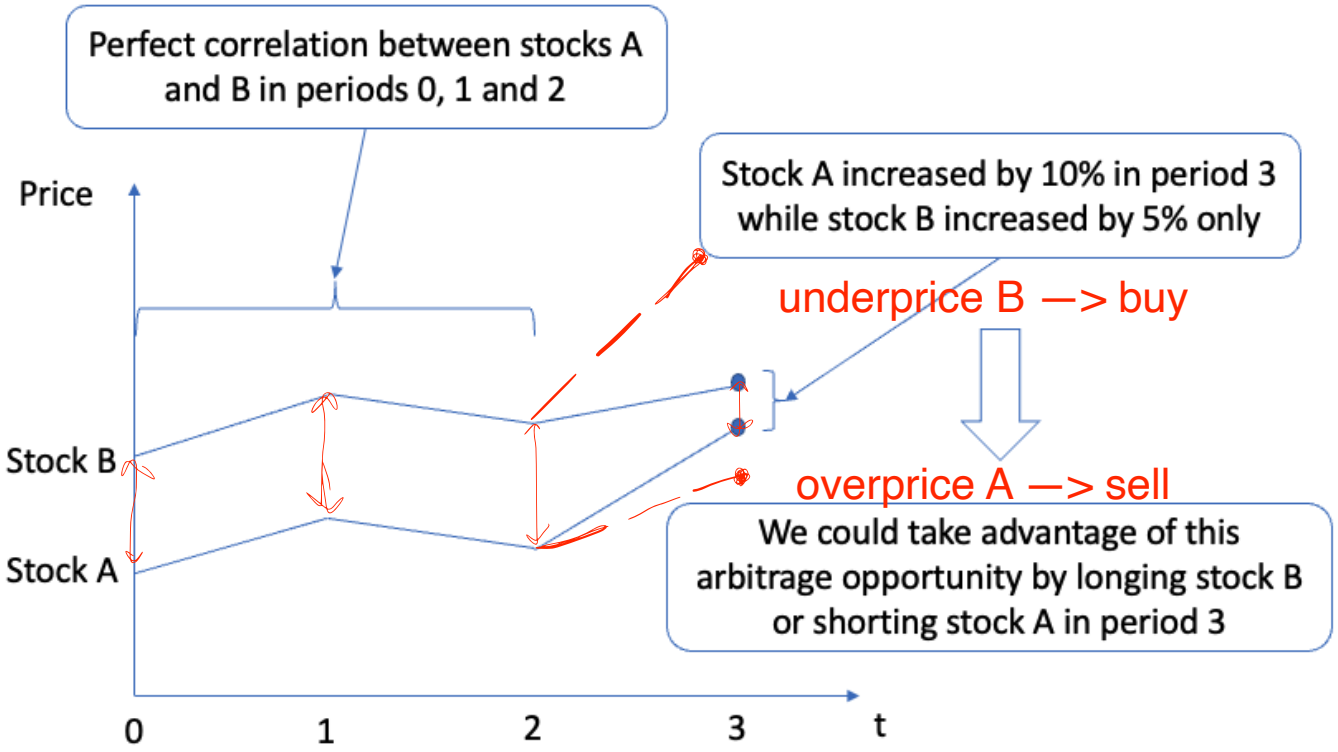
In-class quiz

- Q5-8

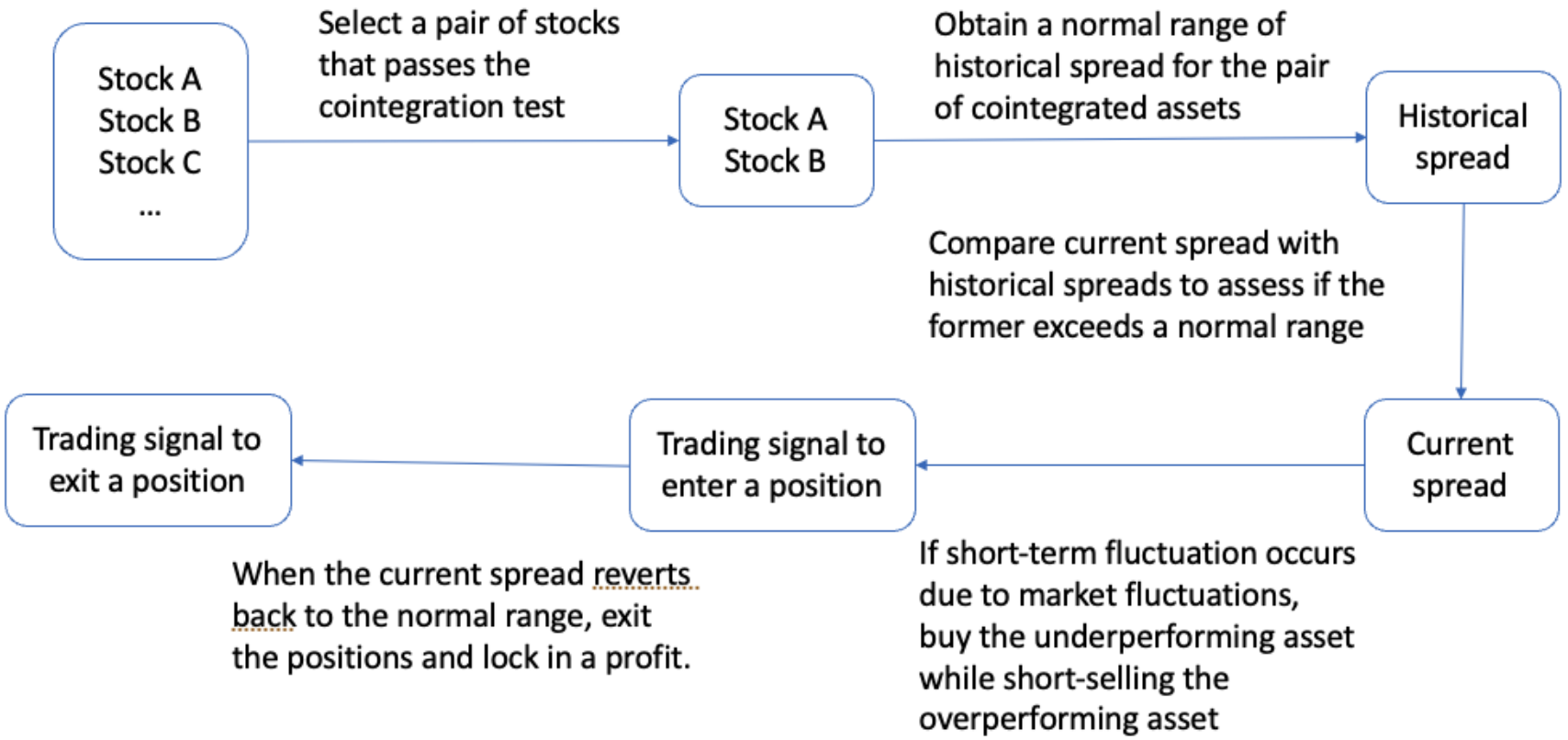
Mean Reversion Strategy

- Prices tend to revert to their historical average after significant deviations.
- Execute trades expecting prices to move back towards their long-term average.
- Statistical Arbitrage: Exploiting pricing inefficiencies between related securities.
- Pairs Trading: Simultaneously buying undervalued and short-selling overvalued correlated securities.
- Bollinger Bands: Using bands around moving averages to detect price extremes.

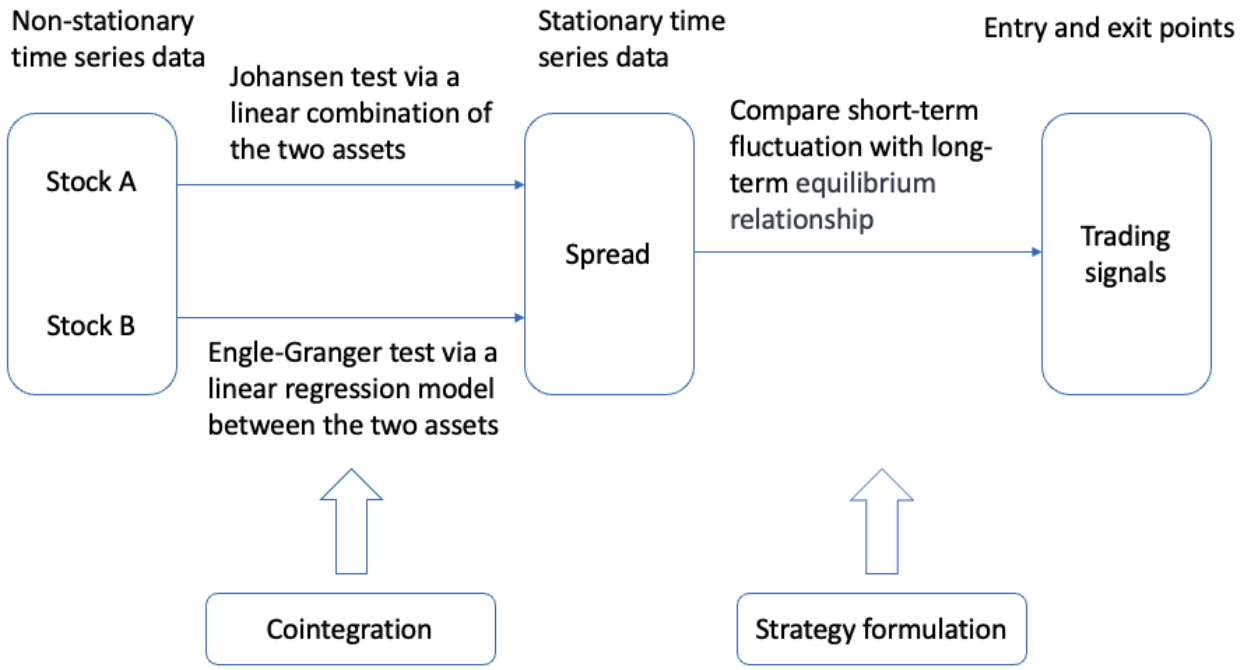
A Simple Example on Statistical Arbitrage



Dissecting Pairs Trading



Cointegration



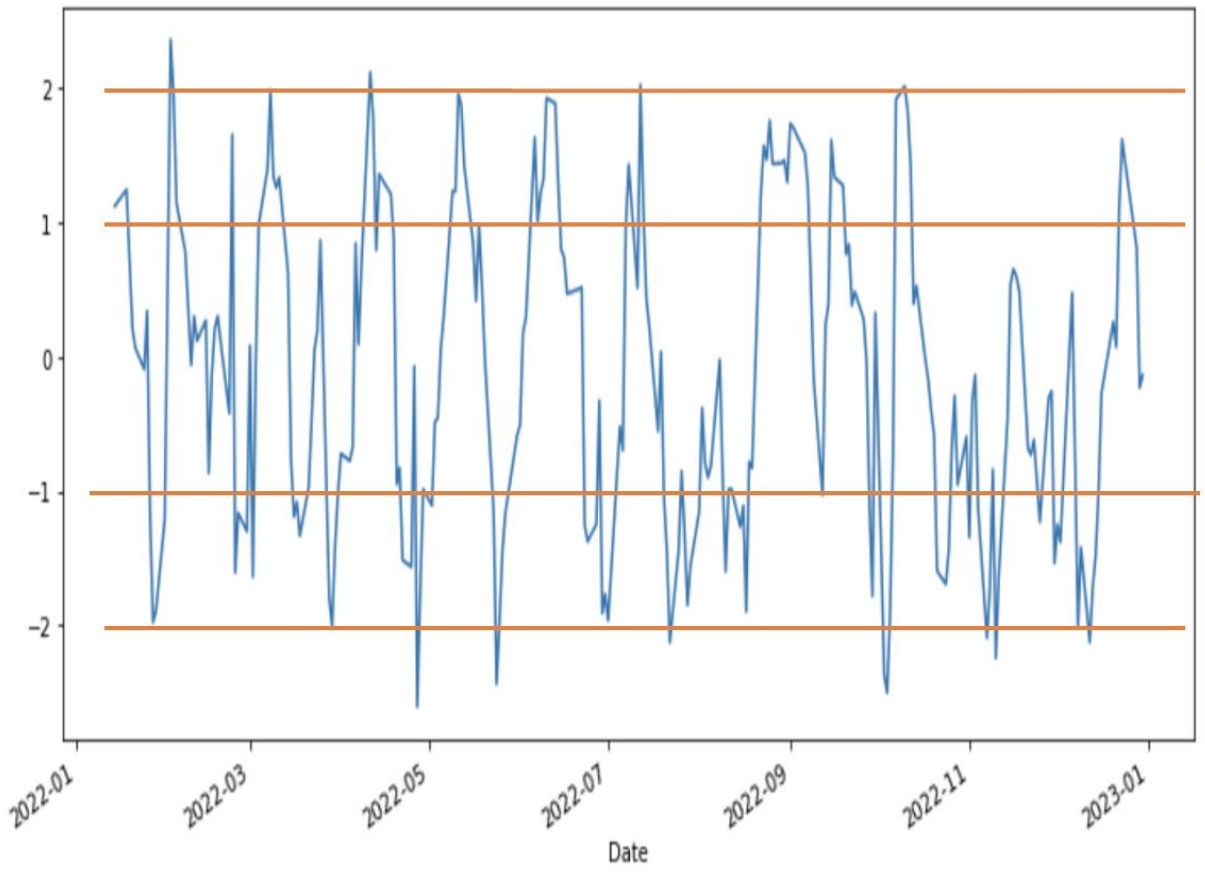
$$y = \beta_0 + \beta_1 x + \epsilon$$

$$\epsilon = y - (\beta_0 + \beta_1 x)$$

Test for cointegration

- Engle-Granger two-step method
  - Estimate the coefficients of the linear regression model between one stock (as the dependent variable) and the other stock (as the independent variable) using ordinary least squares (OLS).
  - Calculate the residuals from the linear regression model.
  - Test the residuals for stationarity using a unit root test, such as the augmented Dickey-Fuller (ADF) test.
  - If the residuals are stationary, the two stocks are cointegrated. If the residuals are non-stationary, the two stocks are not cointegrated.

Implementing Pairs Trading Strategy



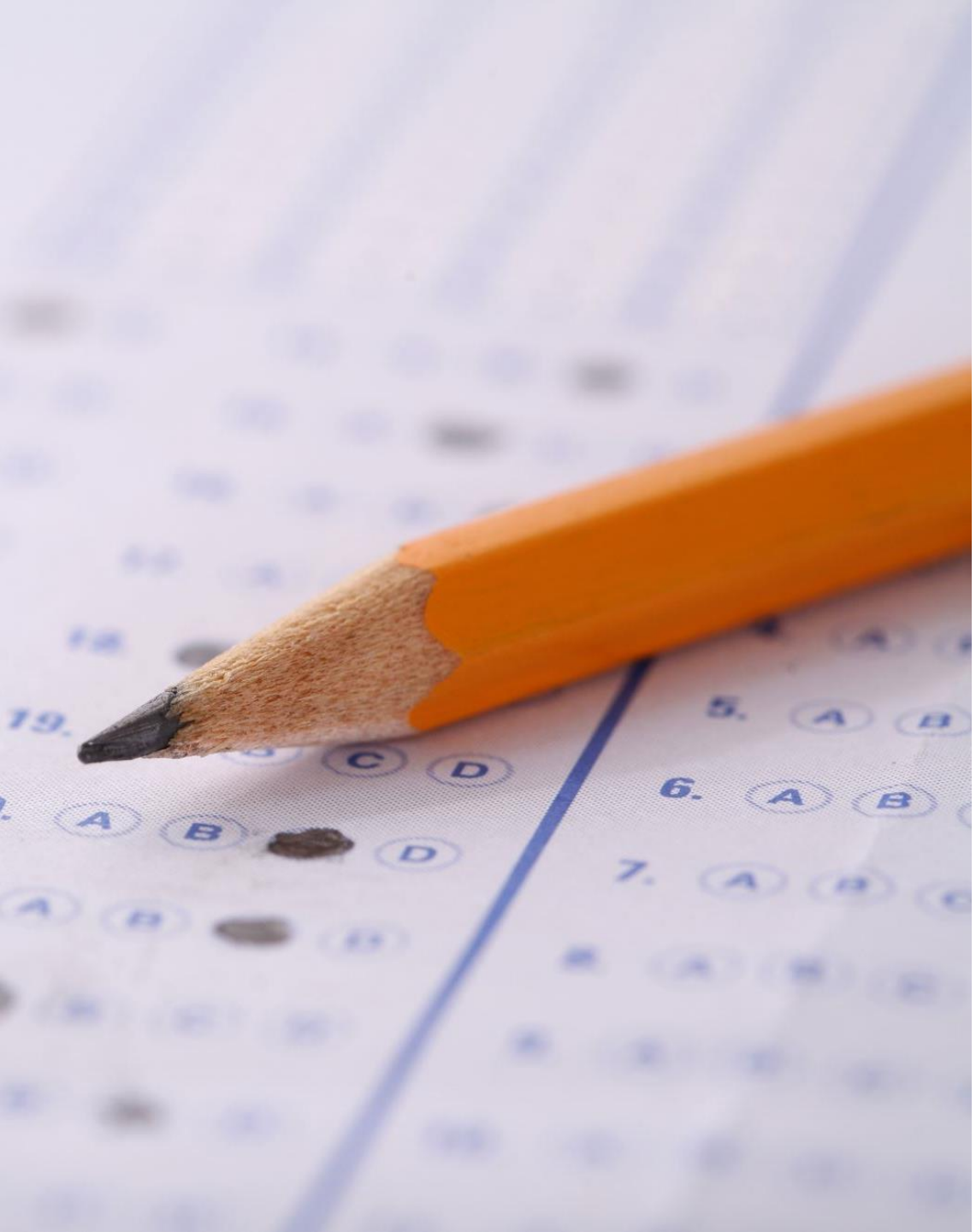
If z-score>2, short stock 1 and long stock 2

Maintain current position if 1<z-score<2

If -1<z-score<1, exit positions in both stocks

Maintain current position if -2<z-score<-1

If z-score<-2, long stock 1 and short stock 2



In-class quiz

- Q9-12

Coding session

Group Homework – Implementing Trend Following and Mean Reversion

- Obtain financial data and perform proper data processing and feature extraction
- Strategy Implementation:
  - Trend Following: Define entry/exit using momentum indicators (e.g., MA crossovers, RSI)
  - Mean Reversion: Entry/exit based on deviations from historical averages (e.g., Bollinger Bands, Z-score)
- Backtesting & Evaluation
  - Evaluate performance metrics (Return, Volatility, Sharpe Ratio, Drawdown)

Due one day before class starts next week

Homework

Watch/review video tutorials and class recording

Post learning reflections and questions if any

Complete group homework