Statistical Arbitrage

MGMT MFE 431-3

Lecture 02

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Plan of the Lecture

1. Universe

2. Trading Frictions

Universe

- Building the universe is complicated
- But it’s crucial to get it right
- Every other database hangs off from universe
- This is Problem Set #1!

Permanent Key

- One key that indicates it is the same stock
- Throughout stock splits, mergers, acquisitions, bankruptcy, name change, etc
- Datastream dscode
- Every other stock identifier hangs off from it
- All other identifiers are *time-dependent*

Other identifiers

- Stock name
- ISIN
- RIC
- Bloomberg code
- IBES ticker
- Industry
- Country

Matlab Structure

- If *n* stocks: (*n*×1) structure: `allstocks`
- `allstocks(1)` is structure with fields:
  - `namelist`
  - `isinlist`
  - `riclist`
  - `bblist`
  - `ibeslist`
  - `industrylist`
  - `indexlist`

Drilling Down

- `allstocks(1).namelist` is (p×1) structured array
- p = number of names stock has had
- `allstocks(1).namelist(1)` is structure with fields:
  - `date`
  - `name`

Example

- `allstocks(1).namelist(1).date = '01-Jan-1998'`
- `allstocks(1).namelist(1).name = 'BNP'`
- `allstocks(1).namelist(2).date = '22-May-2000'`
- `allstocks(1).namelist(2).name = 'BNP PARIBAS'`

Fields

- ISIN: unique identifier for trading and back office, example: `FI0009007926`, changes with every stock split
- ric: Reuters code
- bb: Bloomberg ticker
- IBES: IBES code for analyst forecasts
- Industry: Datastream level-4 sector
- Index: country index to which stock belongs, can be blank if stock gets kicked out

What stocks go into the universe?

- Index constituents
- For every country, choose an index that is (too) broad
- Can always filter later based on liquidity

Stock Indices

- Belgium: BEL-20
- Denmark: OMX Copenhagen 20
- Finland: HEX-20
- France: SBF-120
- Germany: DAX-100
- Holland: AEX-25 + AMX-25
- Italy: MIB-30 + MIDEX
- Norway: OBX-25

More Stock Indices

- Spain: IBEX-35
- Sweden: OMX Stockholm 30
- Switzerland: SMI-20
- UK: FTSE-100
- US: Russell 3000
- Japan: Topix 500

Exclusions

- No preferred shares
- No REITs
- No investment funds
- No foreign stocks (e.g.: ADR)
- If dual listed: keep just one line
- Not conglomerate

Time-Dependent Active List

- `isactivenow`: (t×n) boolean matrix
- 1 if stock is active that day, 0 otherwise
- Switching too often induces turnover (bad)

Criteria for Activation

- Maximum trade size > cutoff
  Example: for $50×50M book, cutoff = $10K
  (average daily volume > cutoff)
- Transaction cost < cutoff
  (median bid-ask spread < cutoff)
- Is member of country index
- Not target of announced takeover
- Free float > 35%

More Criteria

- If bonds are rated, rating > junk
  otherwise: Equity/Assets ratio > cutoff
  (industry dependent)
- Not 51% owned by other company in universe

It's about being...

DISCIPLINED!

Plan of the Lecture

1. Universe

2. Trading Frictions

Maximum Trade Size

- 1% of Average Daily Volume (ADV)
  Can go to 2% if necessary (big book)
- Capped so liquid stocks do not dominate
- Example: cap at $150K
  Can go higher if necessary (big book)

Chan – Quantitative Trading – p.87

In order to minimize market impact cost, you should limit the size (number of shares) of your orders based on the liquidity of the stock. One common measure of liquidity is the average daily volume (it is your choice what lookback period you want to average over). As a rule of thumb, each order should not exceed 1 percent of the average daily volume. As an independent trader, you may think that it is not easy to reach this 1 percent threshold, and you would be right when the stock in question is a large-cap stock belonging to the S&P 500. However, you may be surprised by the low liquidity of some small-cap stocks out there.

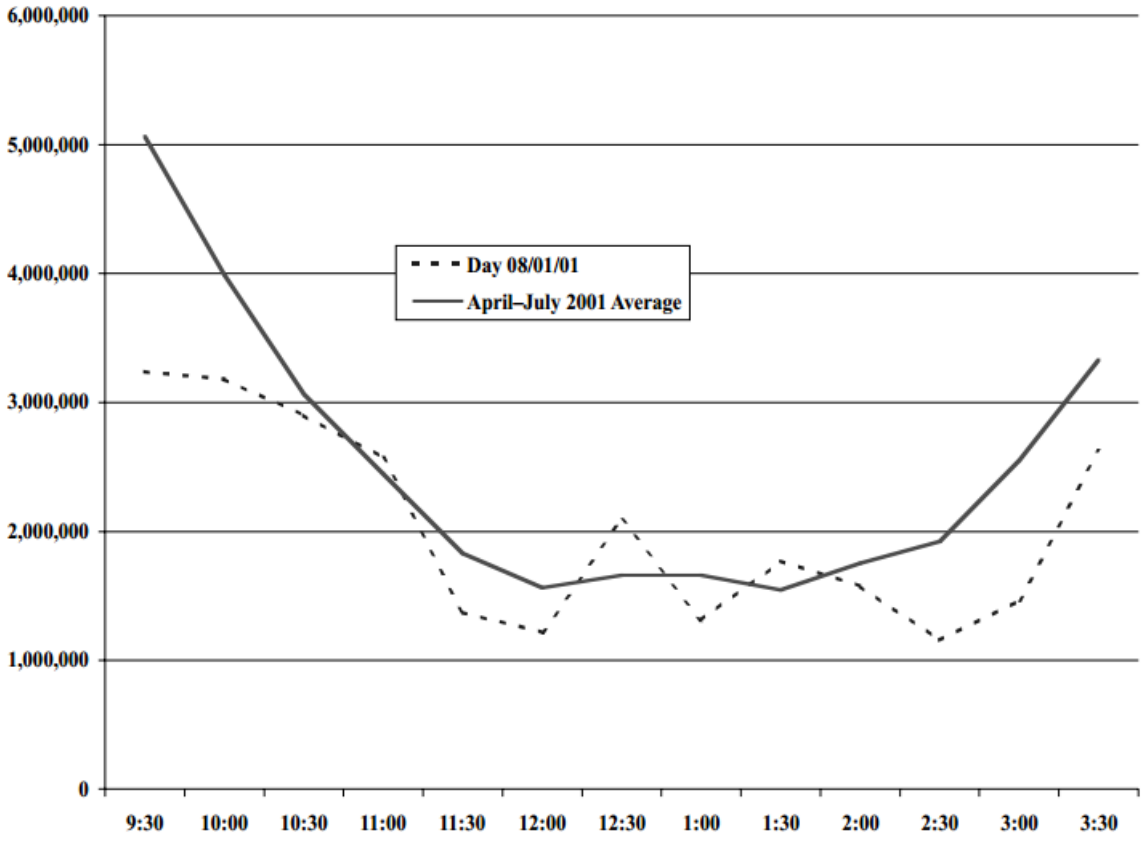
VWAP

- MaxTrade formula assumes you use VWAP:
  Volume-Weighted Average Price
- Don’t time it, spread it over period
- Typically: period = 1 day
- More advanced: period = 1 hour
  Multiple trades per day
- Brokers provide electronic VWAP engines as standard

VWAP Strategies – A. Madhavan

EXHIBIT 3

Microsoft Corporation Share Volume by Time of Day—April–July 2001



How to Estimate Transaction Costs?

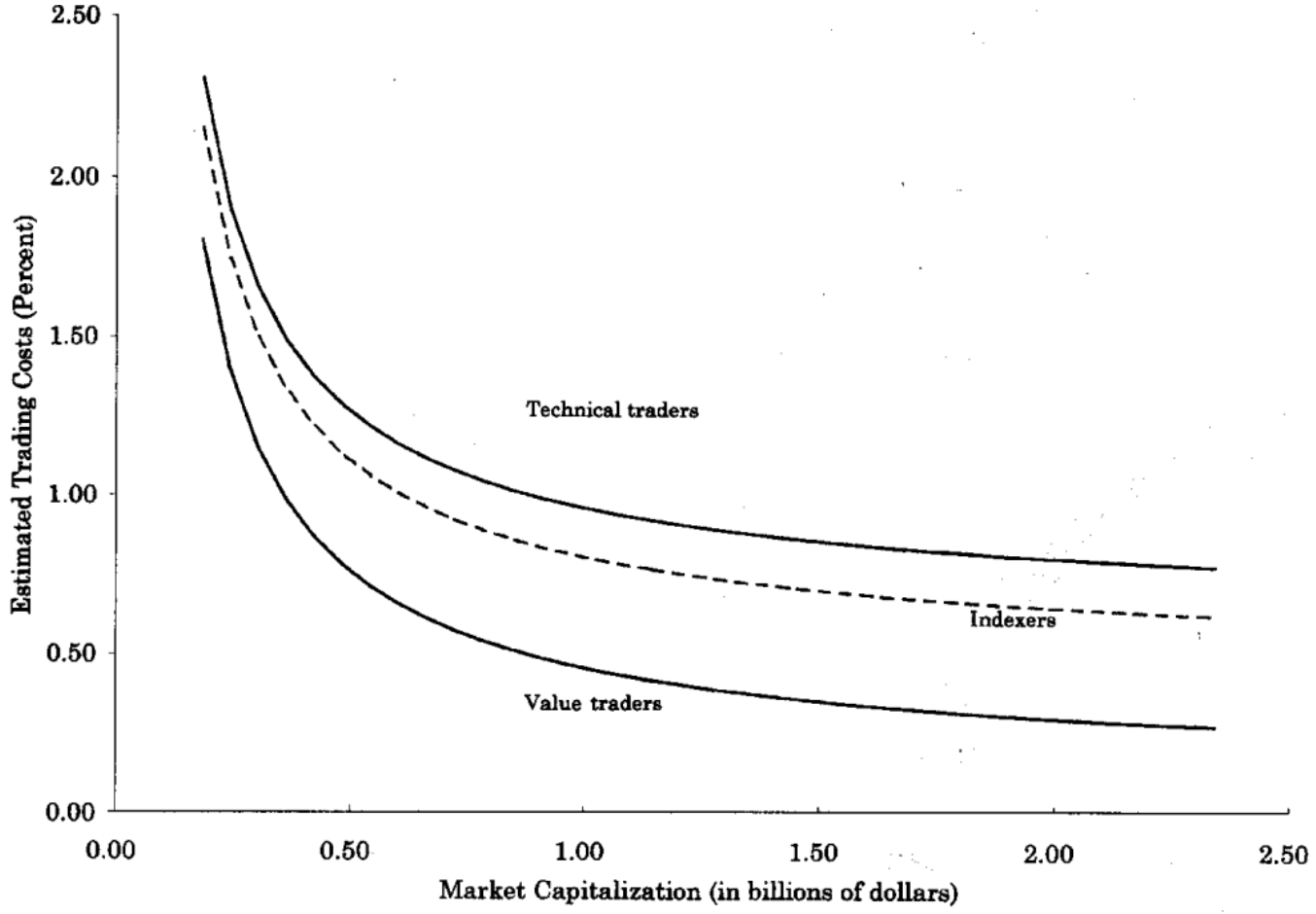
Keim and Madhavan (JFE 1997)

- 62,000 stock orders
- 21 institutional traders
- Volume = $83 billion
- 1991 – 1993

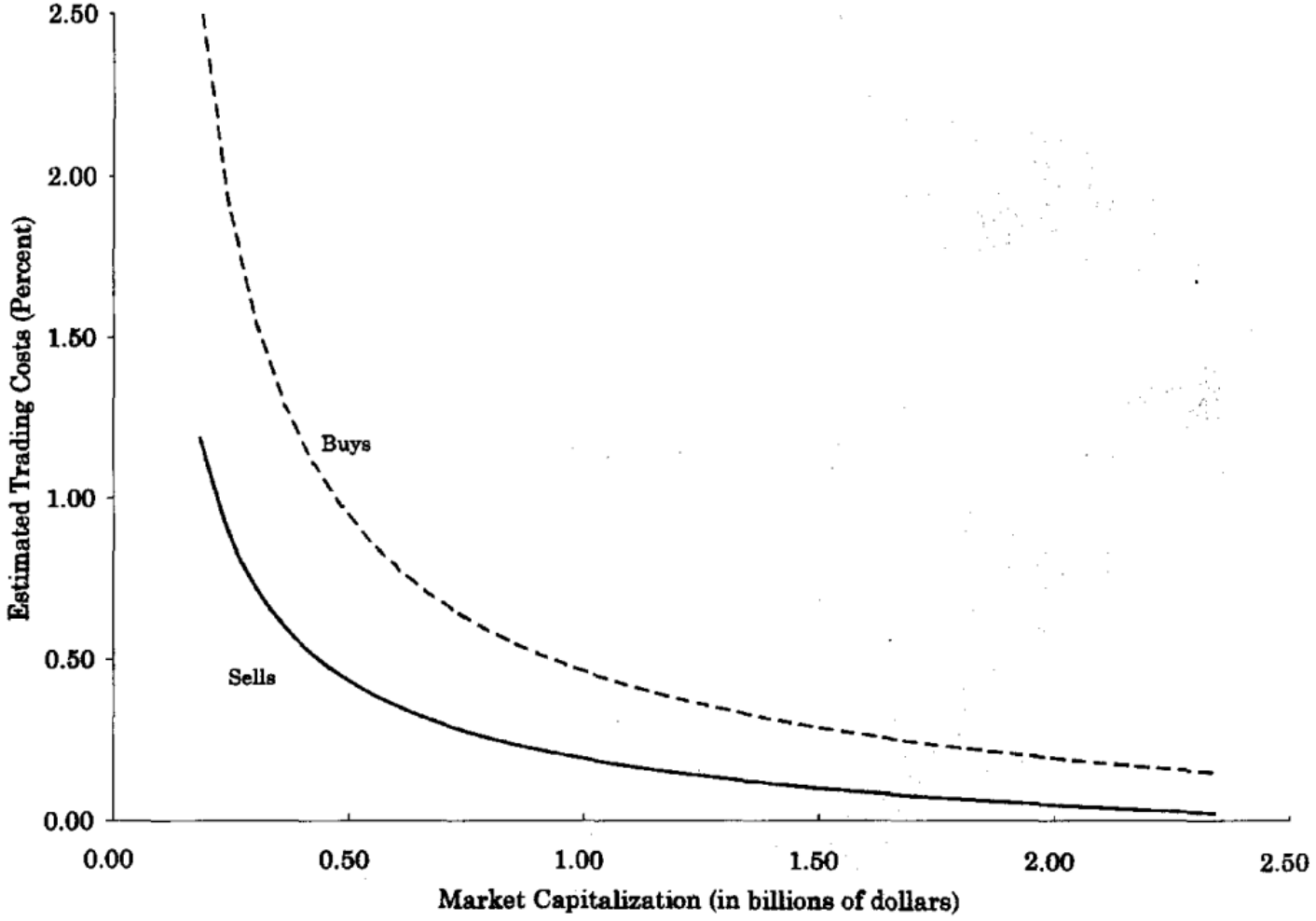
Regression Model

Variable	Buyer-initiated orders		Seller-initiated orders		All orders	
	Estimate	Standard error	Estimate	Standard error	Estimate	Standard error
Intercept	0.767	0.325	0.505	0.449	0.687	0.269
D^{NASDAQ}	0.336	0.052	0.058	0.085	0.239	0.045
Trsize	0.092	0.016	0.214	0.030	0.165	0.005
Logmcap	− 0.084	0.019	− 0.059	0.027	− 0.076	0.016
$1/P_i$	13.807	1.356	6.537	1.482	9.924	1.029
D^{TECH}	0.492	0.050	0.718	0.049	0.607	0.035
D^{INDEX}	0.305	0.049	0.432	0.074	0.451	0.040
Adjusted R^2	0.046		0.086		0.060	

By Trading Style



By Direction



Simple Transaction Cost Model

- Commission + 1bp + median bid-ask spread / 2

- Good approximation to get started (small book)
- Ignores price impact
- In reality, t-cost depends on trade size
- As you grow book, build your own t-cost model

- This is why you must increase book size slowly!

Chan – Quantitative Trading – p.23

Transaction costs vary widely for different kinds of securities. You can typically estimate it by taking half the average bid-ask spread of a security and then adding the commission if your order size is not much bigger than the average sizes of the best bid and offer. If you are trading S&P 500 stocks, for example, the average transaction cost (excluding commissions, which depend on your brokerage) would be about 5 basis points (that is, five-hundredths of a percent). Note that I count a round-trip transaction of a buy and then a sell as two transactions—hence, a round trip will cost 10 basis points in this example. If you are trading ES, the E-mini S&P 500 futures, the transaction cost will be about 1 basis point. Sometimes the authors whose strategies you read about will disclose that they have included transaction costs in their backtest performance, but more often they will not. If they haven't, then you just to have to assume that the results are before transactions, and apply your own judgment to its validity.

Equity Market Impact

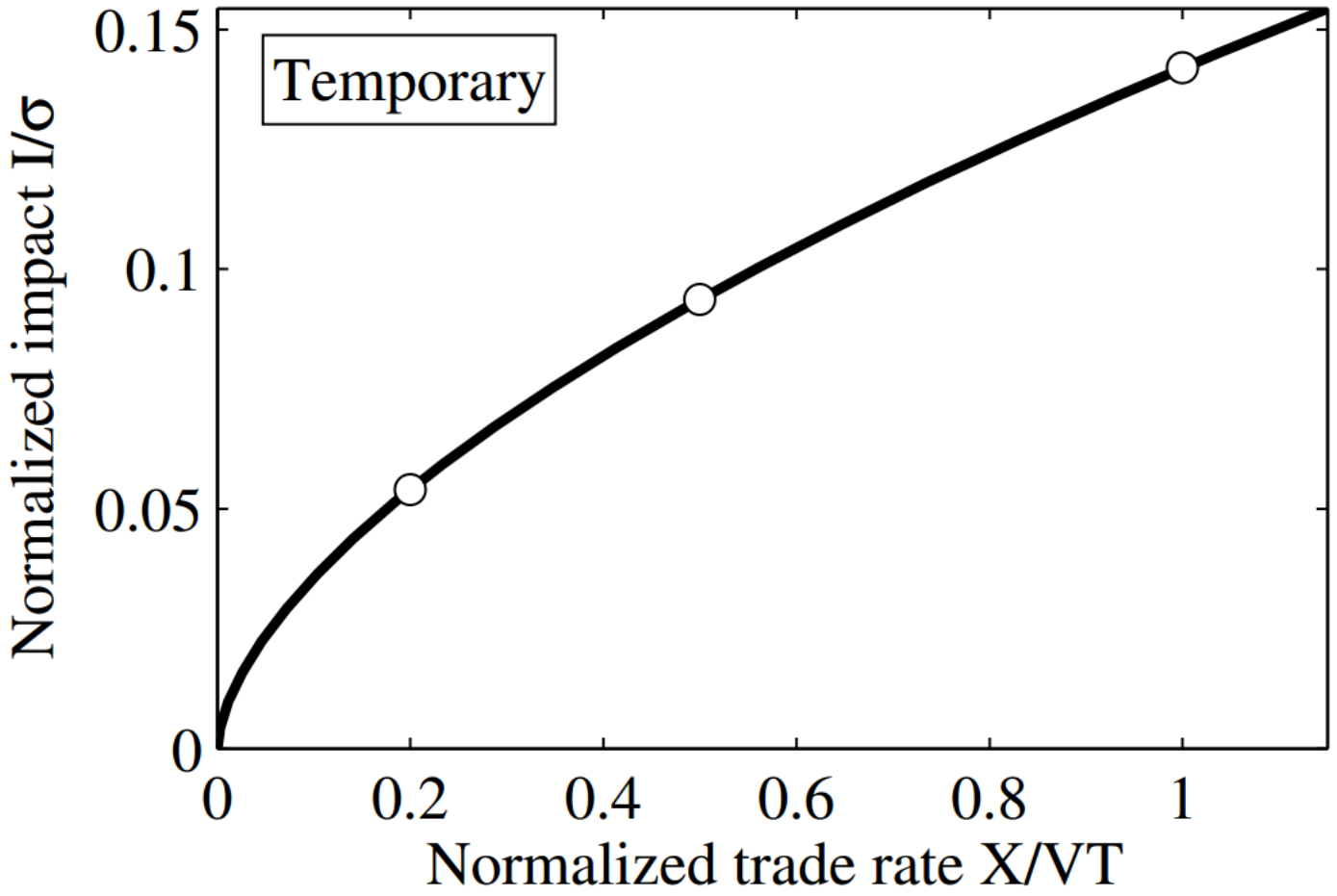
- Robert Almgren + 3 Citigroup Quants
- 700,000 US orders executed by Citigroup Equity Trading desks 12/2001 $\rightarrow$ 6/2003
- I = temporary price impact
- s = daily volatility
- X = trade size
- V = average daily volume
- T = trade duration (in days)

Market Impact Model

- I= temporary price impact
- σ = daily volatility
- X = trade size
- V = average daily volume
- T = trade duration (in days)

$$I / \sigma = \text{constant} \cdot \text{sign}(X) \cdot |X/VT|^{\beta} + \text{noise}$$

Price Impact in Power 3/5

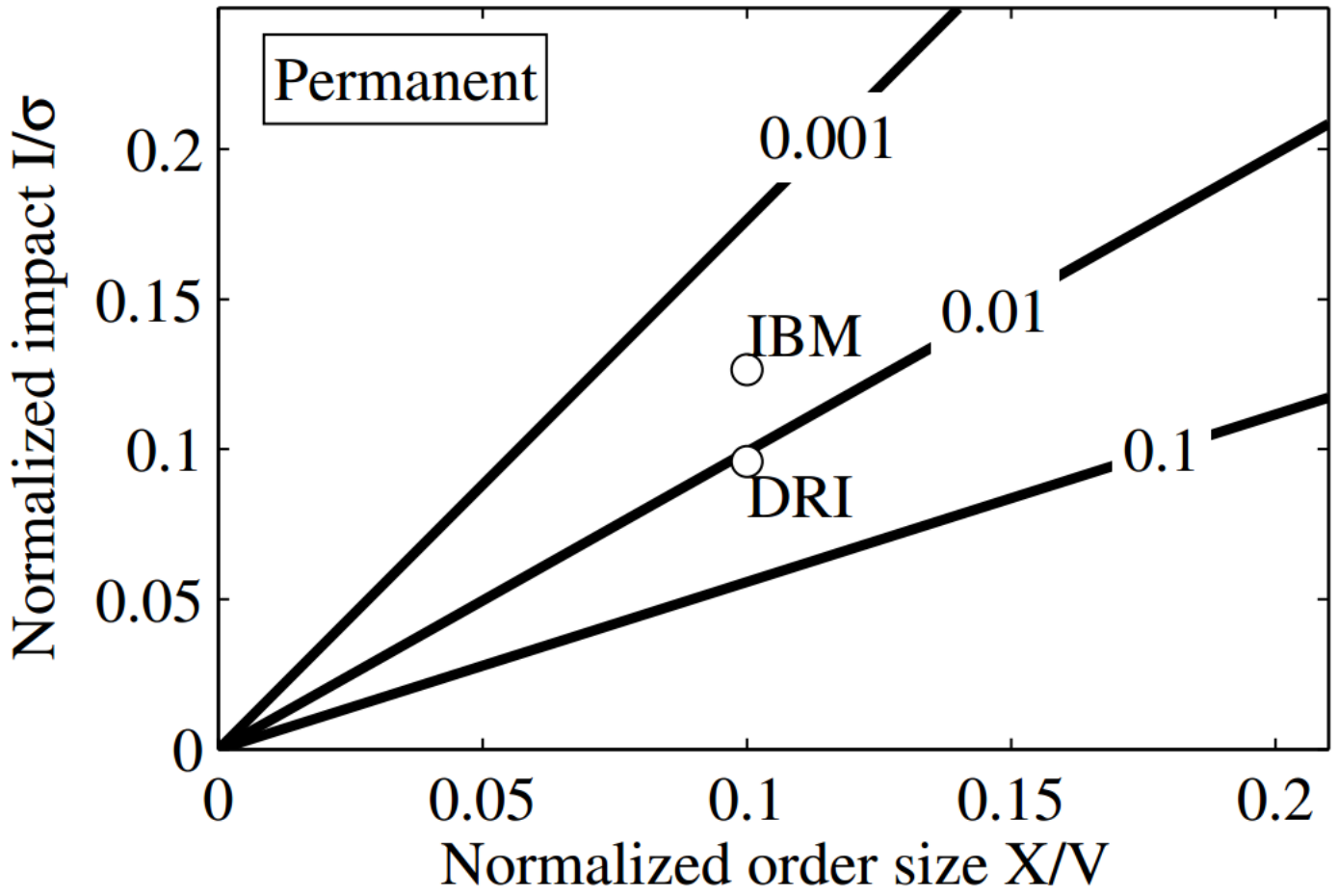


Permanent Price Impact

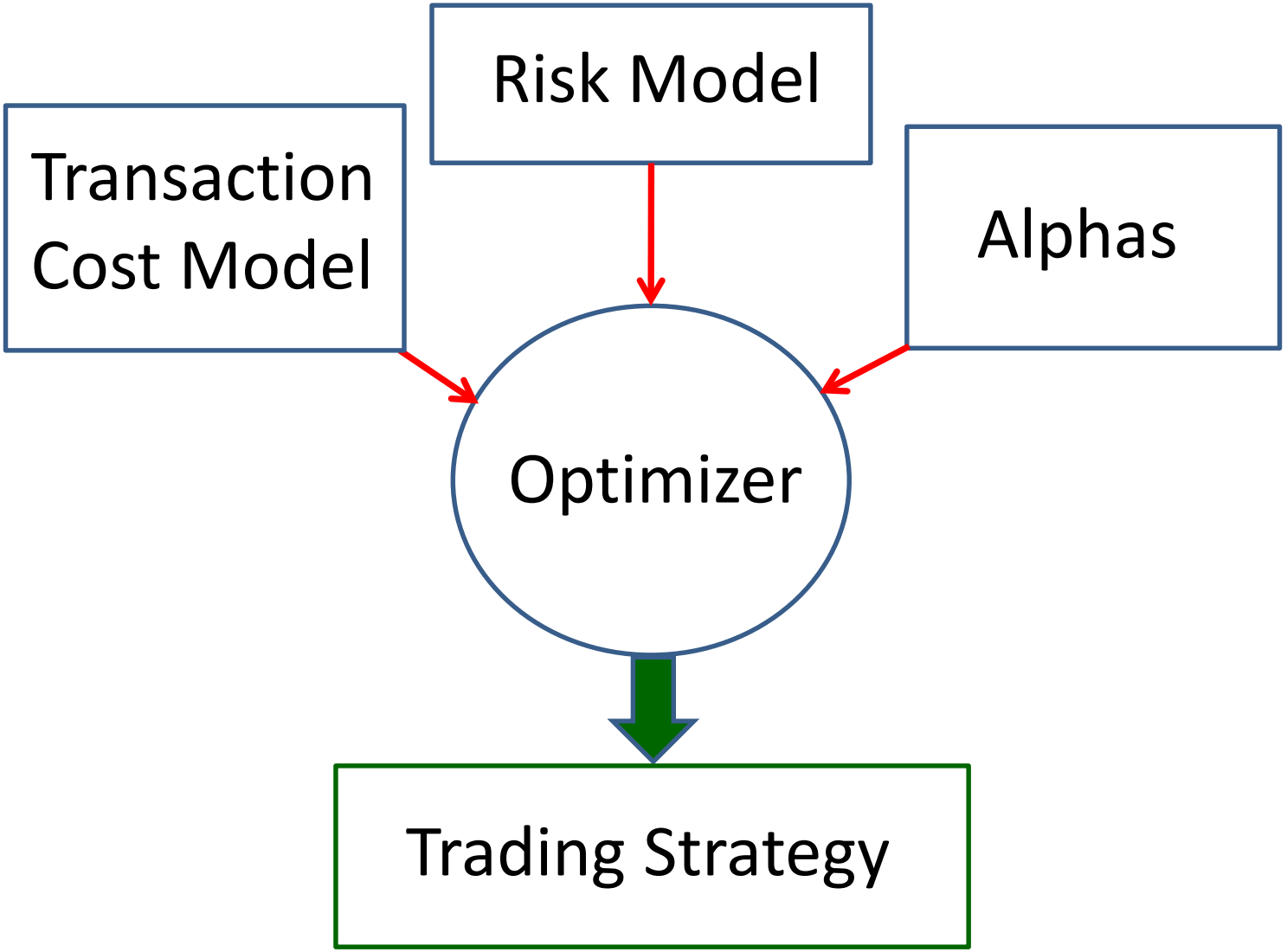
- I = permanent price impact
- Θ = shares outstanding
- X = trade size
- V = average daily volume

$$I / \sigma = \text{constant} \cdot (X/V) \cdot (\Theta/V)^{\delta} + \text{noise}$$

Permanent Impact in Power 1/4



Overall Structure



Notation

- x: (n × 1) vector of desired portfolio weights
- w: (n × 1) vector of initial portfolio weights
- Σ: (n × n) covariance matrix of stock returns
- α: (n × 1) vector of aggregate alphas
- β: (n × 1) vector of historical betas
- τ: (n × 1) vector of transaction costs

Objectives and Constraints

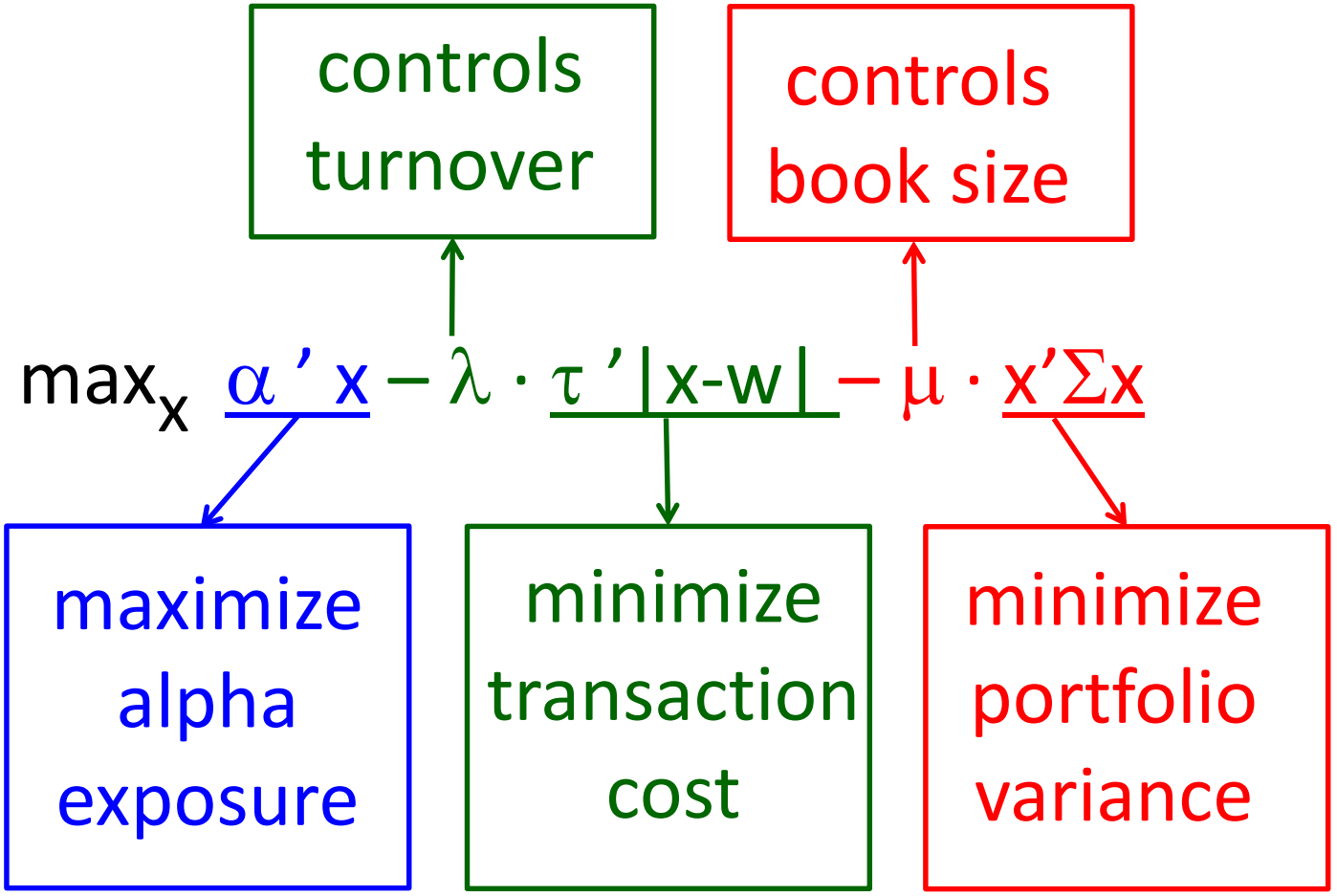
- Minimize risk: $x' \Sigma x$
- Maximize exposure to alpha: $\alpha' x$
- Neutralize exposure to beta: $\beta' x = 0$
- Minimize transaction costs: $\tau' |x-w|$

Optimization Problem

$$\max_x \ \alpha' x - \lambda \cdot \tau' |x-w| - \mu \cdot x'\Sigma x$$

subject to: $\beta' x = 0$

Objective Function



Overall Problem

$$\max_x \quad \alpha' x - \lambda \cdot \tau' |x\text{-}w| - \mu \cdot x'\Sigma x$$

Subject to:

- beta neutrality: $\beta' x = 0$

Is this standard Quadratic Programming?

Quadratic Programming

- Quadratic programming (QP) is fast, efficient and guaranteed to converge
- Excellent off-the-shelf software
- Matlab optimization toolbox

- Problem: the absolute value in the transaction cost term is not *standard* quadratic programming: $\tau' |x-w|$

Split Variables

- Classic solution: split each variable into 2
- Drawback: twice as many variables
- Advantage: no need to use nonlinear programming
- Define:
  - $y = \max(x-w,0)$
  - $z = \max(w-x,0)$
- Then $y \geq 0$, $z \geq 0$, $x = w + y - z$ and $|x-w| = y+z$

Indeterminacy?

- Initial problem strictly convex
  $\Rightarrow$ unique solution in x
- Twice as many variables:
  solution still unique in y and z?
- Replace y by y+1 and z by z+1
  $\Rightarrow$ x = w + y – z remains unchanged!

- Still OK because |x-w| = y+z penalized

New Formulation

$$\max_{y,z} \alpha'(w+y-z) - \lambda \cdot \tau'(y+z) - \mu \cdot (w+y-z)'\Sigma(w+y-z)$$

Subject to:

- beta neutrality: $\beta\,'\,(w+y-z) = 0$

Non-quadratic part has been removed.

Required Readings for Next Lecture

- “Short-Term Persistence in Mutual Fund Performance (2004)”, by Nicolas Bollen and Jeffrey Busse

- “Inadmissibility of the usual estimator for the mean of a multivariate normal distribution” (1956), by Charles Stein