"Successful investing is anticipating the anticipations of others."

John Maynard Keynes (Economist)

Quantitative Strategies

Development and Optimization

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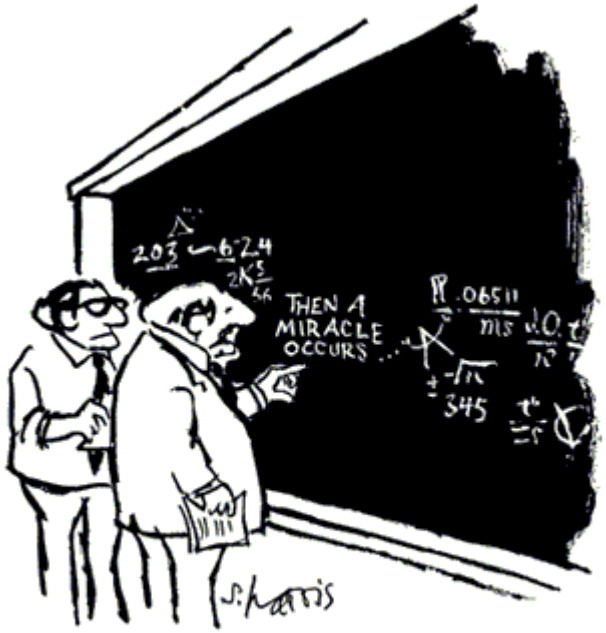
Some Definitions



"I think you should be more explicit here in step two."

Systematic Trading: **Trading decisions** in a methodical way defining trading goals, risk controls and rules

Quantitative Trading: Trading **signal generation** based on quantitative analysis

Algorithmic Trading: **Execution of trades** using automated pre-programmed trading instructions

Hi-Frequency Trading: Algorithmic trading characterized by **high speed**, high turn-over rates and high order-to-trade

The Power of Large Numbers

Tale of Two Styles

Asset manager A is a discretionary manager and follows 10 stocks diligently. Asset manager B is a systematic manager and have enough computational power to track 500 stocks. Investors seek outperformance and confidence.

Question #1: What is the hit ratio for A to achieve outperformance in at least 50% (total 5 stocks) of his portfolio with at least 95% probability

Question #2: What is the hit ratio for B to achieve outperformance in at least 50% (total 250 stocks) of his portfolio with at least 95% probability

The Power of Large Numbers

Tale of Two Styles

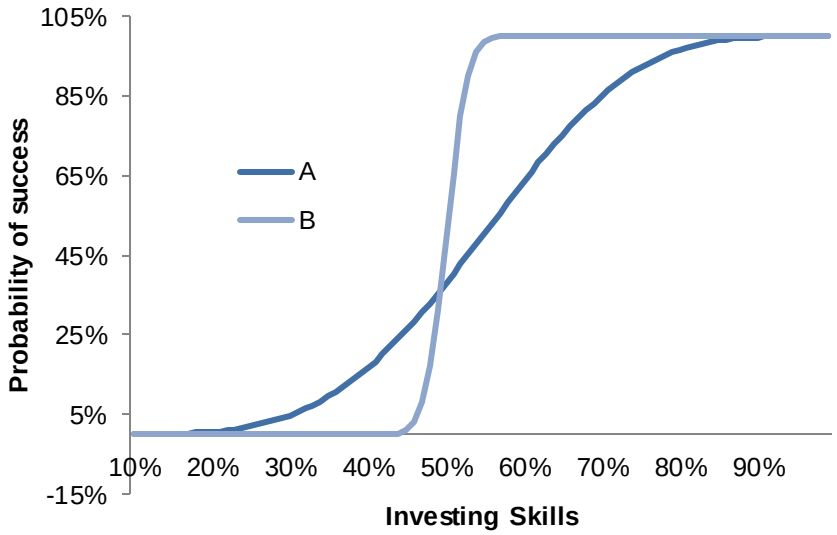
Solution: Let the success rate be p. Total required success n, total trial N. Probability of n success out of N trials is the binomial distribution

$$\Pr(n \mid N, p) = {}^{N}C_{n}.p^{n}.(1-p)^{N-n}$$

Probability of at least n success

$$P = 1 - \sum_{i=1}^{n} \Pr(i \mid N, p)$$

Compute the probability (1 - BINOM.DIST in Excel, with cumulative True). Solve for p, such that P is 0.95 in both cases.



Fundamental Law

The fundamental law of investment management: $IR \approx IC \cdot \sqrt{N} \cdot TC$

Information Ratio (IR)

Measure of success – risk adjusted returns over the chosen benchmark

Information Coefficient (IC)

Linear relationship between predicted asset returns and realized returns, usually in the range of 0 to 1 (unlike correlation range of -1 to 1, as you can always short the prediction of someone who is consistently wrong!!).

Number of Bets (N)

Number of **independent** bets that can be made in a given time-frame.

Transfer Coefficient (TC)

The linear relationship between predicted asset returns and actual trading positions. This ideally should be one, but can be lower (risk limits, capital limit, bandwidth problem due to work overload etc.)

The Strategy Spectrum

Quant	Momentum (time-series or cross-sectional)	Pair-trading, most types of statistical arbitrage	Advanced models (e.g. HMM, regime switching)	HF Market-making, Cash-futures arbitrage	News-based automated trading
Technical	MA cross-over, Continuation patterns	Swing, Retracement, Pivot trading	Opening range, dual thrusts, patterns	Range-based short gamma (vol selling)	Nothing much here
Fundamental	Factor-based investing	value investing	value/ RV (relative value) strategies	Cross-asset, cross country RV/ short gamma	Usually discretionary
	Trending	Mean-reverting	Break-out	Carry	Event-based

Trading Strategy

Strategy: A set of rules or a well-defined algorithm to choose an action from the set of all possible actions in any state of a game.

Trading Strategy: Strategy (above). The game is stochastic (state transitions are probabilistic), massively multi-player and potentially long running

$$I = f(P, V, T) \rightarrow (100.02, 100.05, 98.95, \dots)$$ Input data (prices etc.)

↓

$$S = f(I) \rightarrow (1, 0, 0, -1, -1, 0, 0, \dots)$$ Signal function

↓

$$P = f(S, \Pi) \rightarrow (100, 0, 0, -50, -75, 0, 0, \dots)$$ Positioning function

↓

$$\Pi = f(P, R) \rightarrow (100, 98.95, 97.5, 99.5, 100.5 \dots)$$ Portfolio value

Strategy Development: Find S and P such that objective $f(\Pi)$ is maximized for future values of I.

Trading Strategy Stages

IDEATION

Outcome is a **verifiable** hypothesis

- Experience in the markets
- Processing of recent and historical information
- Empirical observations
- Inspirations from other fields

TESTING

Outcome is assessment of the hypothesis

- Convert the hypothesis to programmable rules
- Test on historical data (backtesting)
- Test on simulated data (bootstrapping)
- Test on live data (walk-forward)
- Estimate risk and pnl profile, optimiza

DEPLOYMENT

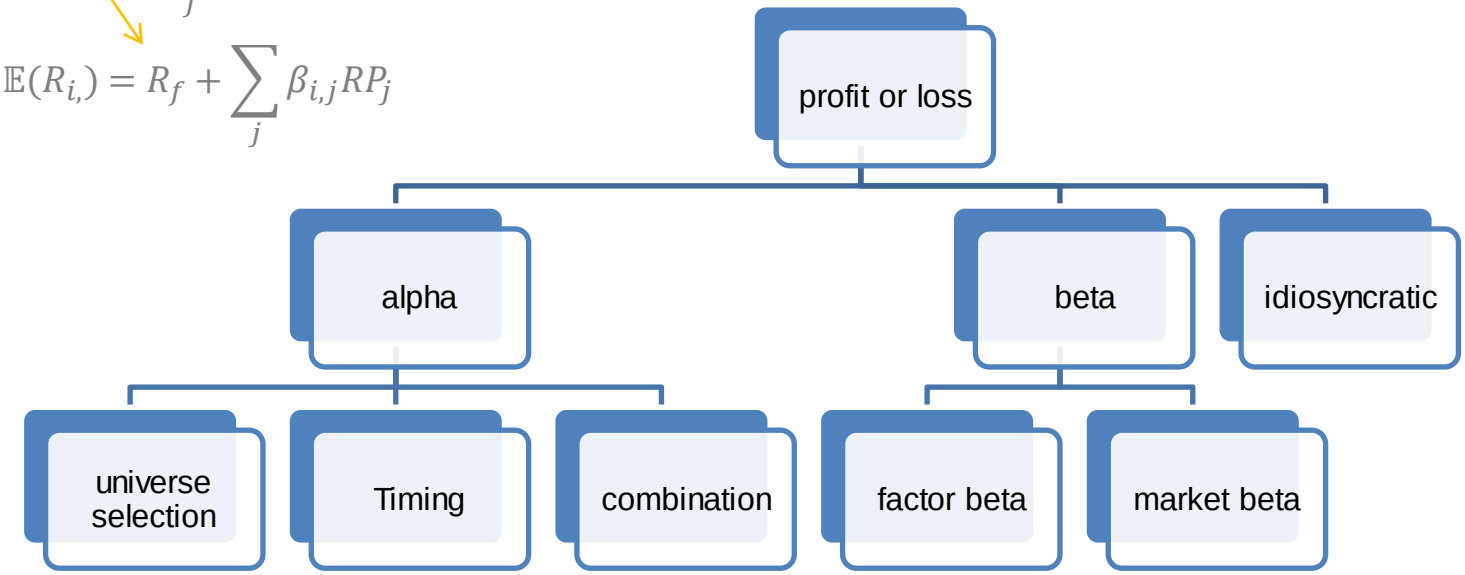
Outcome is risk and pnl

- Develop or choose reliable infrastructure and execution venues/ partners
- Define risk metrics outside strategy parameters
- Deploy and monitor
- Eventually go back to step 1

Sources of Profit

$$R_{i,t} = a_i + \sum_j \beta_{i,j} \Delta F_{j,t} + \epsilon_{i,t}$$

$$\mathbb{E}(R_{i,}) = R_f + \sum_j \beta_{i,j} RP_j$$



1. *ΔF is k-variate I(0) – factor returns, ε is n-variate white noise*
2. *Objective: Create portfolio to beat the market!*
3. *First try: Capture any factor other than market – Jensen's alpha!*
4. *Holy Grail: RP (and ΔF too!) not time-dependent – pure alpha!*
5. *Tough luck: try RP not time-dependent – smart beta is the new alpha?*
6. *Next: RP is stable and consistent – Focus on factor allocation!*
7. *Time-varying but predictable? – Focus on market timing!*
8. *Unstable and unpredictable on all scale? – go back to passive investing!*

A Simple Trading Strategy

IDEATION

Observations *(and heard elsewhere): If the range in the opening hour is broken, the market continues in the same direction after break-out*

A Simple Trading Strategy

IDEATION

Simplistic variation of opening range breakout

Next step: Backtesting?

Statutory warning: Strategy development is hard work. What follows is demonstration only and not advice nor solicitation.

A Simple Trading Strategy

IDEATION

***Step 1**: Deep-dive (to form a hypothesis)*

Observations are good, but are they anecdotes or statistics?
Let go through historical data and decide

We do not want to test (back-test) right away:

1) *it is hard-work and we are not sure if it worth our time*
2) *we do not yet have a concrete hypothesis to test*
3) *we do not have idea about the possible relationship between signals and outcome (opening range and next move) to optimize at all!*

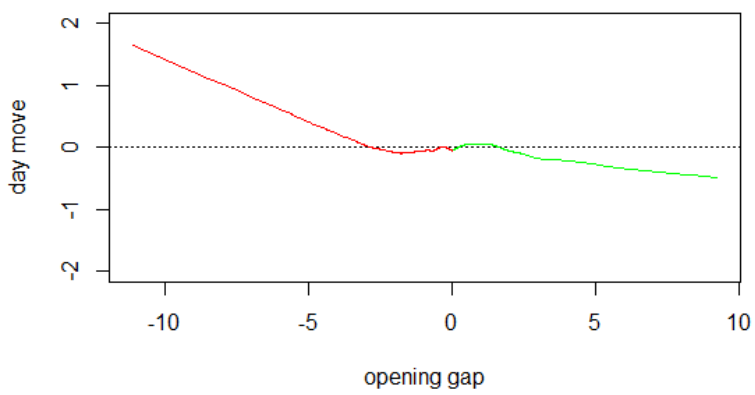
Let's try following

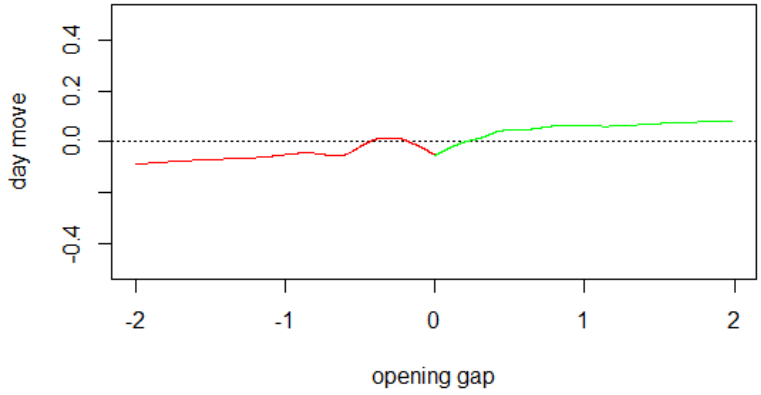
1) *Get the daily prices (why?) of a bunch (why?) of stocks*
2) *Approximate opening range gap as gap between last high (low) and next open*
3) *Approximate day move as difference between day close and day open*

A Simple Trading Strategy

IDEATION

***Step 1**: Deep-dive (to form a hypothesis)*





Observations:

1. *Signal vs. outcome is highly non-linear*
2. *At large range (very large moves), it shows mean-reversion behaviour*
3. *At small range (small opening gap), it shows the behaviour we are seeking*

A Simple Trading Strategy

TESTING

Step 1: Convert a loose observation to a concrete statement that can be verified

Define opening range is to be the n-minute (say 30 min) candle after the market open. Define the closing bar as the daily candle (open-high-low-close) from yesterday.

Signal function

1. Normalize the gap by dividing by daily 1-vol move (?)
2. If closing bar high is lower than low of opening range, signal is positive, entry level is high of opening range
3. If closing bar low is higher than high of opening range, signal is negative, entry level is low of opening range

Position function

Deploy all available capital equally each day

Entry Rule

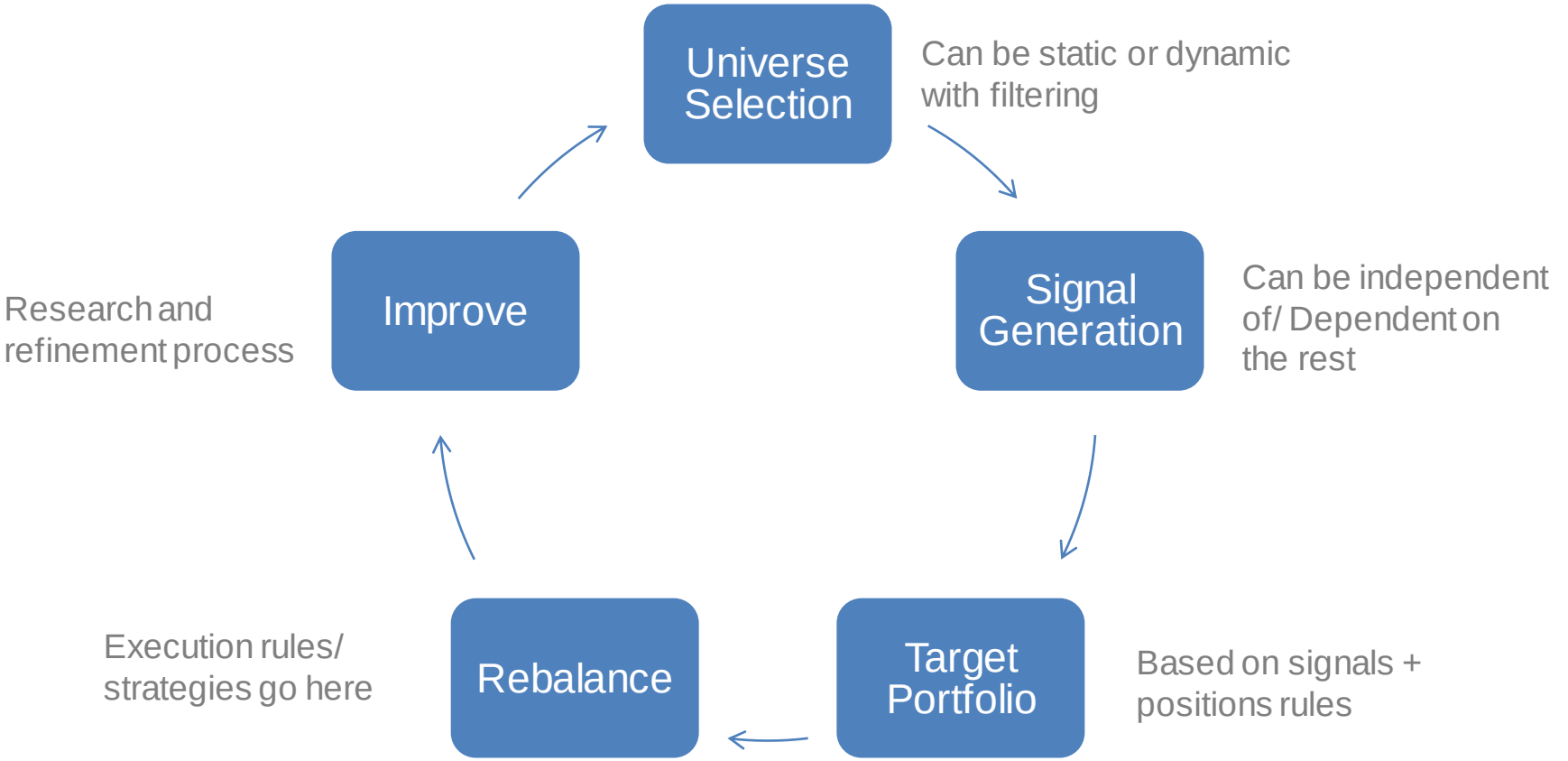
1. Entry allowed only in the first n minutes (say 1 hour after the opening range)
2. If positive signal and entry level is breached, enter long
3. If negative signal and entry level is breached, enter short

Exit Rule

1. Exit all positions (if any) n minutes (say 30 min) before market close

Let's run the backtest at https://blueshift.quantinsti.com/

Systematic Strategy Design Cycle



A Simple Trading Strategy (Contd.)

TESTING

Step2: Evaluation

Start Date	End Date	Starting Capital	Ending Capital
Wed Jan 1 2014	Tue Feb 25 2020	100,000	236,720

Performance Metrics

Annual Returns	15.17 %
Cumulative Returns	136.72 %
Annual Volatility	22.5 %
Sharpe Ratio	0.74
Maximum Drawdown	-40.53 %
Omega Ratio	1.21
Sortino Ratio	1.1
Skew	0.06
Kurtosis	12.42
Stability of Timeseries	51.24 %

A Simple Trading Strategy (Contd.)

TESTING

Step3: Optimization

What are the parameters of our strategy

1. *The signal threshold (0.0)*
2. *Look-back duration for volatility calculation (20 days)*
3. *The time (T1) for opening range calculation (30 min from open)*
4. *The time (T2) for entry trades (1 hour after opening range calculation)*
5. *The time (T3) for exit (30 min from market close)*
6. *A binary position function*

How to optimize? Which to optimize

$$f(\Pi) = f(P).R = f\big(S(I,\Theta)\big).R$$

Optimize objective function $f(\Pi)$ with respect to parameter set Θ, potentially subject to constraints (long-only, max leverage, max holding time (day-trading) etc.

A Simple Trading Strategy (Contd.)

TESTING

Step3: Optimization

What most people do?

*Run a search (*simple *exhaustive*, advanced *genetic algorithm*, or *simulated annealing* or *ML* and what not*) on the entire parameter space.*

Most commercially available backtesting platform offer (and tout) this feature

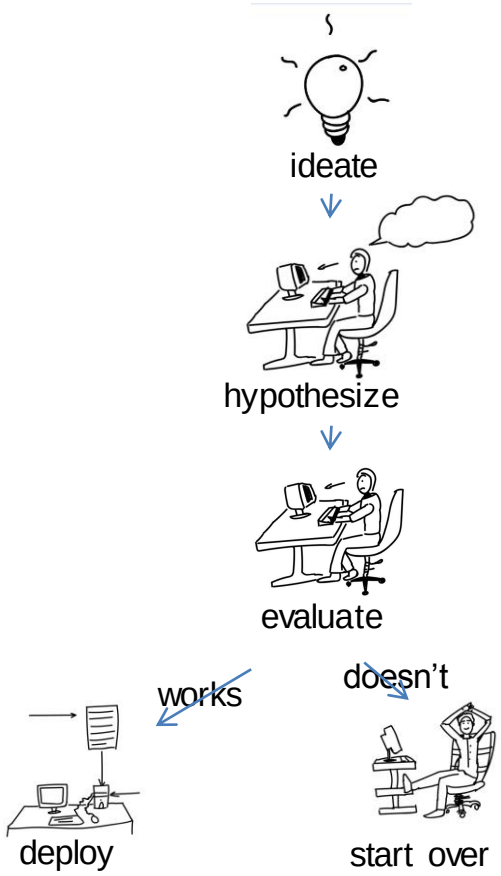
If you are doing this, you need to stop, NOW!

Why?

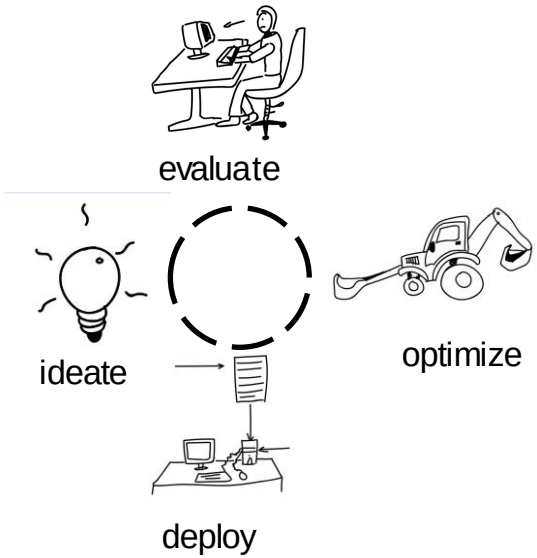
Back-testing: Optimize?

Scientific way of developing a strategy:

TESTING



The way most of us end up with:



Back-tests are useful for hypothesis testing
Not a data-fitting tool

We do not want to optimize our backtest performance. We want to optimize expected live performance.

This is why on blueshift, we do not offer a parameter search optimization tool

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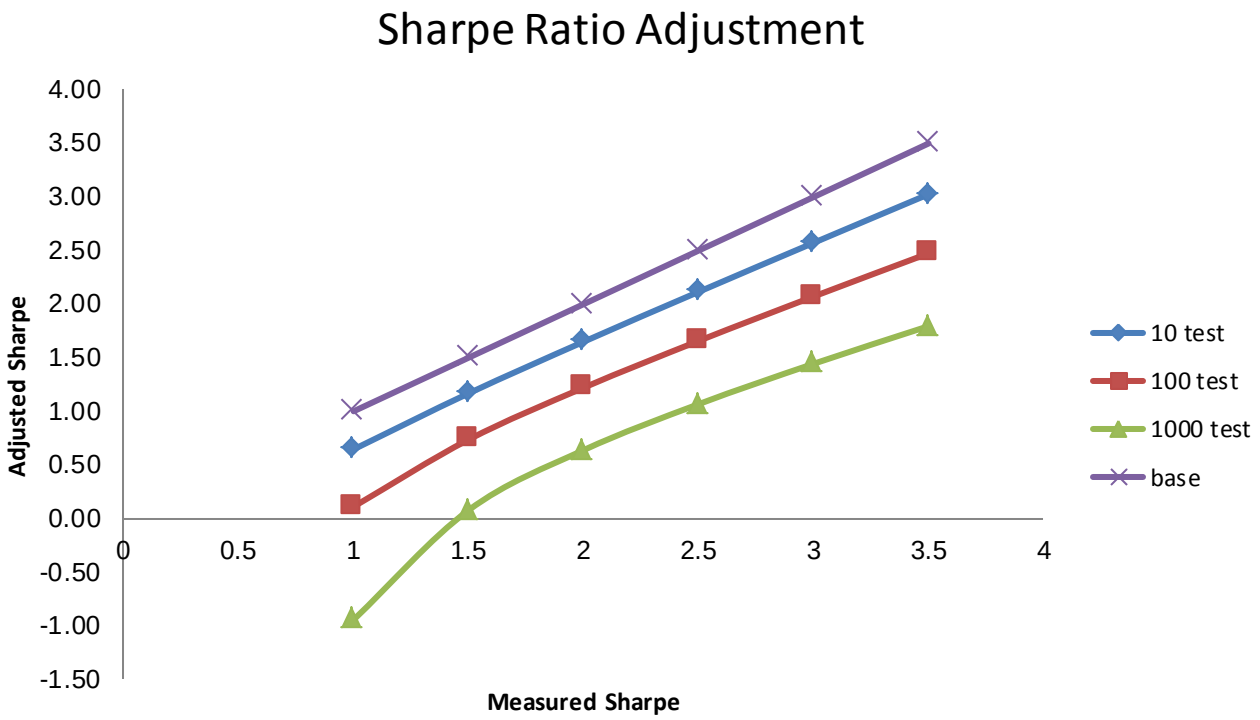
Problems[1] with Optimization

TESTING



Alternative to Optimization by parameter space search

1. Simulated data optimization (bootstrapping)
2. research: With empirical/ economic/ behavioural justification
3. Adaptive Strategies: Example Change Point Analysis

1. See here for more on this

A Simple Trading Strategy (Contd.)

TESTING

Step3: Other optimization techniques

Simulated data (boot-strapping)

1. *Simply over-sampling does not work for trading strategy backtesting (why?)*
2. *Research and fit a time-series model (as complex as you like) on the available historical data*
3. *Generate simulated data from the model*
4. *Optimize parameters based on generated data (not historical data)*

Scientifically solid approach. Difficult to generate model, for certain cases can remove the source of model alpha.

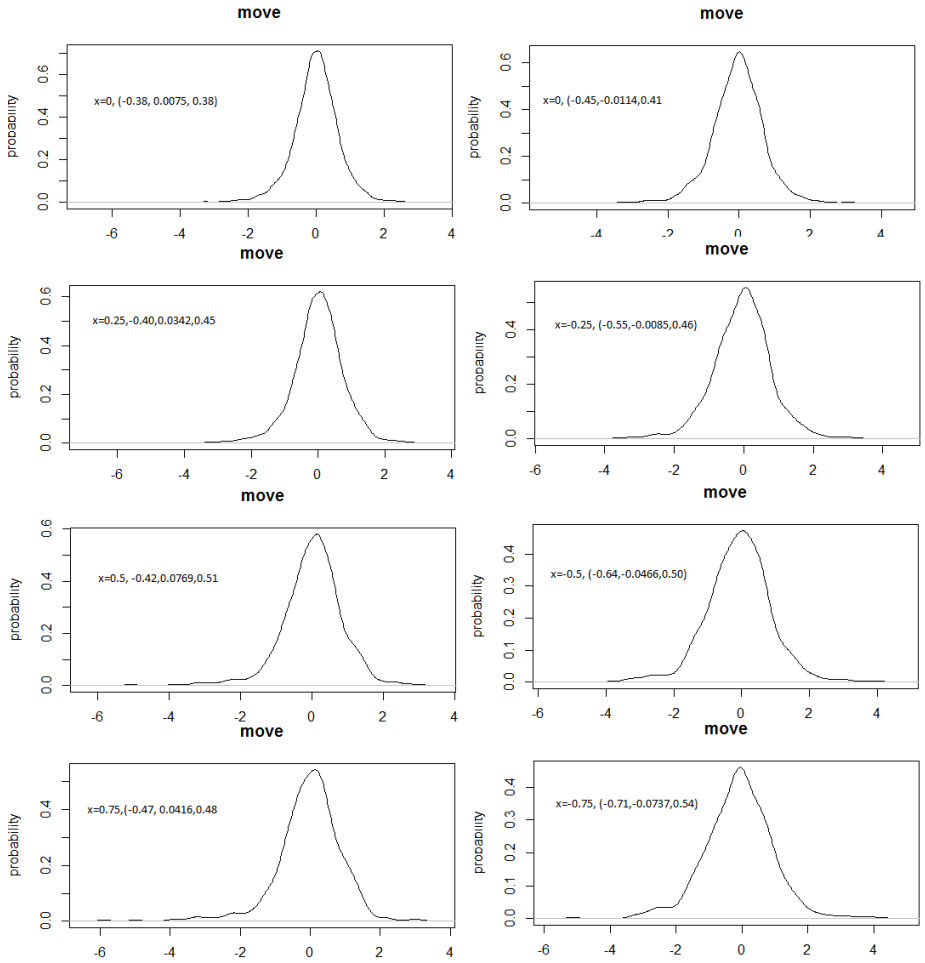
Research :Observe and analysis

The economic way. Scientifically as solid. Difficult to generalize this approach, depends on particular case.

A Simple Trading Strategy (Contd.)

TESTING

Step3: optimization effort 1 – change signal threshold?



Threshold 0.5 for the up side and -0.75 for the downside looks optimal on the daily data

Let's try this out

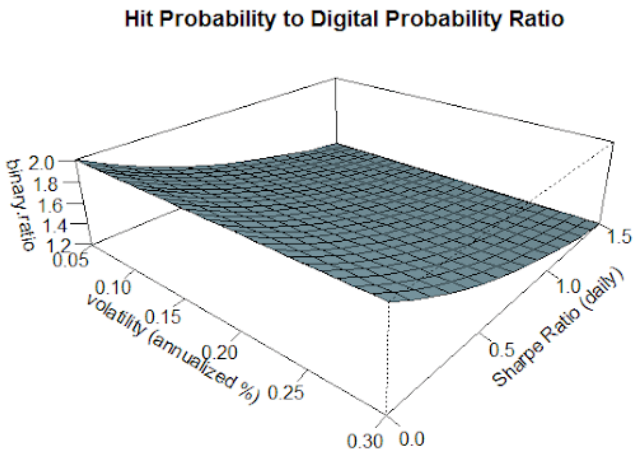
A Simple Trading Strategy (Contd.)

TESTING

Step3: optimization effort 2 & 3: add take profit (and test that threshold)?

May be we are losing out on some reversal? Why not use a take-profit

Update exit condition to enter either 30 min before market close, or whenever we hit our profit target (1 SD move from our entry levels in our favour)



Ratio of exercise probability of 1-day barrier vs. European options

Buy and hold till day-end is equivalent to a one-day optionality on the underlying stock

Take-profit improves the hit ratio at the expense of upside – we win more often but our max upside is limited to take profit size

For a high prediction power (high Sharpe in the picture), take profit strategy is relatively bad

For real-life, our prediction power is usually low

1. See here for more on this

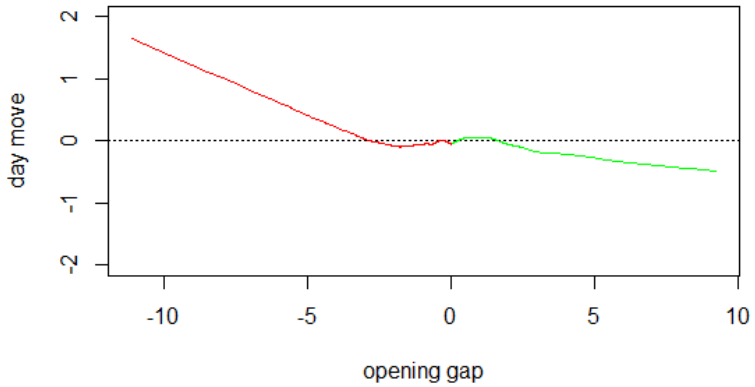
A Simple Trading Strategy (Contd.)

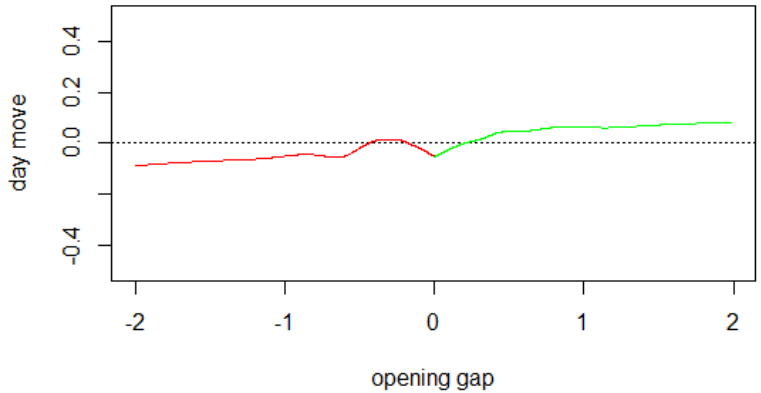
TESTING

Step3: optimization effort 4: remember the signal-outcome distribution?

The reason may be effort #1 did not work is we selectively skewed towards high x, getting in to the zone where the signal-outcome relationship flips (left-hand chart)

Let's try putting an upper-bound on the signal instead





A Simple Trading Strategy (Contd.)

TESTING

Step3: optimization : what about stop-loss?

Stop-loss is a risk control mechanism and should not be used as a signal mechanism

Stop-loss can be natural part of the signal (model) if the model is based on (positive) serial auto-correlation (e.g. momentum) AND the underlying does exhibit serial auto-correlation

In all other cases, stop-loss a losing proposition theoretically, especially in the presence of trading costs.

Instead, use stop-loss as a risk control overlay over the total profit-and-loss of the strategy (as opposed to trade-wise)

1. See here for more on this

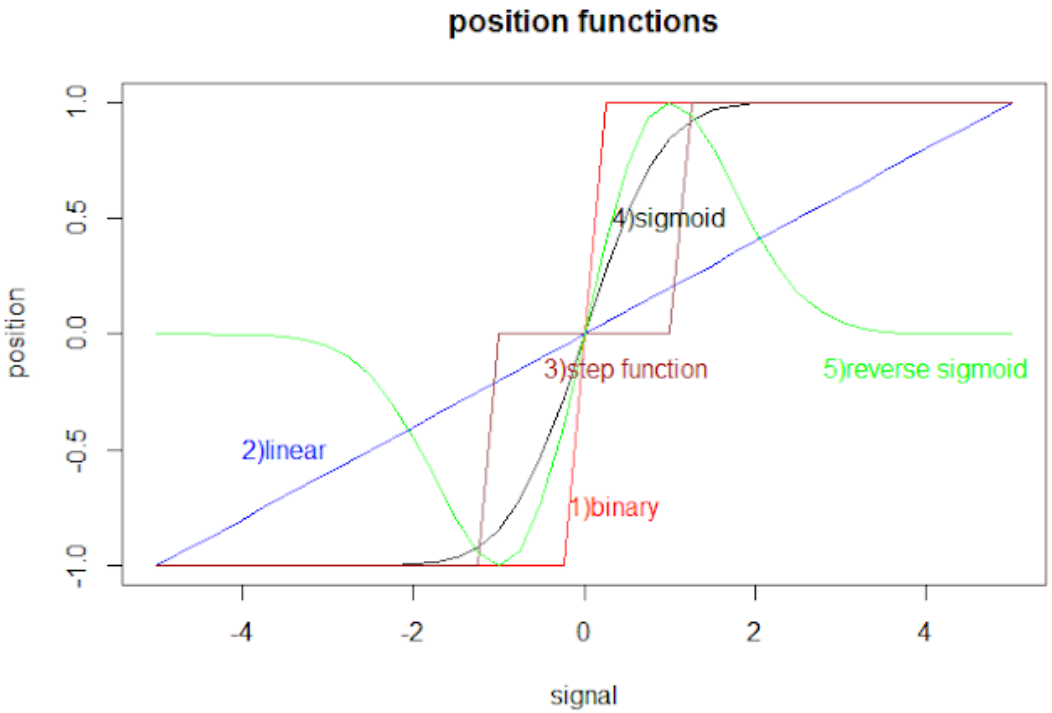
A Simple Trading Strategy (Contd.)

TESTING

Step3: optimization effort 5: What about the position function?

So far we tried tweaking the signal function. What about the position function

Let's try the sigmoid curve instead of the current binary position function



A Simple Trading Strategy (Contd.)

TESTING

Step3: optimization effort : What else we could have done?

Add filters to conditions/ Combine other signals

1. *Use vol filters – more likely to hit the take profit target*
2. *Add a 'market regime' signal? (see signal vs. outcome during 2016-17)*
3. *Add a momentum filter or a candlestick filter or any other thing you fancy*

Be careful, as we add more filters, we move towards data-fitting (number of trades (signal trigger) become increasingly less compared to number of signals measurements)

Create adaptive strategies – topic for another day

A Simple Trading Strategy (Contd.)

TESTING

Once the development is done, time to deploy for paper trading (or if not available, live trading with small capital)

Things to know before deployment

1. *How is the trading profile of my strategy – how often does it trade? how is the distribution of the holding period? How large are the individual orders?*

2. *What are the operational risks – what happens if I get bad input data (missing etc.), what happens if connection breaks down, what happens if my algo goes out-of-memory, can my algo get stuck in infinite loop or become unresponsive otherwise? What if my broker's server is down?*

3. *Based on the above set up risk control – minimal list below:*

- *Must put a limit on number of trades per day (to avoid machine-gunning)*
- *Must put a limit on max size per trade (fat-finger error)*
- *Must put a draw-down limit (the strategy stop-loss we talked about)*
- *Must put a kill-switch (in case algo gets unresponsive, or you found a better one!)*

On top, the algo code must handle missing data, failure in placing trades, avoid any infinite loop (check every loop in your strategy) and should be single-threaded (to avoid race-condition).

A Simple Trading Strategy (Contd.)

DEPLOYMENT

Ideally there should be no (or minimal change) in codes from backtest to live trading.

On blueshift going live is easy – set your risk parameters, select your broker and confirm. It also comes with a dashboard for monitoring and optional Telegram notification. Let's go live.

Summary

Summary of the development

Strategy	Returns	Drawdown	Sharpe	Stability	Omega	Skew
Base	136.72	-40.53	0.74	54.24	1.21	0.06
#1	23.36	-37.91	0.29	0	1.11	-0.08
#2	146.54	-31.03	0.91	75.31	1.26	-1.34
#3	135.61	-31.89	0.78	70.67	1.12	-0.58
#4	148.41	-25.78	0.94	79.88	1.28	-1.29
#5	120.58	-11.34	1.28	84.11	1.47	-0.67

We started with a simple idea, then moved to the stages of Ideation, Testing and Deployment.

We went through optimization, avoiding blind parameter space search

Finally we came up with a decent strategy and deployed for paper-trading

Get all the codes at https://github.com/QuantInsti/blueshift-demo-strategies

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