



COMPUTATIONAL FINANCE & RISK MANAGEMENT

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UNIVERSITY *of* WASHINGTON

Department of Applied Mathematics

# Introduction to Trading Systems

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# Outline

- 1 Introduction to trading systems
- 2 Elements of a quantitative trading system
- 3 Trading system example
- 4 Trading system evaluation
- 5 Overview of trading system optimization
- 6 Trading system development process
- 7 Package demos
- 8 Wrap up

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# Lecture references

- Trading Systems by Urban Jaekle and Emilio Tomasini
  - chapter 1-2
- Evaluation and Optimization of Trading Strategies by Robert Pardo
  - chapter 2-3
- Quantitative Trading Strategies by Lars Kestner
  - chapter 1, 4
- Evidence-Based Technical Analysis by David Aronson
  - chapter 1

# Trading systems and systematic trading

## Trading System

A *trading system* is a precise set of rules that automatically defines, without any human discretionary intervention, the entry and the exit on the markets

Trading Systems, Jaekle & Tomasini

## Systematic Trading

*Systematic Trading* utilizes computer models, mainly based on *technical analysis* of market data or fundamental economic data, to identify and make trades, with limited manager intervention

Morningstar Investing Glossary

# Different names for systems trading

Common synonyms for *trading system*:

- mechanical trading system
- automated trading strategy (system)
- quantitative trading strategy (system)
- systematic trading strategy (system)
- technical trading system
- rules-based trading
- systematic trading
- systems trading
- algorithmic trading system

Whatever the term, we are referring to the trading process that does not involve human interpretation or discretionary decision making in operation

# Systematic versus discretionary trading

Attribute	Systematic	Discretionary
Fixed trading rules	yes	no (can be yes)
Event reaction	slow	fast
Risk control	total	limited
Emotions	none	yes
Backtesting	yes	no

- Discretionary trading relies on one's judgment for entry and exit orders
- Systematic trading is a mechanical set of rules covering entry and exit orders based on a preestablished and predefined plan
- Systematic traders are able to test their systems through historical data, using those data to prepare their risk management strategies

# Technical analysis

## Technical Analysis

A method of evaluating securities by analyzing statistics generated by market activity, such as past prices and volume. Technical analysts do not attempt to measure a security's intrinsic value, but instead use charts and other tools to identify patterns that can suggest future activity

Investopedia

## Technical Analysis

Market or security analysis through the study of price movement and trading activity by charts or graphs. Unlike fundamental analysis, the intrinsic or perceived value of the security is not considered

Morningstar Investing Glossary



# Objective versus subjective technical analysis

Objective technical analysis:

- methods that are well-defined repeatable procedures that issue unambiguous signals
- can be implemented as computerized algorithms and back tested on historical data
- results produced by a back-test can be evaluated in a rigorous quantitative manner

# Objective versus subjective technical analysis

## Subjective technical analysis:

- methods that are not well-defined analysis procedures
- vague rules that require an analyst's private interpretations
- ad hoc methods that defy computerization, back testing, and objective performance evaluation
- impossible to either confirm or deny a subjective method's efficacy
- insulated from evidentiary challenge

# Objective versus subjective technical analysis

## Objective Technical Analysis:

- moving averages
- new highs, new lows
- price channels
- linear regression lines
- numerical technical indicators
  - relative strength index
  - stochastics
  - MACD
  - average true range

## Subjective Technical Analysis:

- Dow theory
- Fibonacci lines
- Gann lines
- chart patterns
  - trend lines
  - head and shoulders
  - cup and saucer
  - pennants

# Programmability criteria

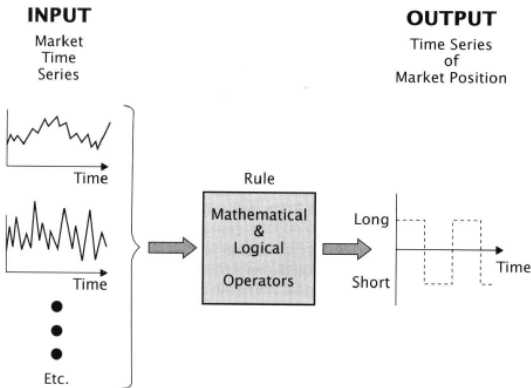
An objective technical analysis method satisfies the programmability criteria<sup>†</sup>:

- A method is objective if and only if it can be implemented as a computer program that produces unambiguous market positions (long, short, or neutral)
- All methods that cannot be reduced to such a program are subjective

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<sup>†</sup>Evidence-Based Technical Analysis, Aronson

# Illustration of programmability criteria



Evidence-based Technical Analysis, David Aronson (used with permission)

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## Trading System Elements

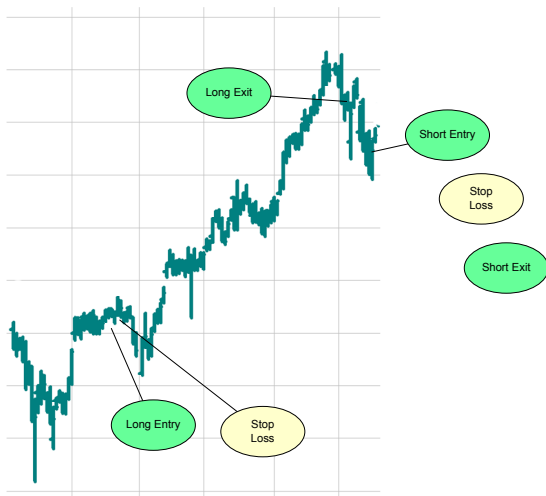


## Trading System Elements

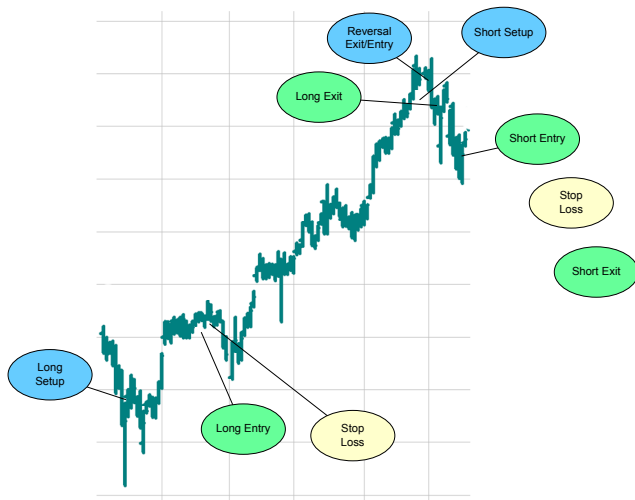




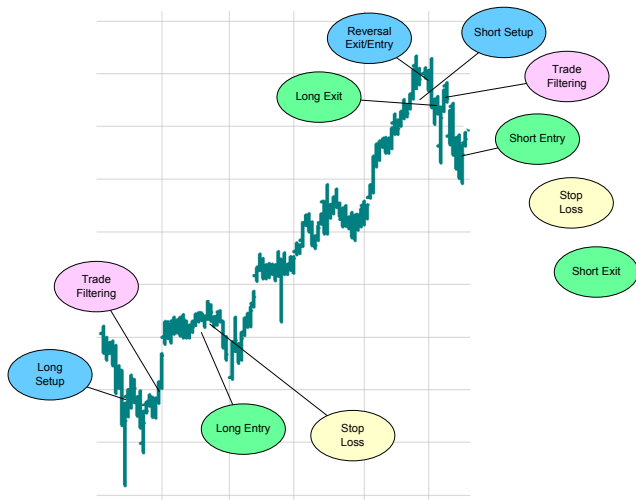
## Trading System Elements



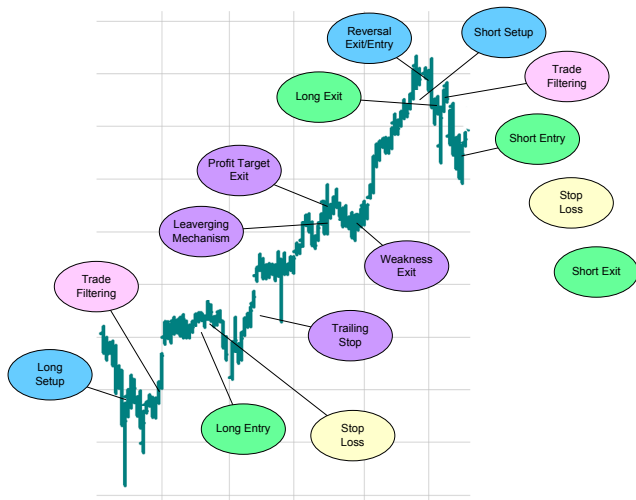
## Trading System Elements



## Trading System Elements



## Trading System Elements



# Trading system rules

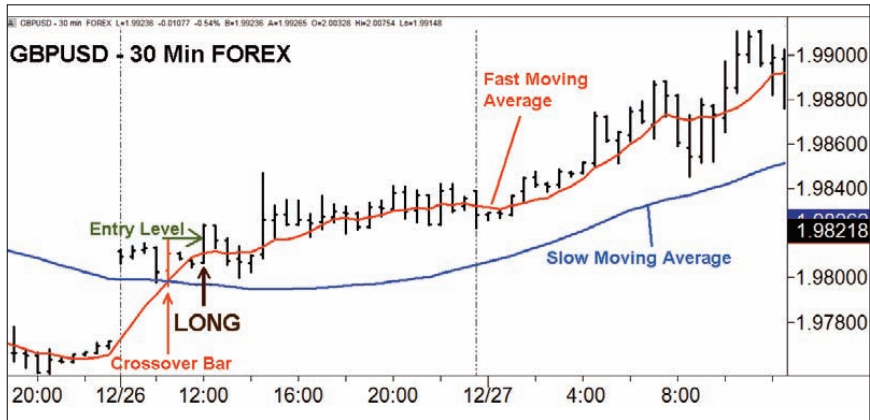
Markets	What to buy and sell
Position Sizing	How much to buy and sell
Entries	When to buy and sell
Exits	When to get out of winning positions (planned exits)
Stops	When to get out of losing positions (non-planned exits)
Tactics	How to buy and sell

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<http://www.tradingblox.com/originalturtles/>

# Luxor strategy

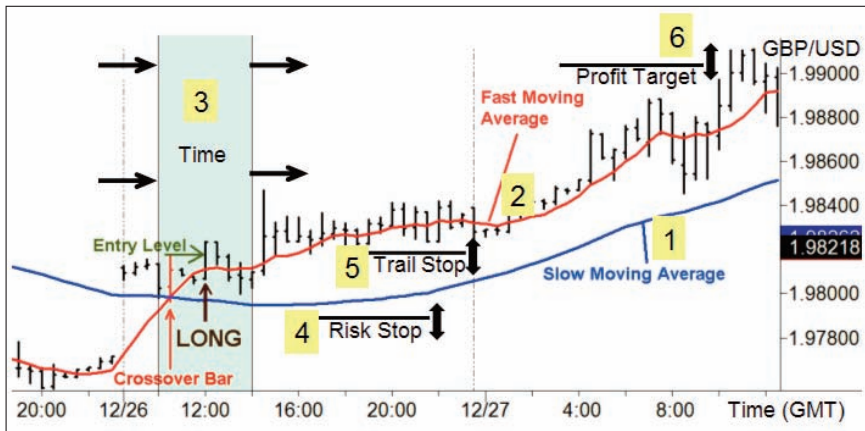
The Luxor strategy is presented in Trading Systems by Emilio Tomasini and Urban Jaekle (Harriman House, 2009)



- Luxor is basically a intra-day dual moving average crossover system

# Luxor strategy

Fully implemented, the Luxor system includes 6 separate optimizable design elements.



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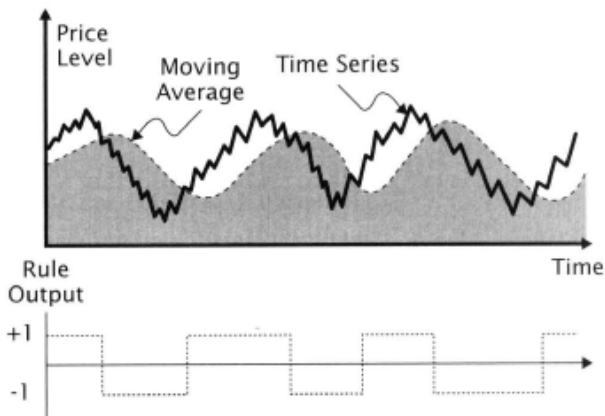
# Tactical asset allocation system

- A Quantitative Approach to Tactical Asset Allocation by Mebane T. Faber<sup>†</sup>, The Journal of Wealth Management, Spring 2007
- Simple mechanical trading system:
  - Buy and hold asset when monthly price  $>$  10-month simple moving average (SMA)
  - Sell asset and hold cash when monthly price  $<$  10-month SMA

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<sup>†</sup>Mebane T. Faber, Managing Director, Cambria Investment Management, Inc.  
<http://www.cambriainvestments.com>

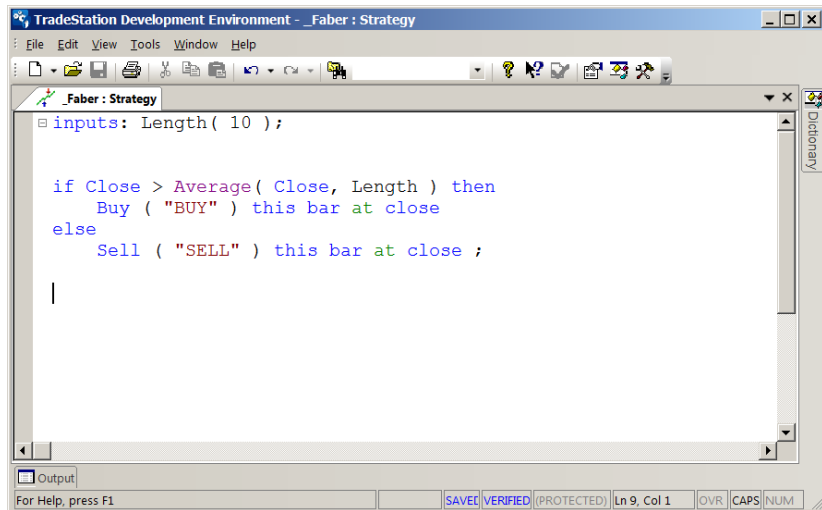
# Illustration of tactical asset allocation system



Evidence-based Technical Analysis, David Aronson (used with permission)

- rule output = 1 for long-position
- rule output = -1 flat-position (i.e. holding cash)

# Pseudo-code for the basic Faber system

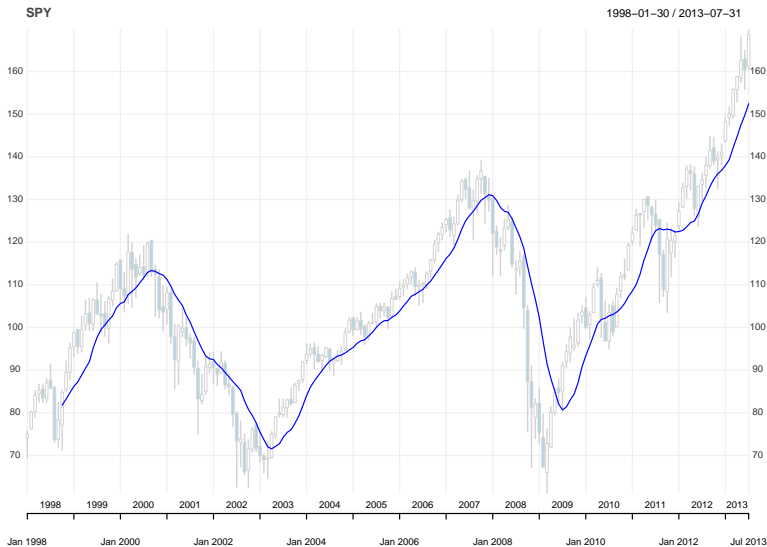


The screenshot shows the TradeStation Development Environment window titled "\_Faber : Strategy". The menu bar includes File, Edit, View, Tools, Window, and Help. The toolbar contains various icons for file operations and editing. The main text area displays the following pseudo-code:

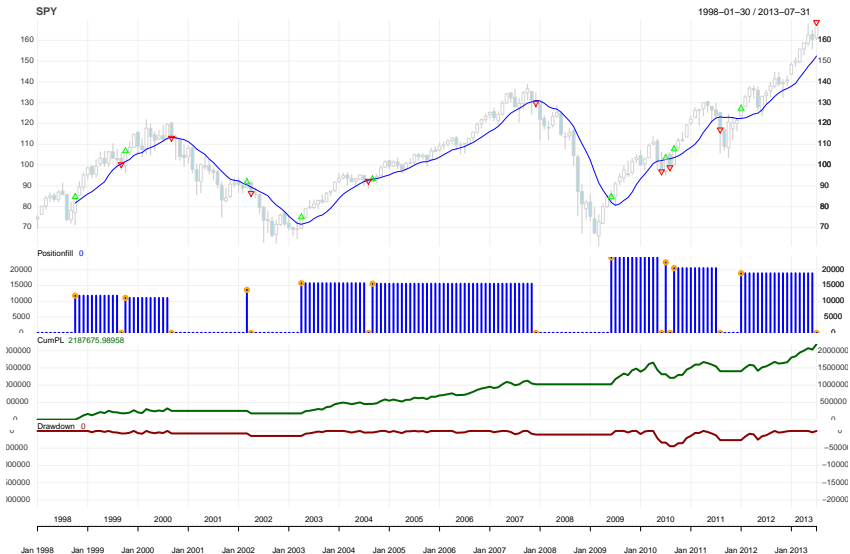
```
inputs: Length( 10 );  
  
if Close > Average( Close, Length ) then  
    Buy ( "BUY" ) this bar at close  
else  
    Sell ( "SELL" ) this bar at close ;  
  
|
```

The status bar at the bottom shows "For Help, press F1", "SAVE VERIFIED (PROTECTED)", "Ln 9, Col 1", and "OVR CAPS NUM".

# Monthly SPY and 10-month SMA



# Performance plot



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# Trade statistics

<b>Portfolio</b>	bFaber	<b>Avg.Win.Trade</b>	237993.61
<b>Symbol</b>	SPY	<b>Med.Win.Trade</b>	184069.65
<b>Num.Txns</b>	18	<b>Avg.Losing.Trade</b>	-51566.24
<b>Num.Trades</b>	9	<b>Med.Losing.Trade</b>	-51566.24
<b>Net.Trading.PL</b>	1562822.8	<b>Avg.Daily.PL</b>	223260.39
<b>Avg.Trade.PL</b>	173646.97	<b>Med.Daily.PL</b>	232435.24
<b>Med.Trade.PL</b>	144067.21	<b>Std.Dev.Daily.PL</b>	210750.49
<b>Largest.Winner</b>	568536.65	<b>Ann.Sharpe</b>	16.8168
<b>Largest.Loser</b>	-58152.453	<b>Max.Drawdown</b>	-211534.58
<b>Gross.Profits</b>	1665955.2	<b>Profit.To.Max.Draw</b>	7.3880251
<b>Gross.Losses</b>	-103132.48	<b>Avg.WinLoss.Ratio</b>	4.6152988
<b>Std.Dev.Trade.PL</b>	203165.09	<b>Med.WinLoss.Ratio</b>	3.5695768
<b>Percent.Positive</b>	77.777778	<b>Max.Equity</b>	1562822.8
<b>Percent.Negative</b>	22.222222	<b>Min.Equity</b>	0
<b>Profit.Factor</b>	16.153546	<b>End.Equity</b>	1562822.8

# Total Net Profit and Profit Factor

A trading system will typically have some winning trades and some losing trades

**Gross.Profit**          sum of all profit from winning trades

**Gross.Loss**          sum of all profit from losing trades

**Net.Trading.PL**      sum of Gross Profit and Gross Loss

**Profit.Factor**        absolute value of the ratio of Gross Profit to Gross Loss

- The Net.Trading.PL is not the most important attribute of a good trading system
- Profit Factor is an important metric for comparing trading system performance



# Percent Profitable

**Num.Trades**      total number of completed trades

**Percent.Positive**      ratio of winning trades to total number of trades

- A system can not be evaluated unless the total number of trades is a representative sample (minimum of around 30, preferably 100s)
- It is not necessary that the majority of trades are profitable but if not, the ratio of average winning trade to average losing trade is important

# Avg Trade Net Profit and Avg Win to Avg Loss

Avg.Trade.PL                      average profit from a trade

Avg.Win.Trade                    average gain from a winning trade

Avg.Losing.Trade                average loss from a losing trade

Avg.WinLoss.Ratio              absolute value of ratio of Avg.Win.Trade to  
Avg.Losing.Trade

- The Avg.Trade.PL is an important metric in determining if the system has a positive expectation
- Avg.WinLoss.Ratio in relation to Percent Profitable is important in system evaluation; both can not be low

# Largest Winning Trade and Largest Losing Trade

**Largest.Winner**    profit from the single largest winning

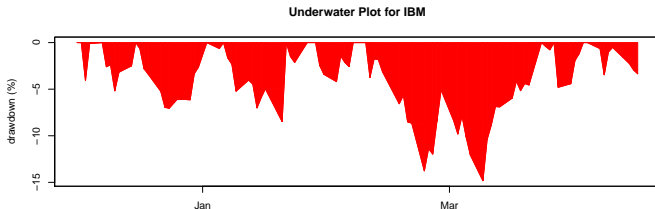
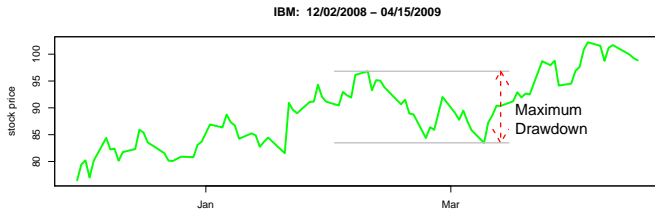
**Largest.Loser**    loss from the single largest losers

- Largest.Winner should be much larger than Largest.Loser
- Its a red flag if the Largest.Winner makes up a large percentage of Net.Trading.PL

# Drawdown Illustration

**Drawdown** amount of decline from an equity peak

**Max.Drawdown** largest decline from an equity peak



# Sharpe ratio

The Sharpe ratio was developed by Nobel Laureate William Sharpe:

$$SR = \frac{\mu - I}{\sigma}$$

where:

$\mu$  = average monthly return

$\sigma$  = standard deviation of monthly returns

$I$  = strategy defined risk-free rate

- despite its criticisms, Sharpe ratio is still the de facto standard measure of risk adjusted performance

The K-ratio was developed by Lars Kestner:

$$\text{K-ratio} = \frac{b_1}{\sigma_{b_1} n_{obs}}$$

where:

$b_1$  = slope of the log-VAMI linear regression line

$\sigma_{b_1}$  = standard error of the slope estimated

$n_{obs}$  = number of observations

- metric of the slope and linearity of the equity curve

# Return Retracement Ratio

Developed by futures trader Jack Schwager<sup>†</sup>:

$$\text{Return Retracement Ratio} = \frac{\text{average annualized return}}{\text{average maximum retracement}}$$

- attempts to measure downside risk without penalizing upside return variation

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<sup>†</sup> Author of *Market Wizards: Interviews with Top Traders*

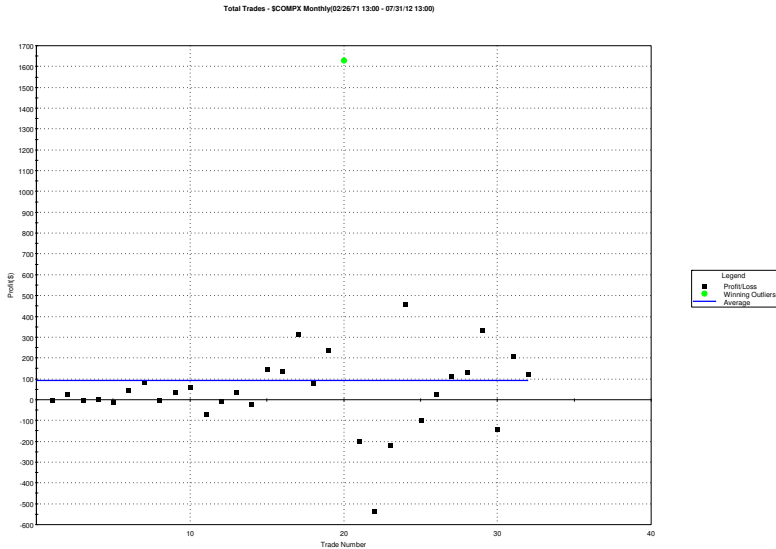
The RINA index is a trade performance metric developed by RINA systems:

$$\text{RINA index} = \frac{\text{Net Profit} - \text{Net Profit of Outliers}}{\text{Average drawdown} \times \text{Percent time in market}}$$

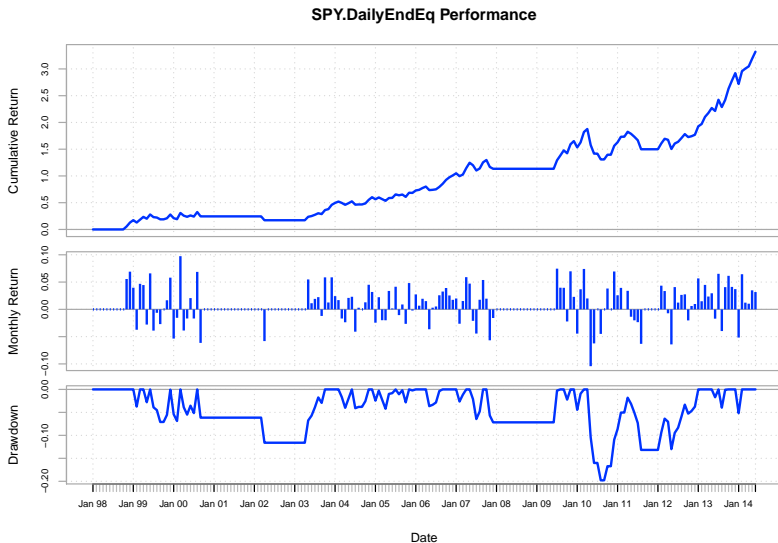
- independent of return on equity and initial capital
- good systems have a RINA index above 30



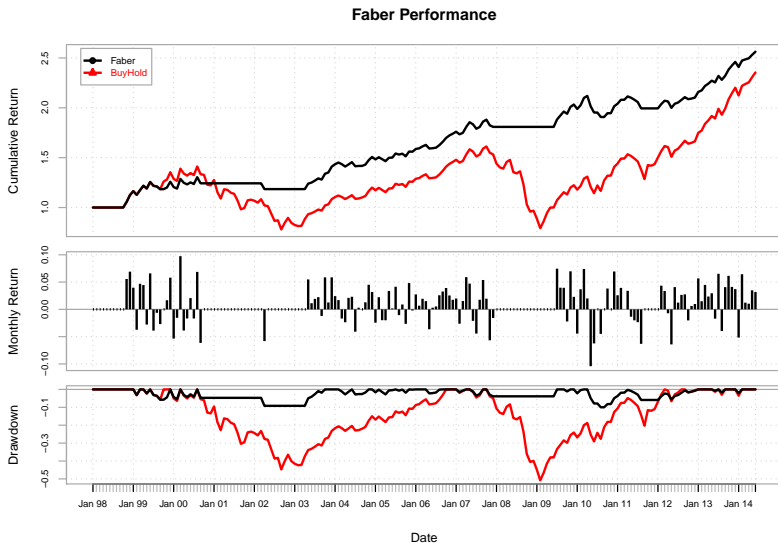
# Trade graphs



# Cumulative return and drawdown



# Faber versus buy-and-hold performance



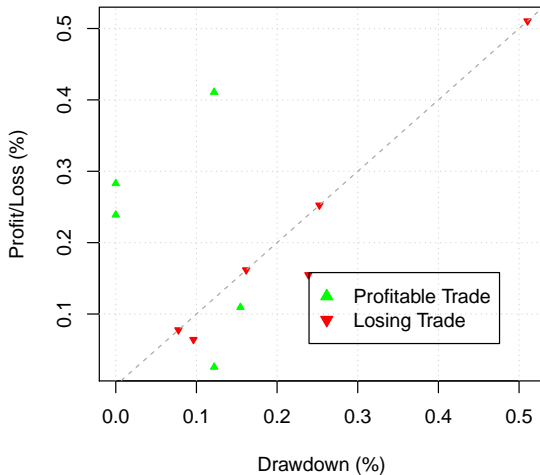
# Per-trade statistics

- *Maximum adverse excursion* (MAE) is the largest loss that a trade suffers while it is open
- *Maximum favorable excursion* (MFE) is the peak profit that a trade achieves while it is open

MAE	MFE	Pct.Net.Trading.PL	Pct.MAE	Pct.MFE	tick.Net.Trading.PL	tick.MAE	tick.MFE
0	256403.0442	0.1841	0	0.2564	1530.0886	0	2131.3636
0	142275.3455	0.0587	0	0.1202	614.7711	0	1258.517
-72898.796	0	-0.0582	-0.0582	0	-523.8488	-523.8488	0
0	319232.8431	0.2325	0	0.2704	1709.0826	0	1987.9988
0	675378.6827	0.3916	0	0.4642	3584.1	0	4248.199
0	628985.8349	0.1441	0	0.3106	1196.9692	0	2580.7723
-104201.2937	0	-0.045	-0.045	0	-456.7428	-456.7428	0
0	457742.4122	0.0866	0	0.2069	914.5116	0	2186.0758
0	1366715.5708	0.5686	0	0.5686	7094.2931	0	7094.2931

# Maximum adverse excursion

**GBPUSD Maximum Adverse Excursion (MAE)**



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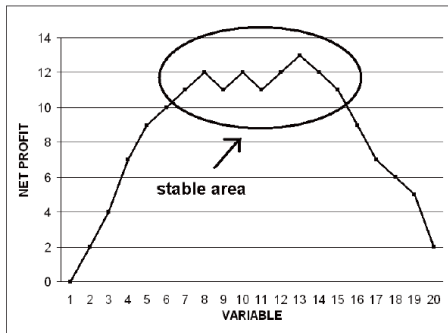
# Trading system optimization overview

- Trading system optimization is the process of varying the input parameters of the system in an effort to maximize (minimize) some performance metric
- Like data-mining, if not done carefully, it can lead to completely useless results
  - curve-fitting
  - over-fitting

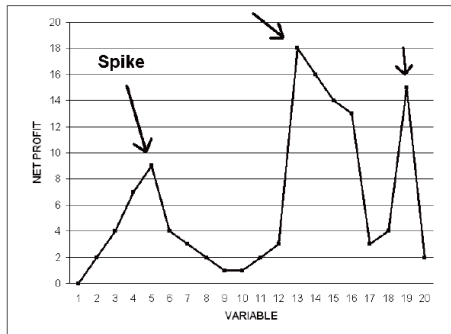
# Strategy robustness

A robust trading strategy would be relatively insensitive to small changes in input parameters

Ideal situation



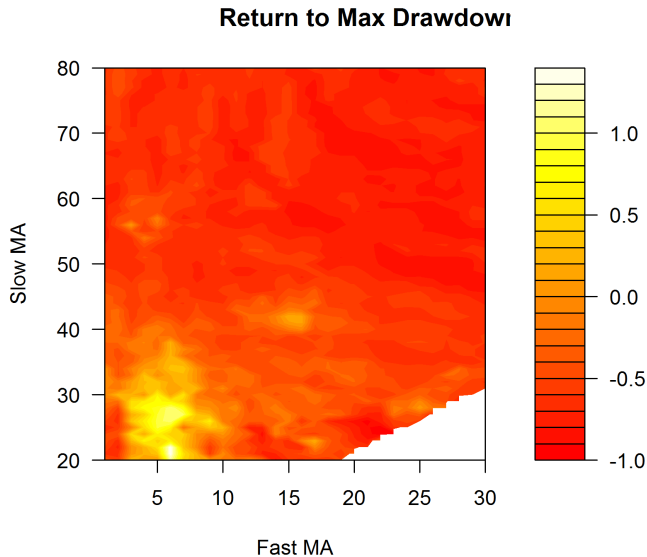
Unstable system



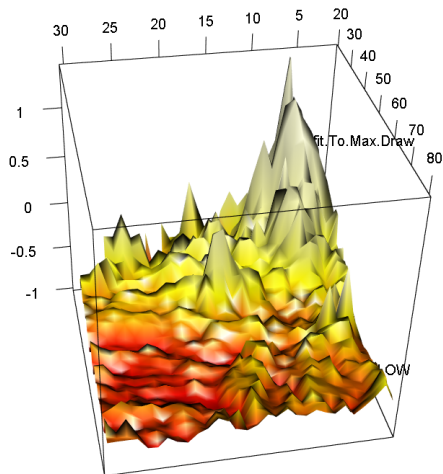
Trading Systems, Jaekle & Tomasini



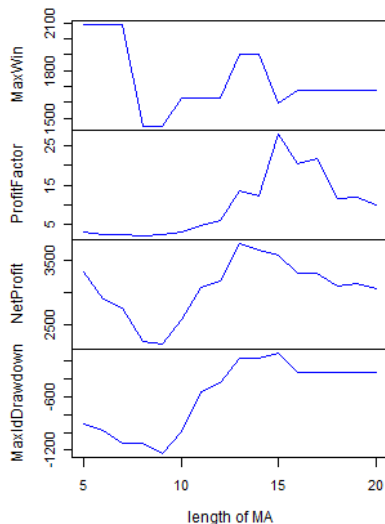
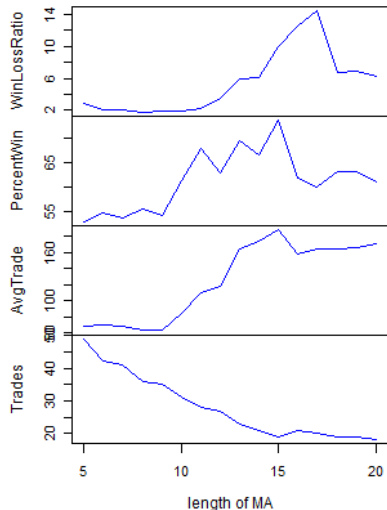
# Return to maximum drawdown



# Return to maximum drawdown



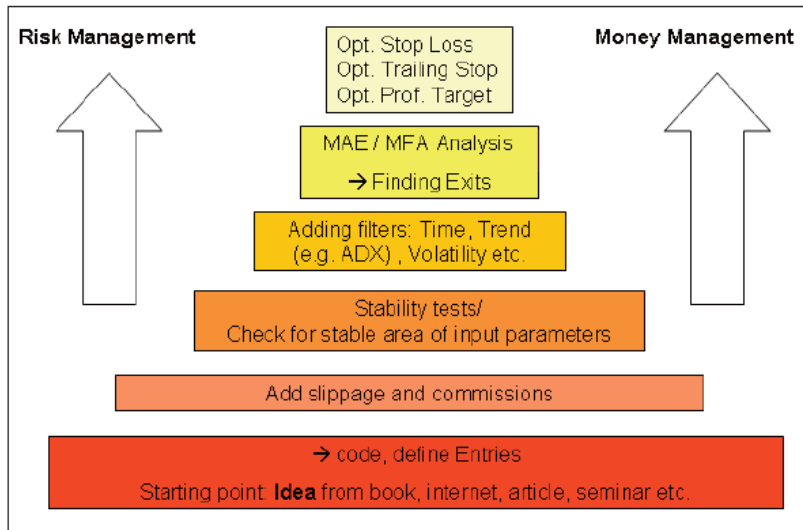
# Various performance metrics versus length of MA



# Outline

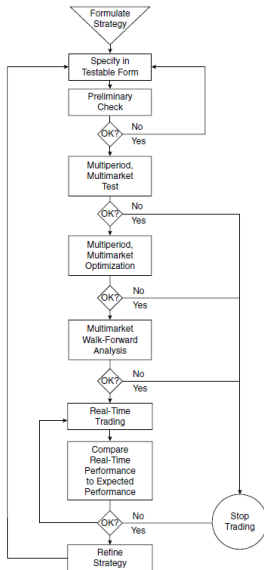
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# Review of system development process (Tomasini/Jaekle)



Trading Systems, Jaekle & Tomasini

# Trading system development process (Pardo)



Evaluation and Optimization of Trading Strategies, R. Pardo

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# Install trading system development packages

```
#  
# install these packages from CRAN (or r-forge)  
#  
install.packages("xts", dependencies=TRUE)  
install.packages("PerformanceAnalytics", dependencies=TRUE)  
#  
# Install these package from r-forge  
#  
install.packages("quantmod", repos = "http://R-Forge.R-project.org")  
install.packages("TTR", repos = "http://R-Forge.R-project.org")  
install.packages("FinancialInstrument", repos = "http://R-Forge.R-project.org")  
install.packages("blotter", repos = "http://R-Forge.R-project.org")  
install.packages("quantstrat", repos = "http://R-Forge.R-project.org")
```

- R-Forge packages can be installed by setting the repos argument to `http://R-Forge.R-project.org`



# Package demos

The `demo` function is used to execute any demos included in a package:

```
help(demo)
```

You can find the name of any demos in a package as follows:

```
demo(package="PackageName")
```

Once a package is loaded, you can run a demo as follows:

```
demo("DemoName")
```

- Experiment with demos from the `blotter` and `quantstrat` packages
- Experiment with code from the `quantmod` lecture

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# Wrap up

- Homework
  - Assignment #3 posted now and due next Thursday
- Mid-term exam
  - Puget-Sound area students:
    - Thursday May 7, 2015 @ 1:30 PM PDT in Lowe 202
  - Out-of-state students:
    - Submit your completed proctor form next week
    - Schedule test for Thursday May 7, 2015 with your proctor

# Wrap up

- Reading
  - Tomasini/Jaekle Chapter 1-2
  - Dark Pools Chapters 18-25
- Next lecture
  - The blotter package
- Questions, comments, concerns
  - Post to the general discussion forum on Moodle
  - Guy, [gyollin@uw.edu](mailto:gyollin@uw.edu)

**W** COMPUTATIONAL FINANCE & RISK MANAGEMENT  
UNIVERSITY *of* WASHINGTON  
Department of Applied Mathematics

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