Trend Following Trading Strategy

Japanese Yen and Gasoline Futures

MATH GR5360 | PROFESSOR CHEKHLOV | FINAL PROJECT

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REVISED VERSION WITH CORRECT SHARPE RATIO

Presentation Outline

- MARKET OVERVIEW
- STATISTICAL TESTING & TREND FOLLOWING STRATEGY
- ASSUMPTIONS AND IMPLEMENTATION DETAILS
- STRATEGY & OPTIMIZATION
- PORTFOLIO RESULTS
- CONCLUSION

Section A
Market Overview

JY Overview

Description

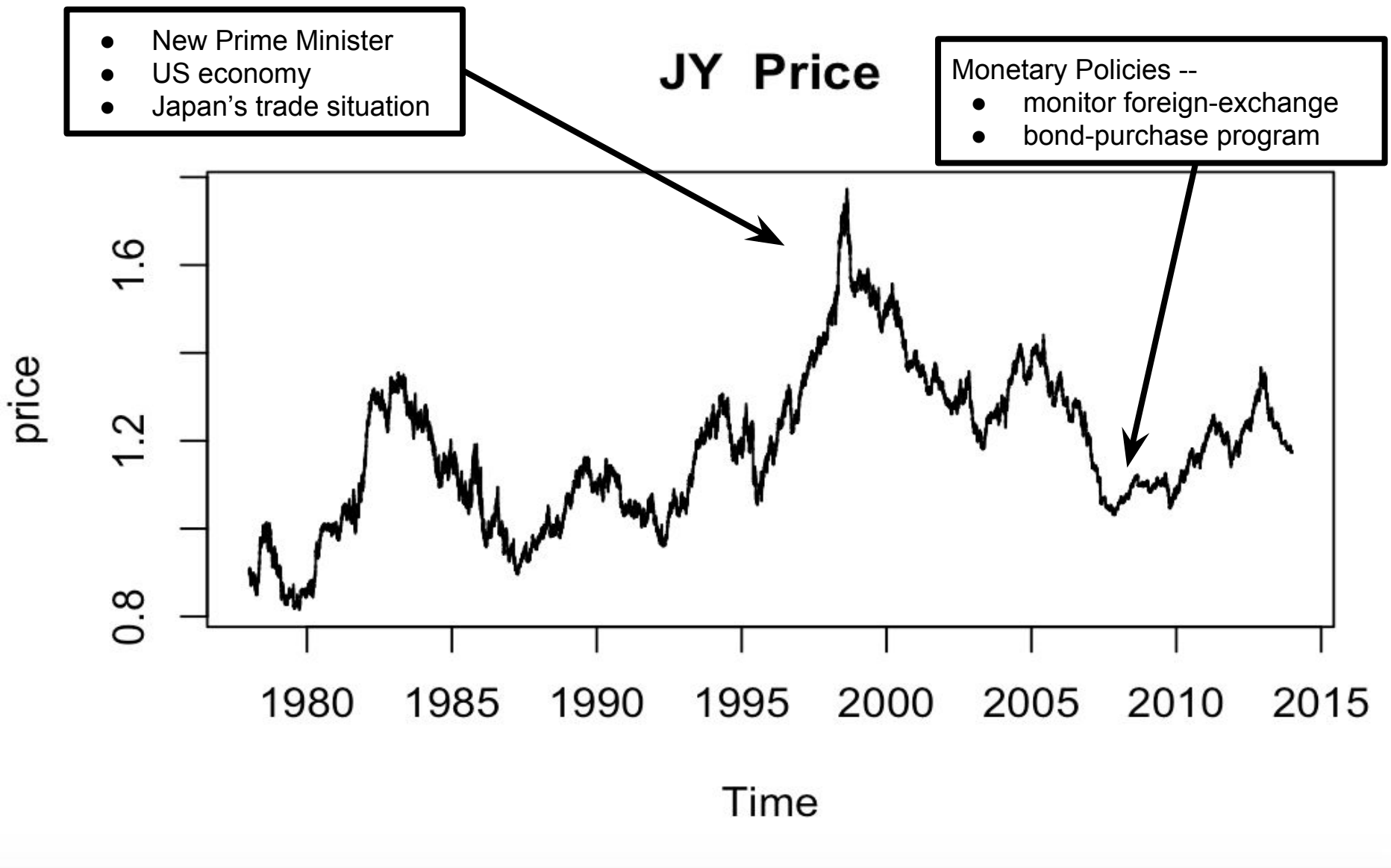
- USD
- Tick value: $6.25
- Tick Size: 0.005
- Trading Hour: 7:20a.m. - 2:00p.m. CST

Price overview

- Current: 89.89 (April 30, 2017)
- Low: 68.07 (August 01, 1998)
- High: 132.10 (October 01, 2011)

Japanese Yen Contract Specifications	
Contract Size	12,500,000 Japanese yen
Trading Hours	**CME Globex:** Sundays: 5:00pm – 4:00pm CT next day. Monday – Friday: 5:00pm – 4:00pm CT the next day, except on Friday – closes at 4:00pm and reopens Sunday at 5:00pm CT.
	CME ClearPort: Sunday – Friday 5:00pm – 4:15pm CT with a 45–minute break each day beginning at 4:15pm
Minimum Price Fluctuation	$.0000005 per Japanese yen increments ($6.25/contract) also for JPY/USD futures intra-currency spreads executed electronically.
Product Code	**CME Globex:** 6J
	CME ClearPort: J1
	Clearing: J1
Listed Contracts	Twenty months in the March quarterly cycle (Mar, Jun, Sep, Dec)
Settlement Method	Deliverable

JY Historical Price



Introduction: Secondary Market - Gasoline (XB)

Description

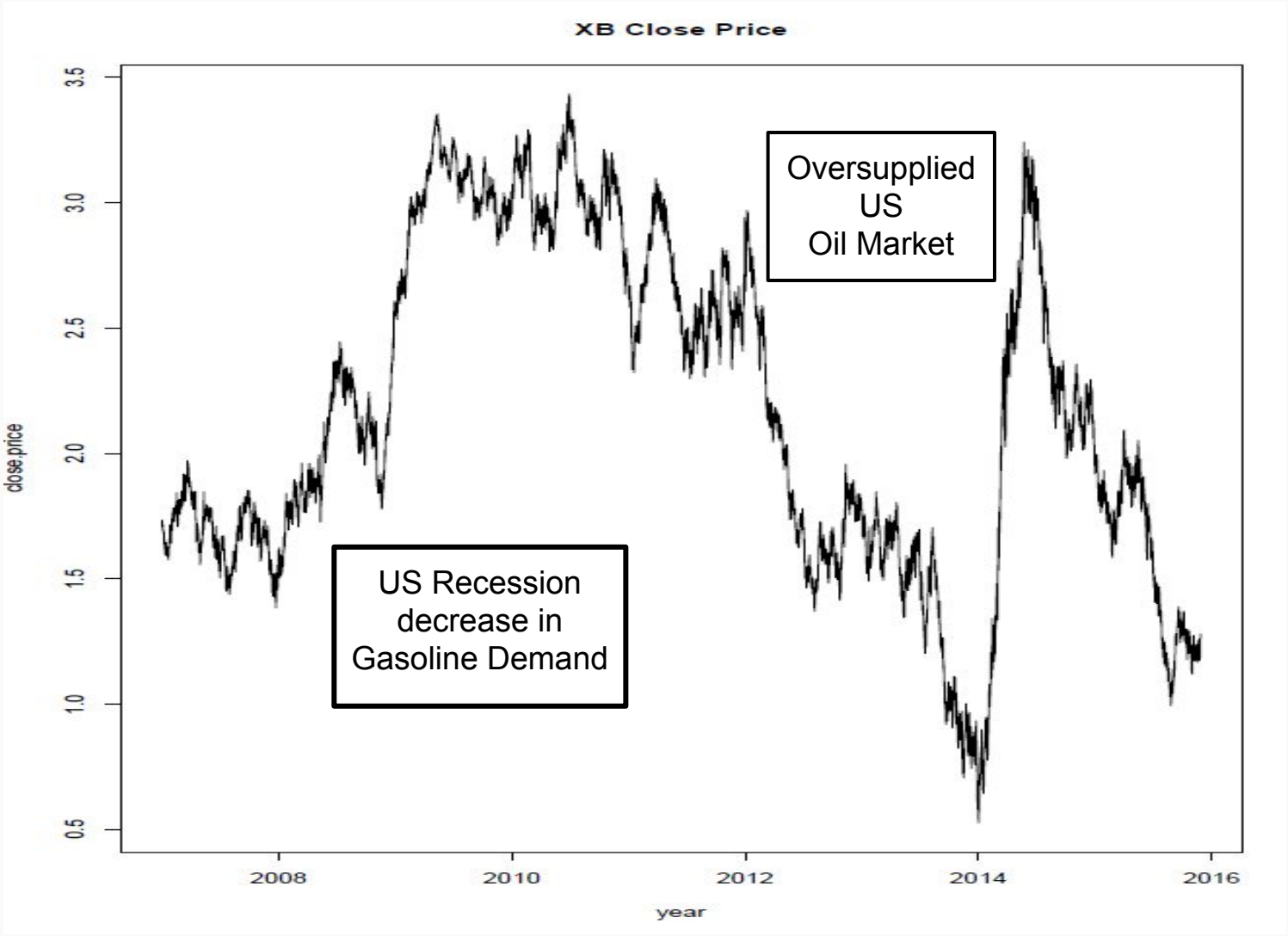
- USD
- Tick value: $4.2
- Tick Size: 0.01

Price overview

- Current: 154.40 (April 5, 2017)
- Low: 78.50 (December 24, 2008)
- High: 363.10 (July 11, 2008)
- Average: 217.44

RBOB Gasoline Contract Specifications	
Contract Size	42,000 gallons
Price Quotation	U.S. dollars and cents per gallon.
Trading Hours	**CME Globex:** Sunday – Friday 6:00 p.m. – 5:15 pm ET with a 45-minute break each day beginning at 5:15 pm ET
	CME ClearPort: Sunday – Friday 6:00 p.m. – 5:15 pm ET with a 45-minute break each day beginning at 5:15 pm ET
Minimum Price Fluctuation	$0.0001 per gallon
Product Code	**CME Globex:** RB
	CME ClearPort: RB
	Clearing: RB
	TAS: RBT
Listed Contracts	Monthly contracts listed for the current year and the next 3 calendar years +1 month. Monthly contracts for a new calendar year will be added following the termination of trading in the December contract of the current year.
Settlement Method	Deliverable

XB Historical Price



Section B

Statistics Tests & Trend Following Strategy

Statistical Testing – Variance Ratio Test

- A measure of the randomness of a return series.
- Variance ratio for q periods is

$$VR(q) = \frac{D[r_t(q)]}{q.D[r_t]} = 1 + 2\sum_{k=1}^{q-1}(1-\frac{k}{q})\rho(k),$$

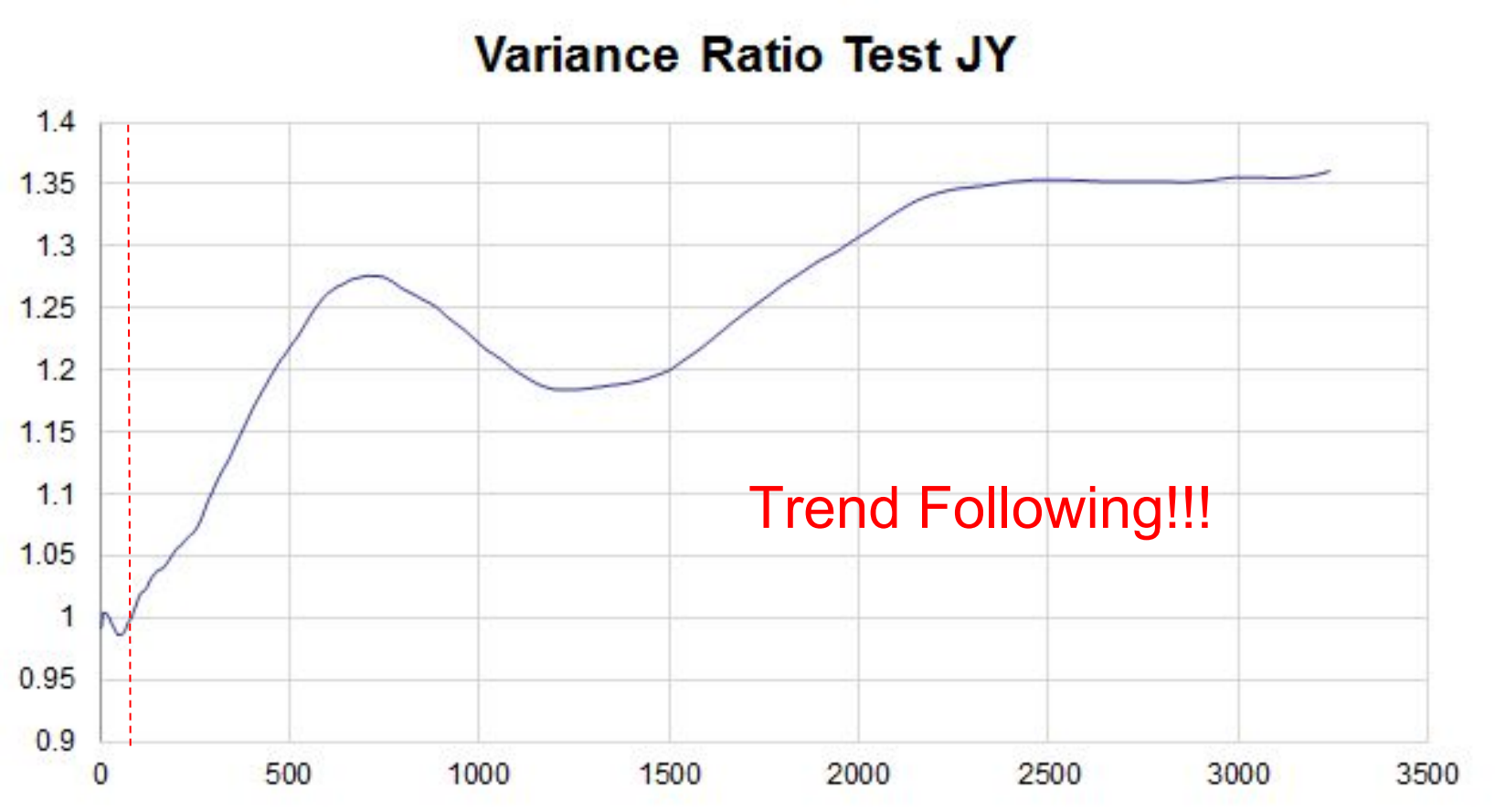
- q is discrete time separation in minutes
- ρ(k) is auto-correlation coefficient of two price changes separated by k minutes

VR>1 — Trend Following

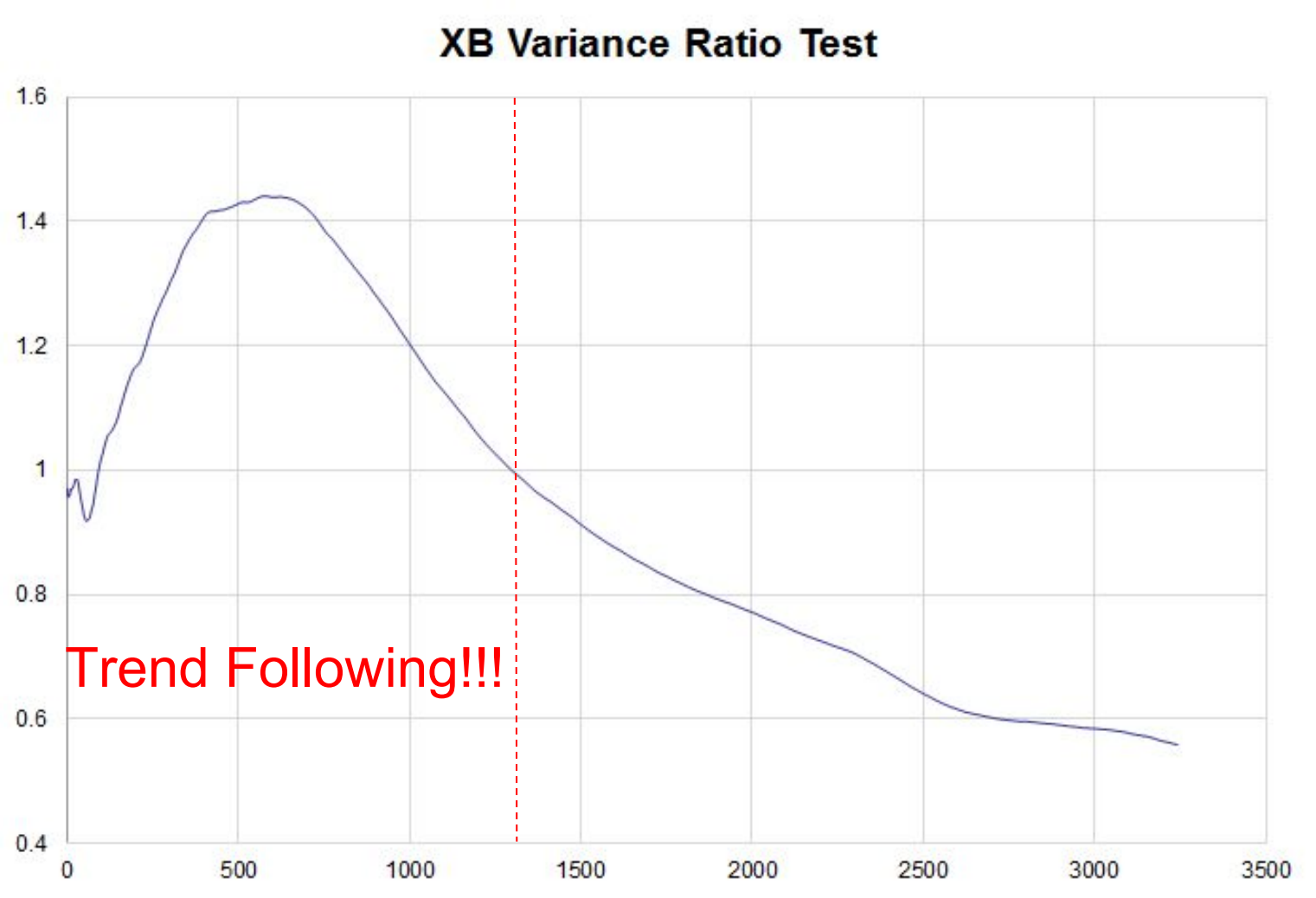
VR=1 — Random Walk

VR<1 — Mean Reversion

Variance Ratio Test Result of JY Market



Variance Ratio Test Result of XB Market



Push Response Test

- This test is free from the fat-tailed bias of the VR test but quickly growing sample error if increase the Δp

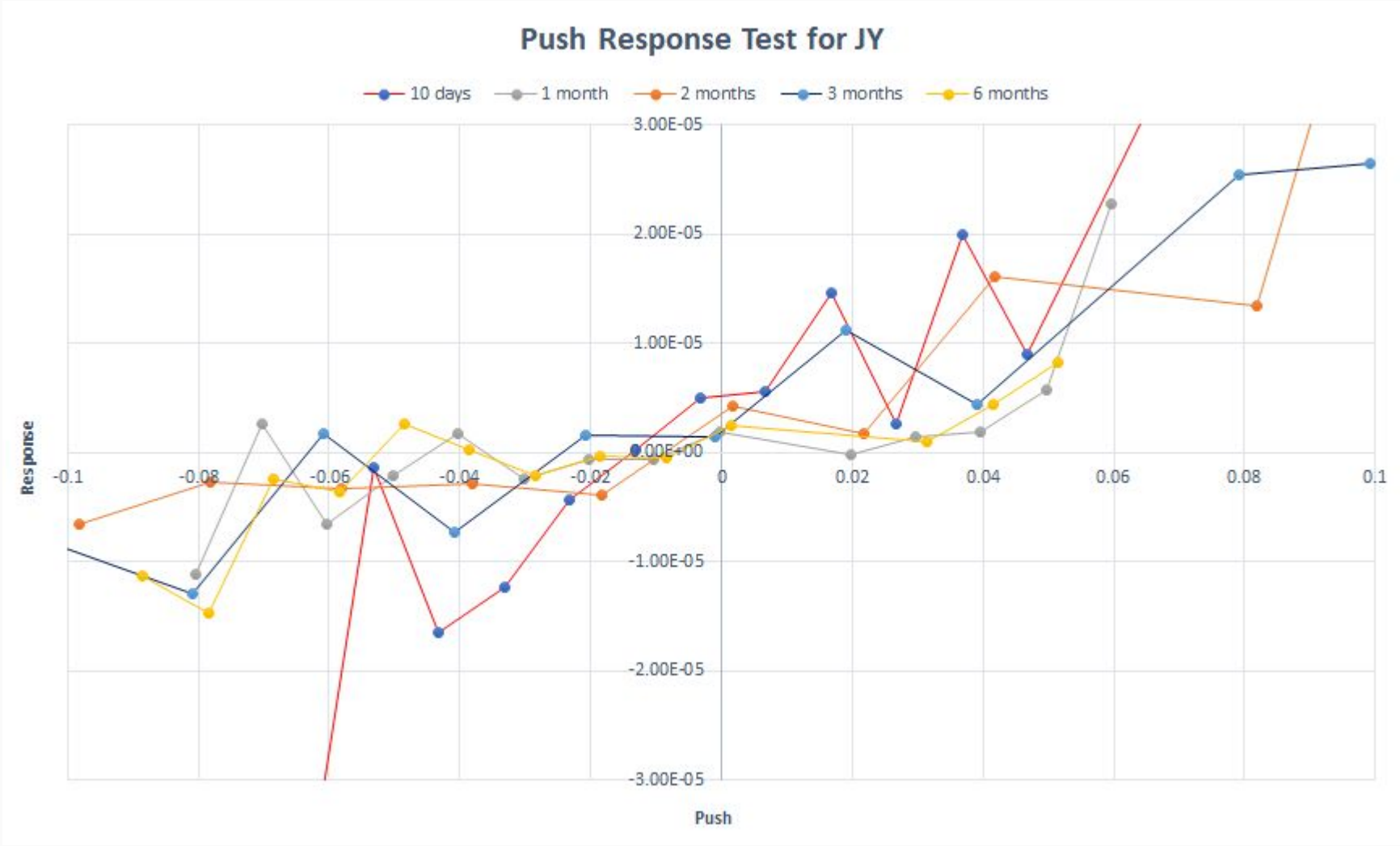
- Push = x = price(t) – price(t – τ)

- Response = (y) ⇒ $\langle y \rangle_x$ = $\int_{-\infty}^{\infty} y * P(y|x) * dx$

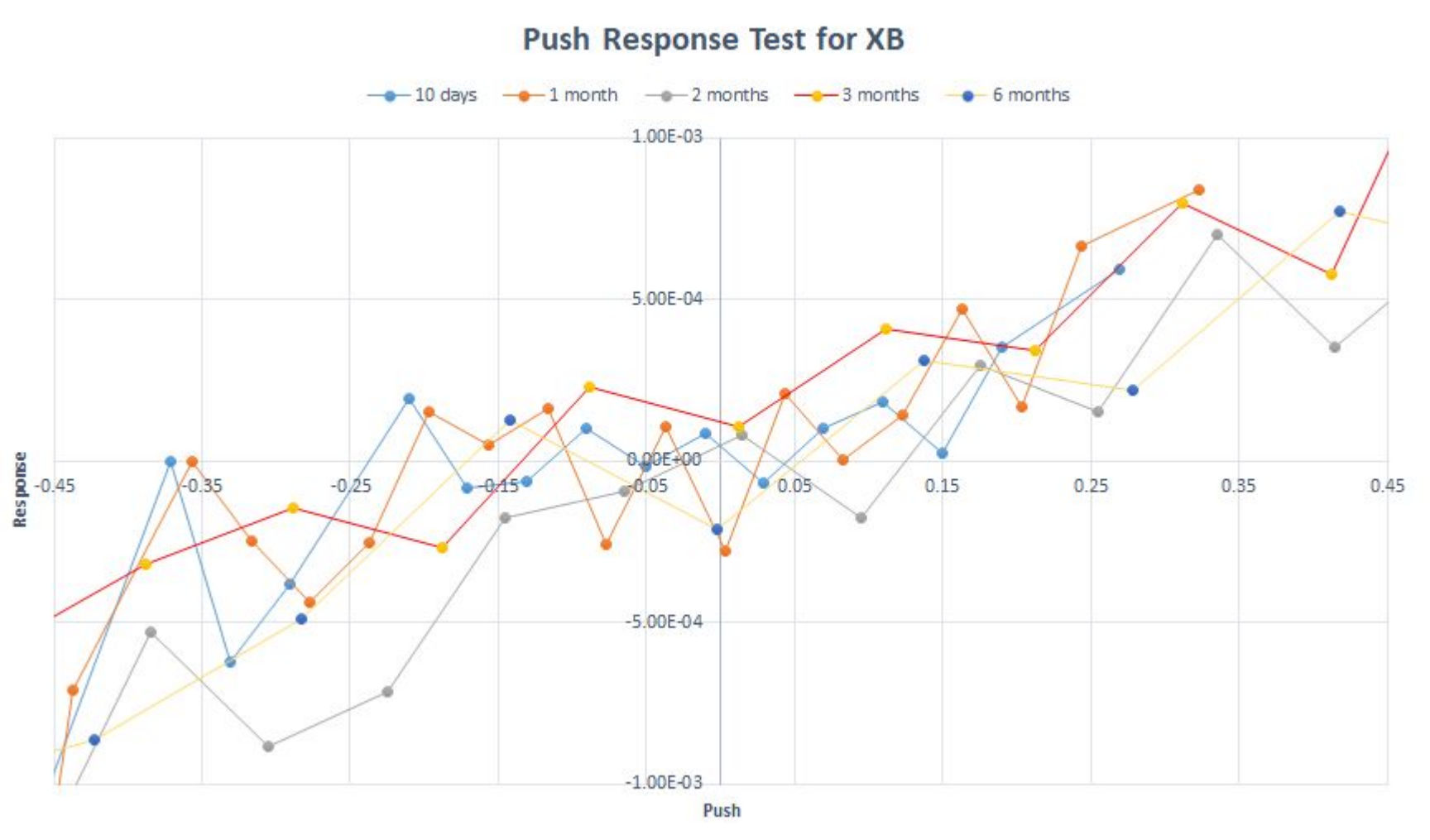
  Here, $P(y|x) = \frac{P(x,y)}{P(x)}$ as the conditional mean response to a “push” x

- Positive slope means trend following!

Push Response Test Results of JY Market



Push Response Test Results of XB Market



Section C
Implementation Details

Optimization Details

- R is not an optimal language for optimization
- We tried to solve this problem by using parallel programming in R
  - R packages: parallel and data.table

```
optim.parallel <- function(cl, index, high.price, low.price, open.price,
                           close.price, date, time, param){
  optimal.result <- parLapply(cl,index,
                              tradestrategy,
                              high.price = high.price,
                              low.price = low.price,
                              open.price = open.price,
                              close.price = close.price,
                              date = date,
                              time = time,
                              param = param
  )
  return (optimal.result)
}
```

Optimization Details

- Additionally, we use AWS to gain access to high-performance computer
- We set up and ran our R code directly on AWS servers
- 40 cores machine
- However, due to the nature of R programming language and our function (which consisted of many loops), the optimization was still take significant computation time

Instance Type	Availability Zone	Instance State	Status Checks
m4.10xlarge	us-west-1c	running	2/2 checks ...
m4.10xlarge	us-west-1a	running	2/2 checks ...
m4.10xlarge	us-west-1c	running	2/2 checks ...

Optimization Alternatives

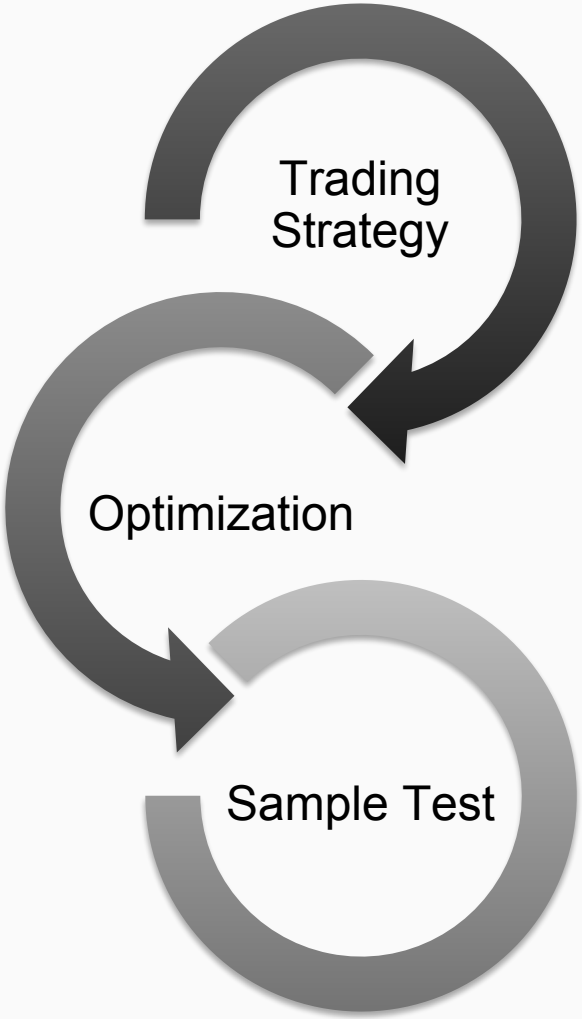
- Golden Section Search and Particle Swarm Optimization
- Hill Climbing and Random Search
- Simulated Annealing!
  - Similar to Hill Climbing method, make a small change to that solution, test it and accept the new solution if it results in an improvement. The key difference between these algorithms is that Hill Climbing only accepts changes that result in an improved solution, whereas Simulated Annealing probabilistically accepts worse solutions.
  -
    - If $c_{new} < c_{old}$: move to the new solution
    - If $c_{new} > c_{old}$: *maybe* move to the new solution

    $$a = e^{\frac{c_{old} - c_{new}}{T}}$$
- Cons: Although these strategies will speed up the optimization process, they sacrificed the accuracy. They may not reach global optimum, only local optimum, so we use brute force

Assumptions

- Data: JY 5min (20 years data) & XB 5min
- Slippage: 53 & 91
- ChnLen:
  - 500 to 10000
  - Increment: 1000
- StpPct:
  - 0.005 to 0.1
  - Increment: .01
- In Sample: 4, 6, 8, 10 year
- Out Sample: 3, 6, 9, 12 Month
- Objective Function:
  - NPWD = - Net Profit / MaxDD

Strategy Framework



Trend-Following Strategy

Method of Exhaustion
-Pros: Get All the solutions from the problem
-Cons: Low Efficiency

In Sample:
JY: (1985-1989), (2000-2004)
XB: (2006-2010)
Out Sample:
JY: 1989/1/2-1989/4/2; 2004/1/2-2004/4/2
XB: 2010/1/2-2010/4/2

Section D

Strategy & Optimization

Basic Factors

Equity calculation:

PV(present value) multiplier x (C_{k+1}-C_k) x PV(x X(exchange rate) - slpg(transaction fee)/2

Starting Equity: E(0) = 100000

Our code:

Change position: equity<- equity+(close.price[i]-entry.price)*PV*PV.multi-slippage/2

Keep position: equity<-equity+(close.price[i-1]-close.price[i])*PV*PV.multi

Net Profit Worst Drawdown:

NPWD = (E(t) - E(0)/DD (Drawdown equals to E(t) - max(E(t)))

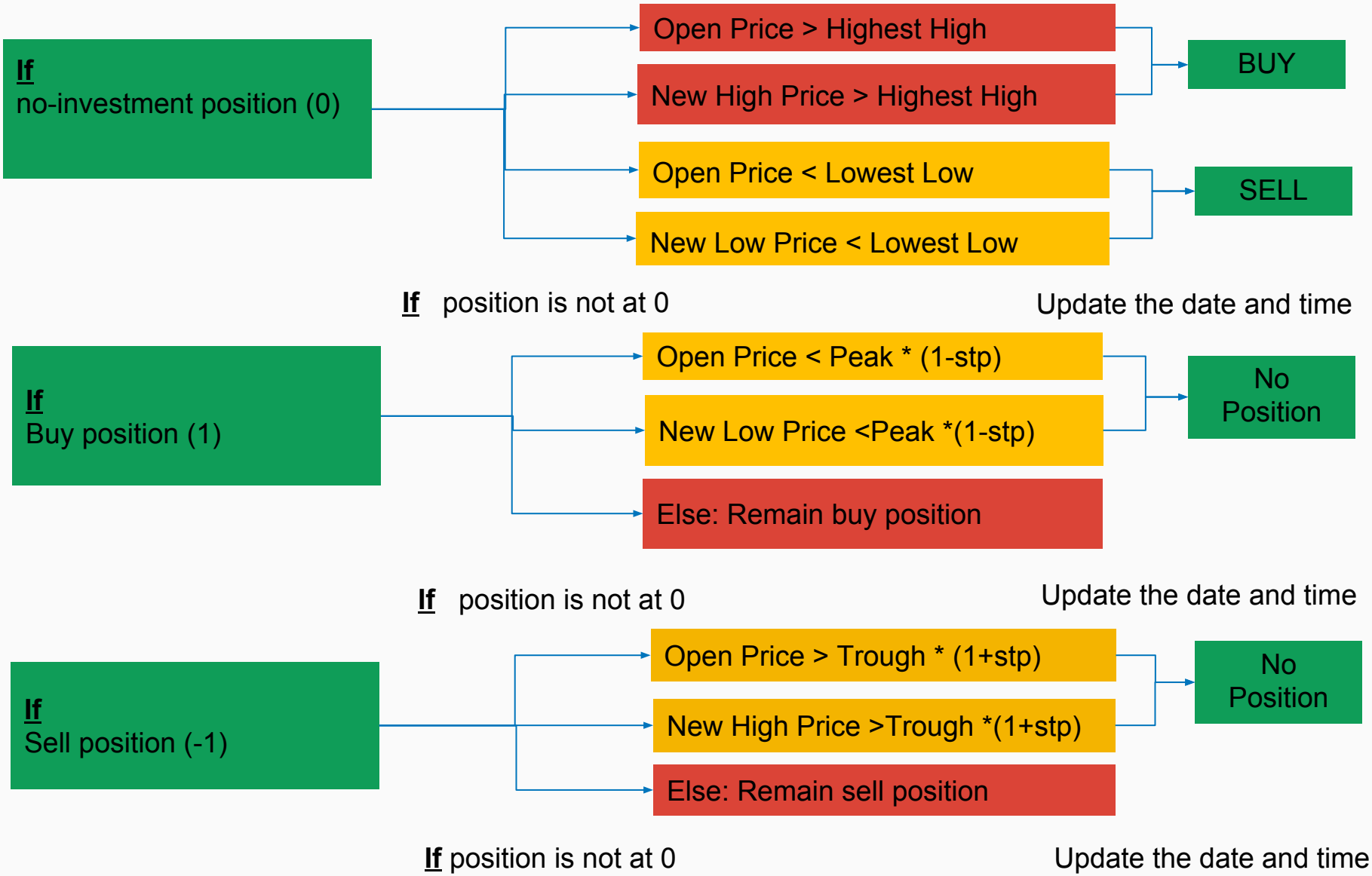
Our code:

```
Gain <- max(Gain,equity-100000)
    Underwater <- equity - Gain - 100000
    maxDD <- min(maxDD, Underwater)
  {NPWD<-(-1)*(equity-100000)/maxDD}
```

Trading Strategy:

No-investment position (0)
Sell position (-1)
Buy position (1)

Trading Strategy



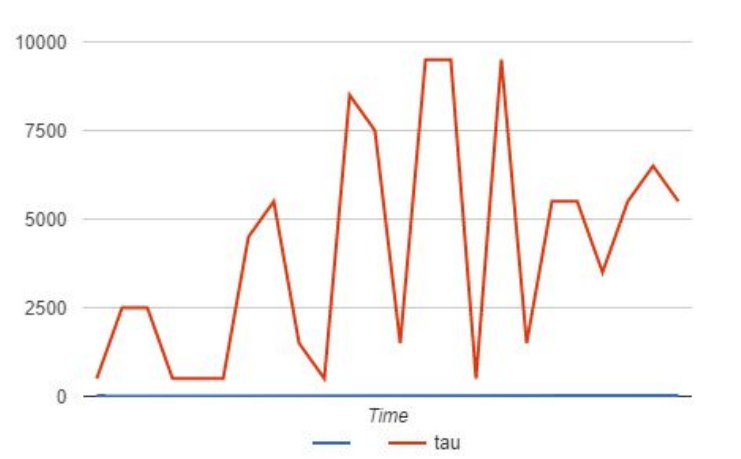
Optimization Result: In-Sample Optimization

Return on Account JY				
	3 months	**6 months**	**9 months**	**12 months**
4 years	233.82%	225.08%	234.88%	226.85%
6 years	196.17%	195.29%	188.74%	191.59%
8 years	191.83%	191.16%	182.97%	187.71%

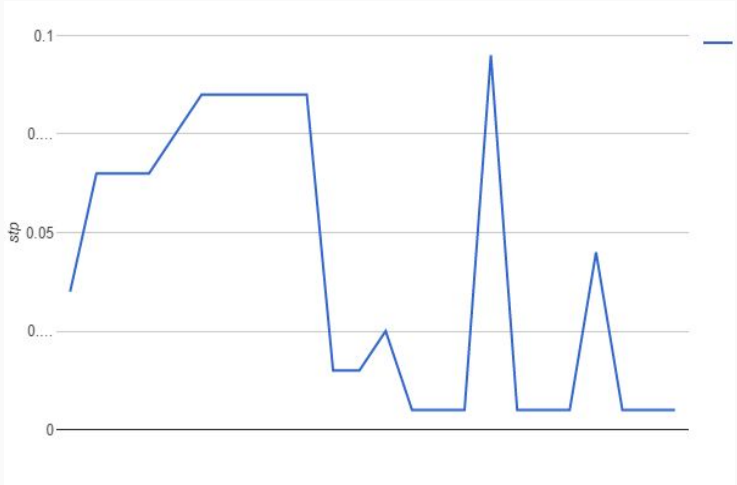
Return on Account XB				
	3 months	**6 months**	**9 months**	**12 months**
4 years	225.48%	220.56%	232.36%	235.63%
6 years	208.05%	205.16%	207.68%	208.39%
8 years	255.16%	245.72%	270.48%	238.30%

Optimization Result: In-Sample Optimization (JY 4 yr 9 months)

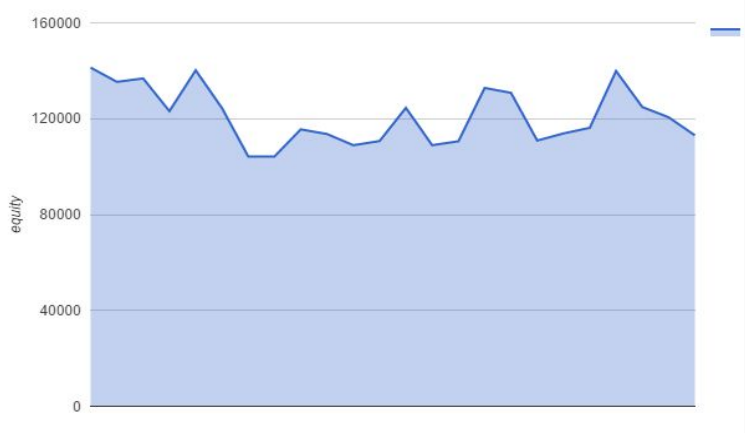
Channel Length



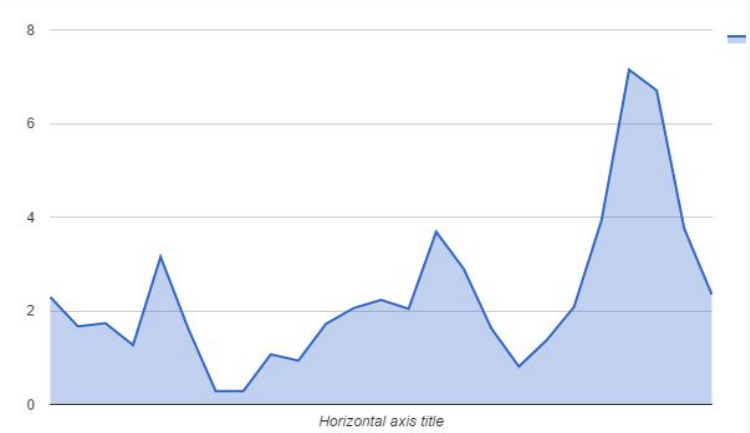
Stop Percent



Net Equity

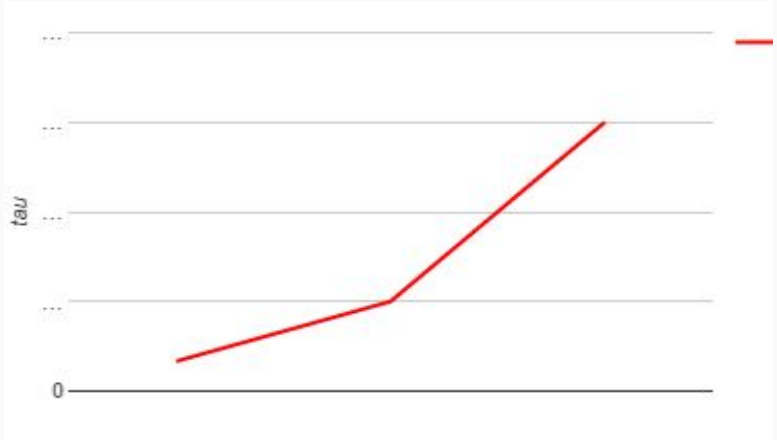


Return on Asset (NPWD)

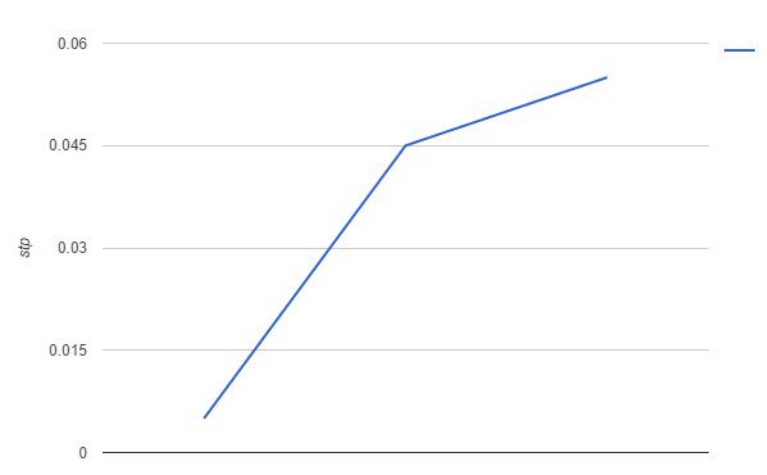


Optimization Result: In-Sample Optimization (XB 8yr 9 months)

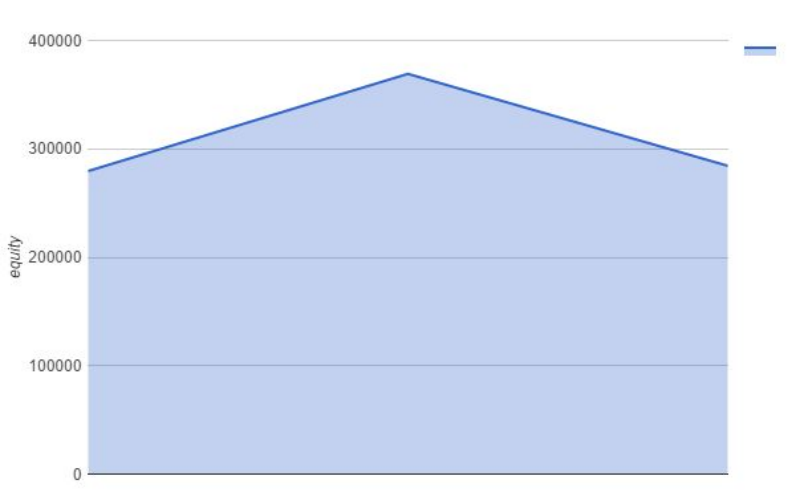
Channel Length



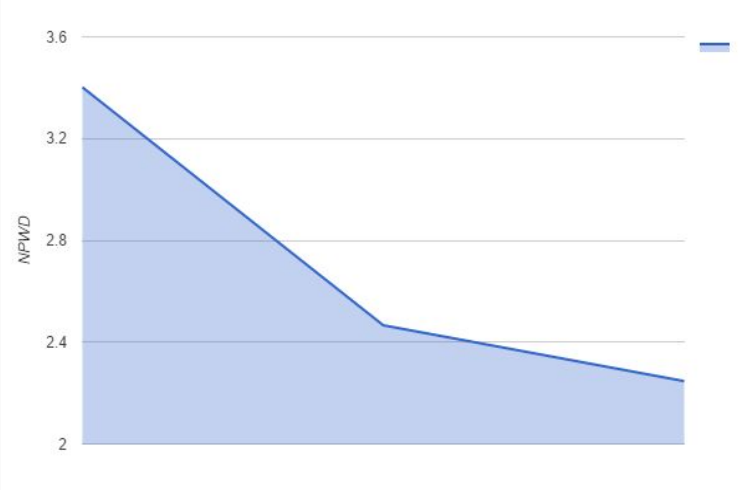
Stop Percent



Net Equity

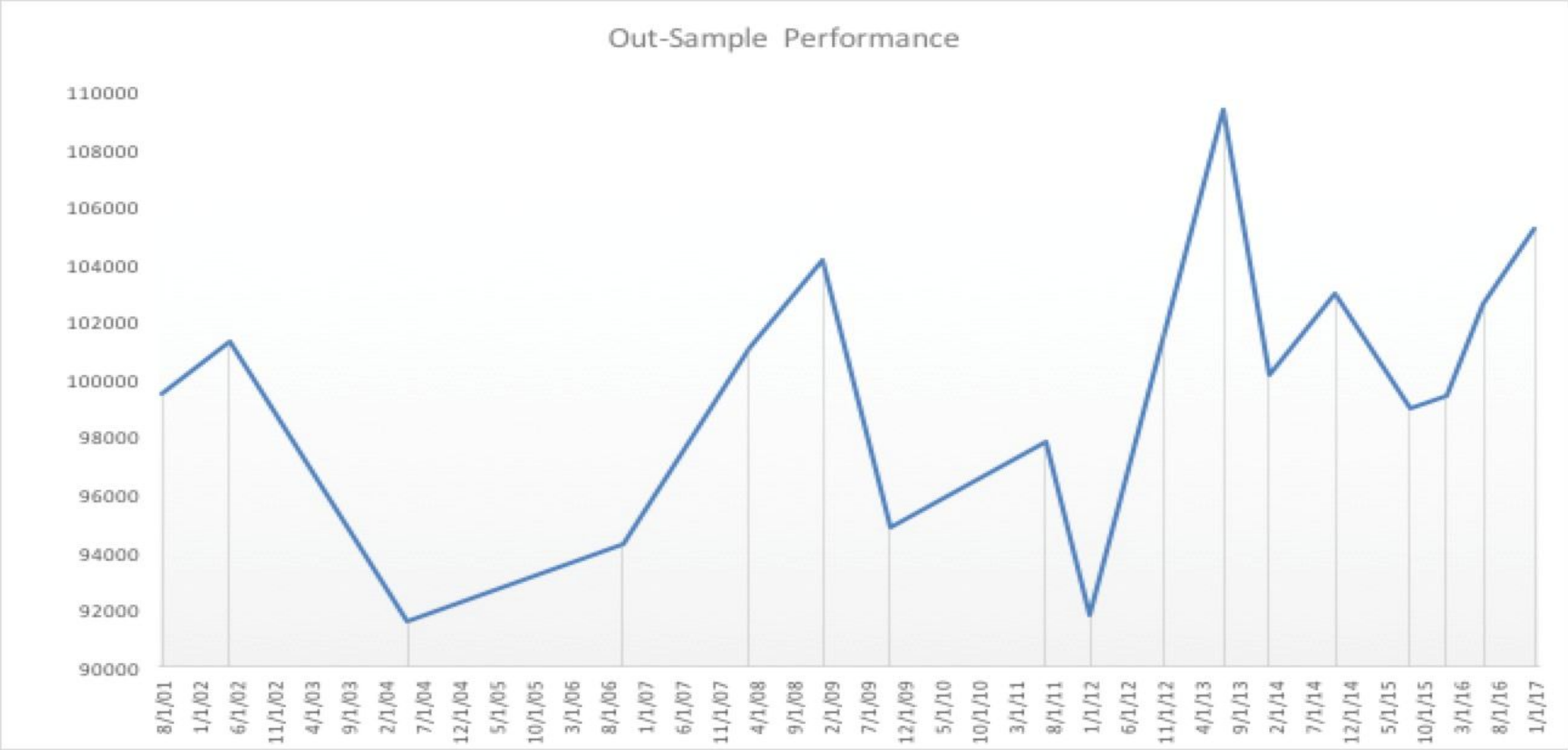


Return on Asset



Optimization Result: Out-Sample Performance (JY)

Chart shows equity fluctuation in each 9 month period in the optimal 4 years 9 months timeframe



The out-sample performance gets better as the strategy adapts to the time

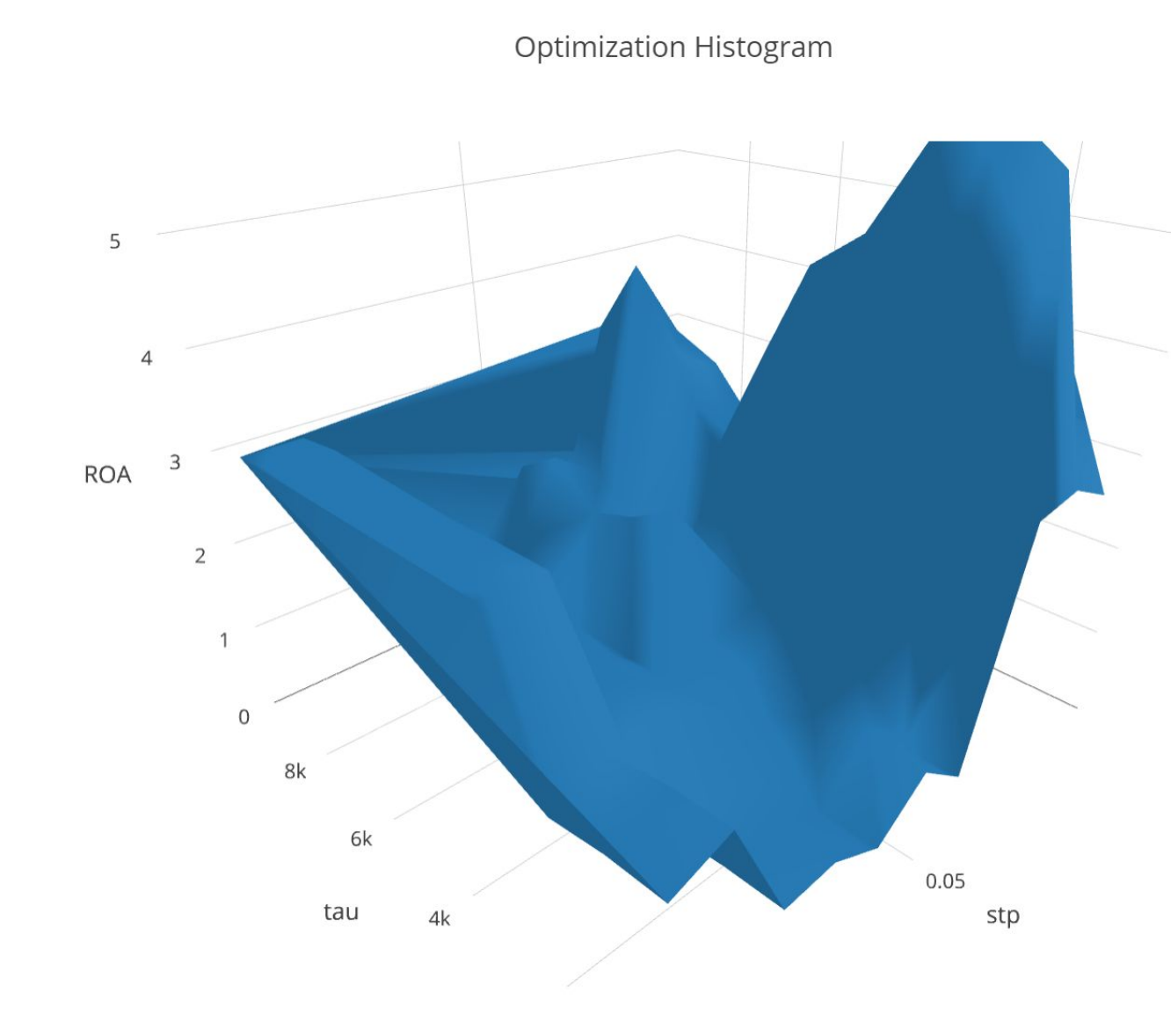
Section E

Portfolio Results: Risk and Return

Optimization Result: JY

- Here, we specifically look at 2 period in JY-5min data, which are:
    - **1985-1989:**
      This period was an economic bubble in Japan from 1986 to 1991 in which real estate and stock market prices were greatly inflated.
    - **2000-2004:**
      The period which the Japanese economic growth was between 0% and 2% and the economy experienced long term liquidity risk.

Sample Test (JY 85-89): Optimization Histogram



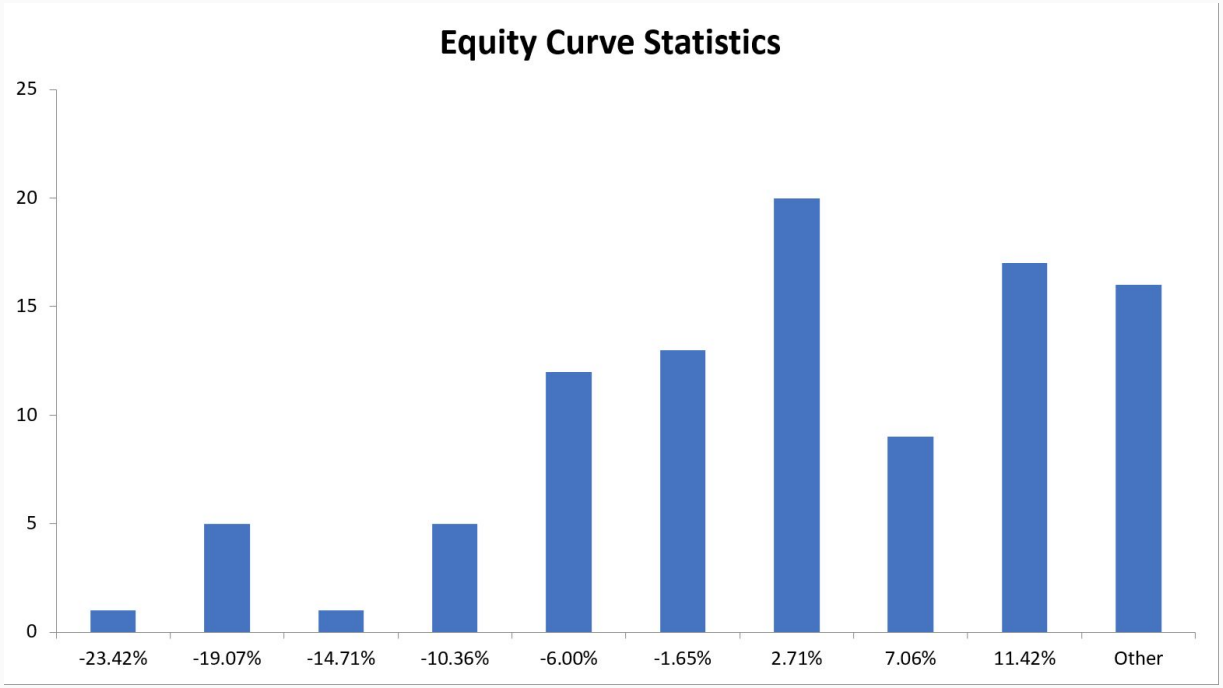
Sample Test (JY 85-89): In Sample Optimization

In Sample Performance Result
Channel Length: 2500
Stop Percent:0.015

Net Equity	$134,368.9375
Net Profit	$34,368.9375
Worst Drawdown	$24,768.5
Net profit to worst drawdown	1.38
Average Net Profit	$34,368.9375
Sharpe Ratio	6.07%

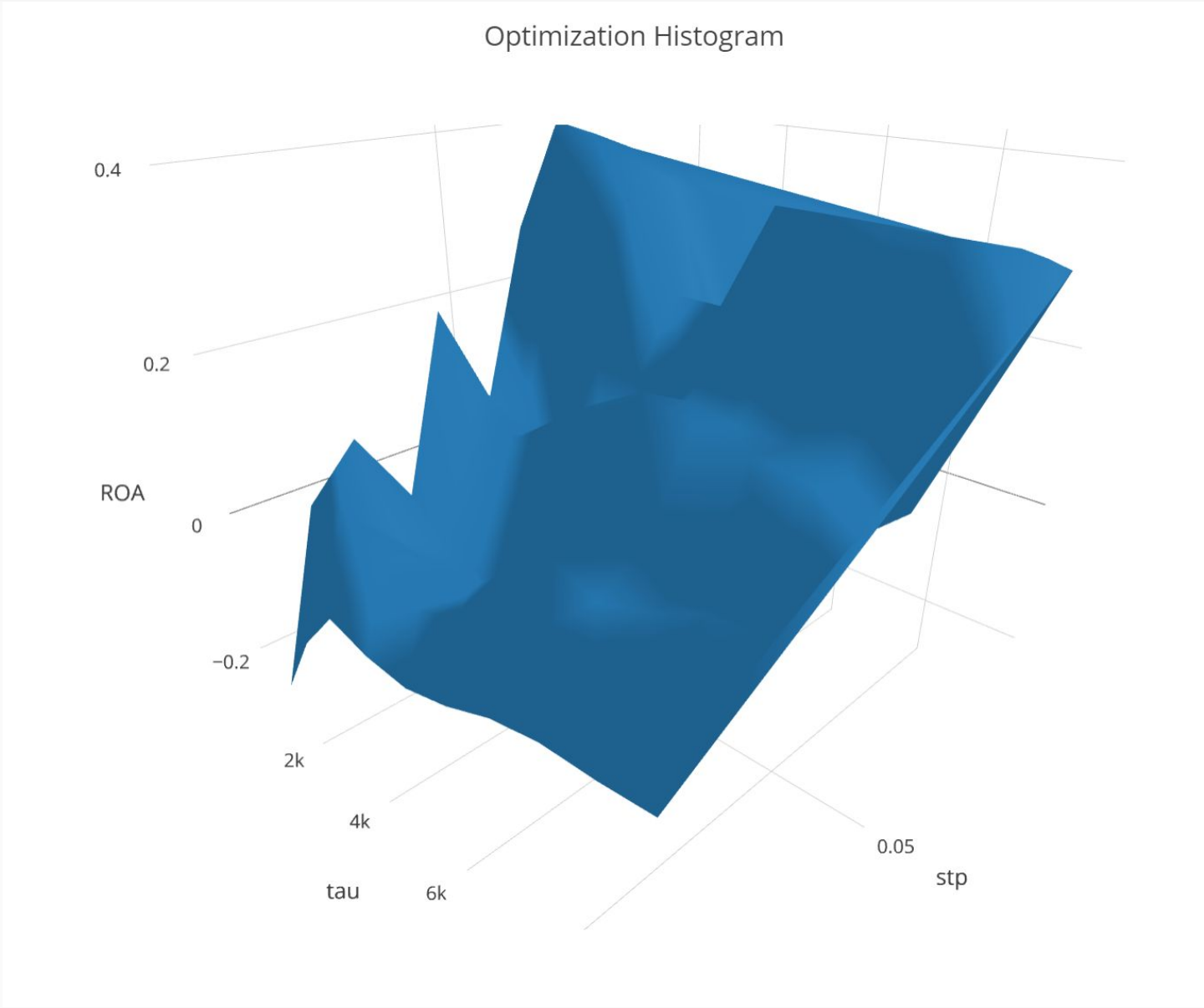
Series Time Start: 1985/01/02 07:25
Series Time End: 1989/01/02 07:25

Sample Test (JY 85-89): Equity Curve Statistics



Return	Frequency
-23.42%	1
-19.07%	5
-14.71%	1
-10.36%	5
-6.00%	12
-1.65%	13
2.71%	20
7.06%	9
11.42%	17
Other	16

Sample Test (JY 00-04): Optimization Histogram



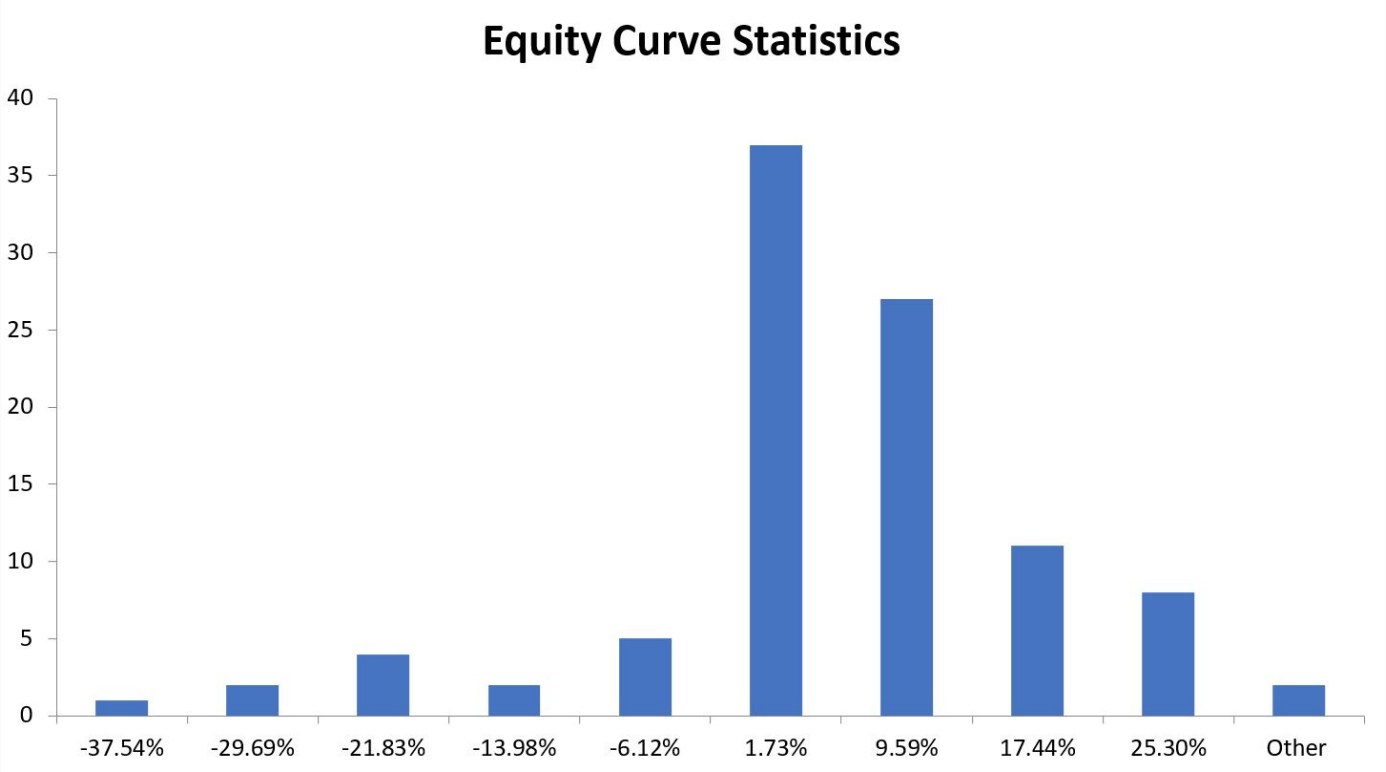
Sample Test (JY 00-04): In Sample Optimization

In Sample Performance Result
Channel Length: 500
Stop Percent:0.075

Net Equity	$139,958
Net Profit	$39,958
Net profit to worst drawdown	1.345
Worst Drawdown	$29,702.56
Average Net Profit	$39,958
Sharpe Ratio	4.99%

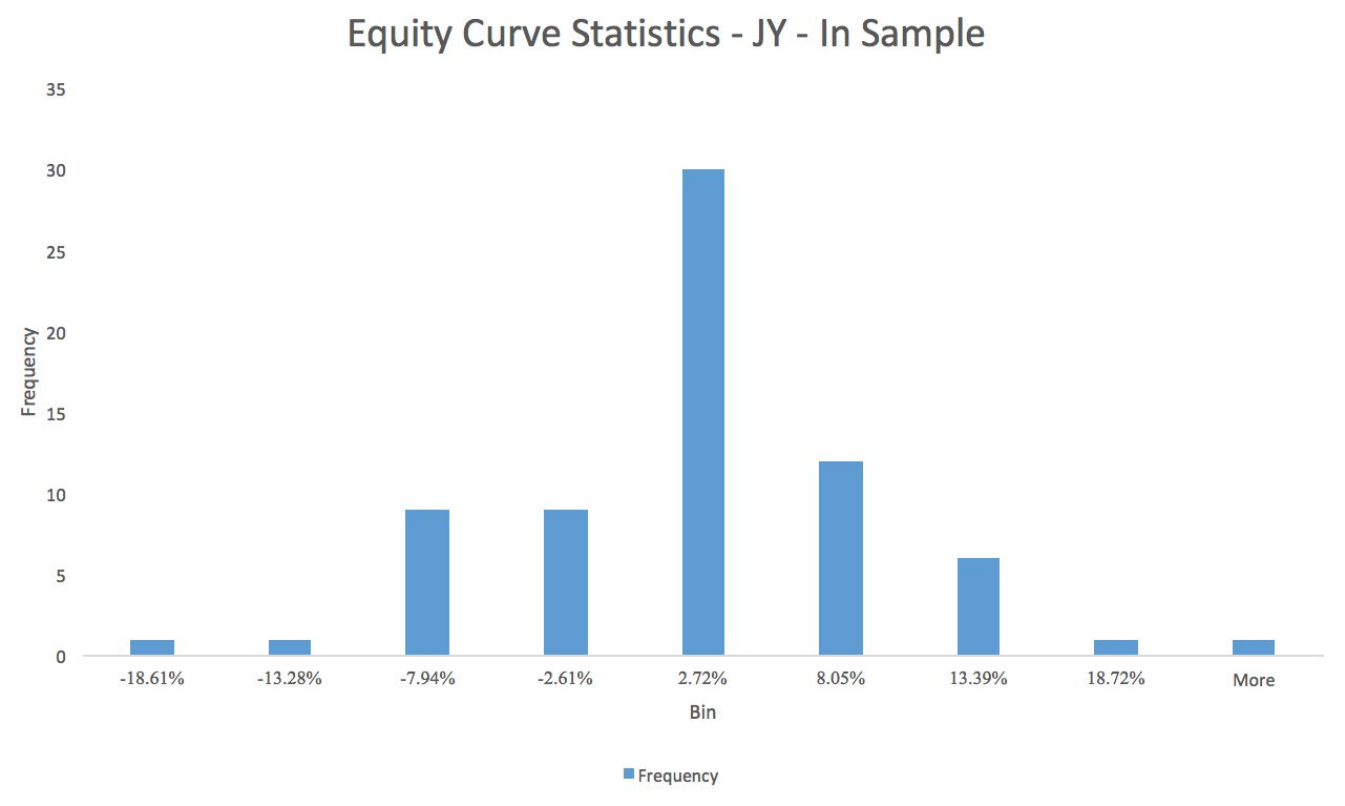
Series Time Start: 2000/01/02 07:25
Series Time End: 2004/01/03 07:25

Sample Test (JY 00-04): Equity Statistics



Return	Frequency
-37.54%	1
-29.69%	2
-21.83%	4
-13.98%	2
-6.12%	5
1.73%	37
9.59%	27
17.44%	11
25.30%	8
Other	2

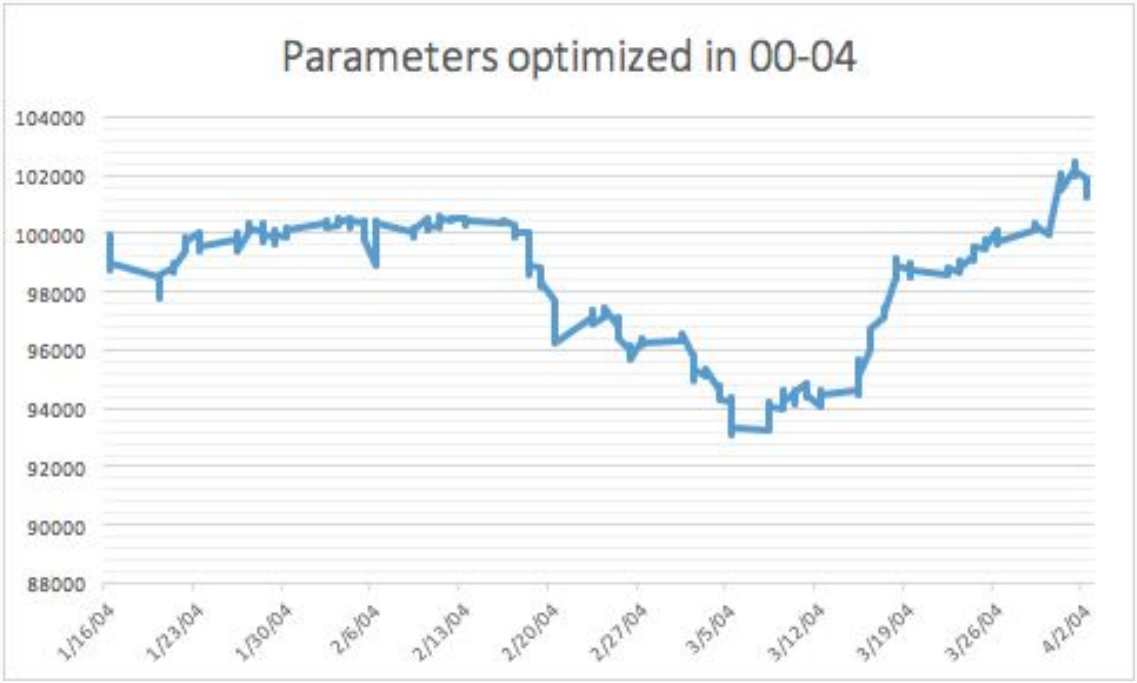
Equity Curve Statistics - JY- (4 year 3 months in-sample)



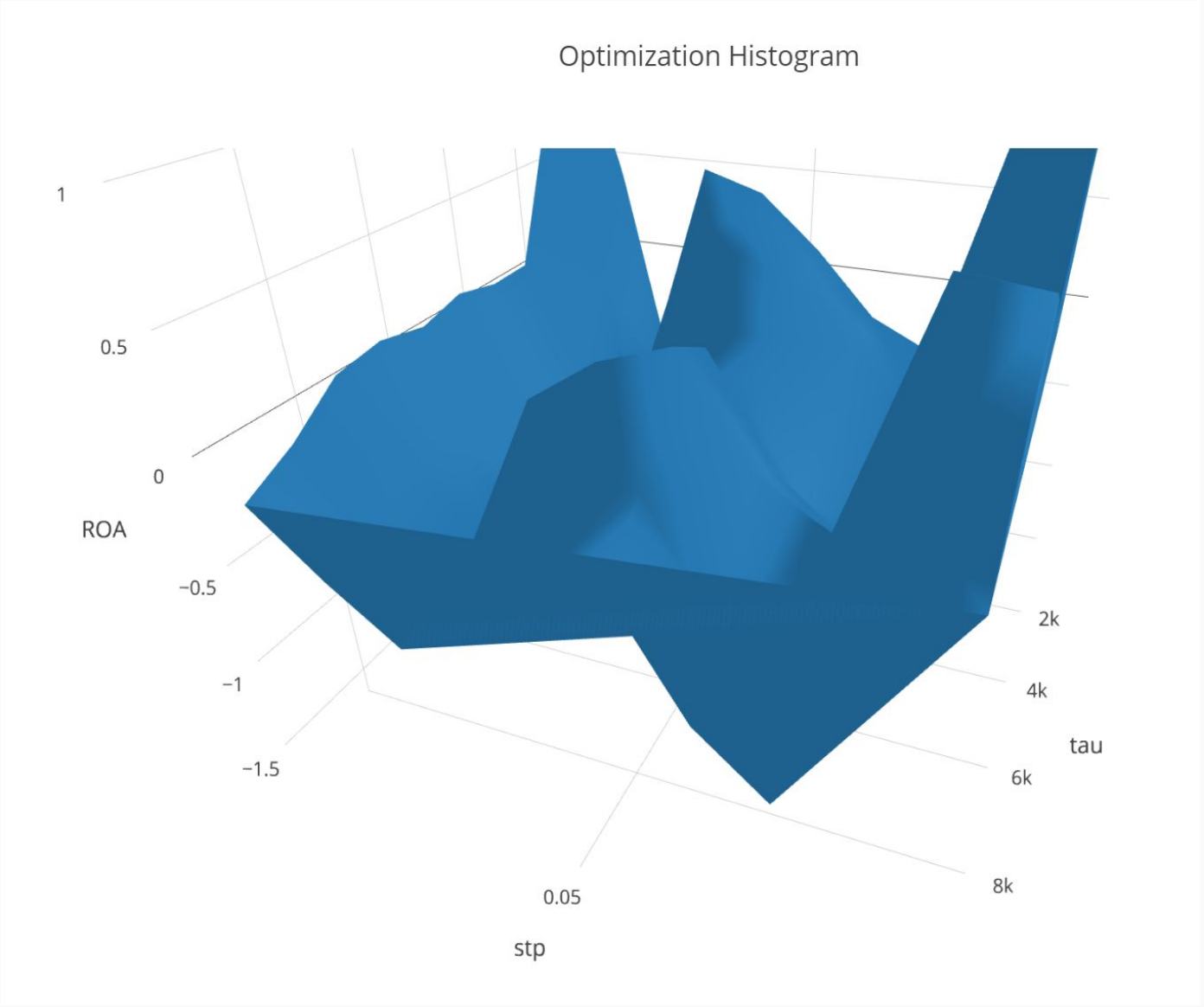
Bin	Frequency	Cumulative %
-18.61%	1	1.43%
-13.28%	1	2.86%
-7.94%	9	15.71%
-2.61%	9	28.57%
2.72%	30	71.43%
8.05%	12	88.57%
13.39%	6	97.14%
18.72%	1	98.57%
More	1	100.00%

JY 3 month Out of Sample Equity Curve

- The optimal parameters obtained in the four year period 00-04:
  - Stppct: 0.075
  - Chnlen: 500
- This Equity Curve shows vastly negative position of the portfolio in 3 months, but we gain at last. If we look at the economic growth and the close price changes, it could explain the loss in the middle of the time interval.



Sample Test (XB 06-10): Optimization Histogram



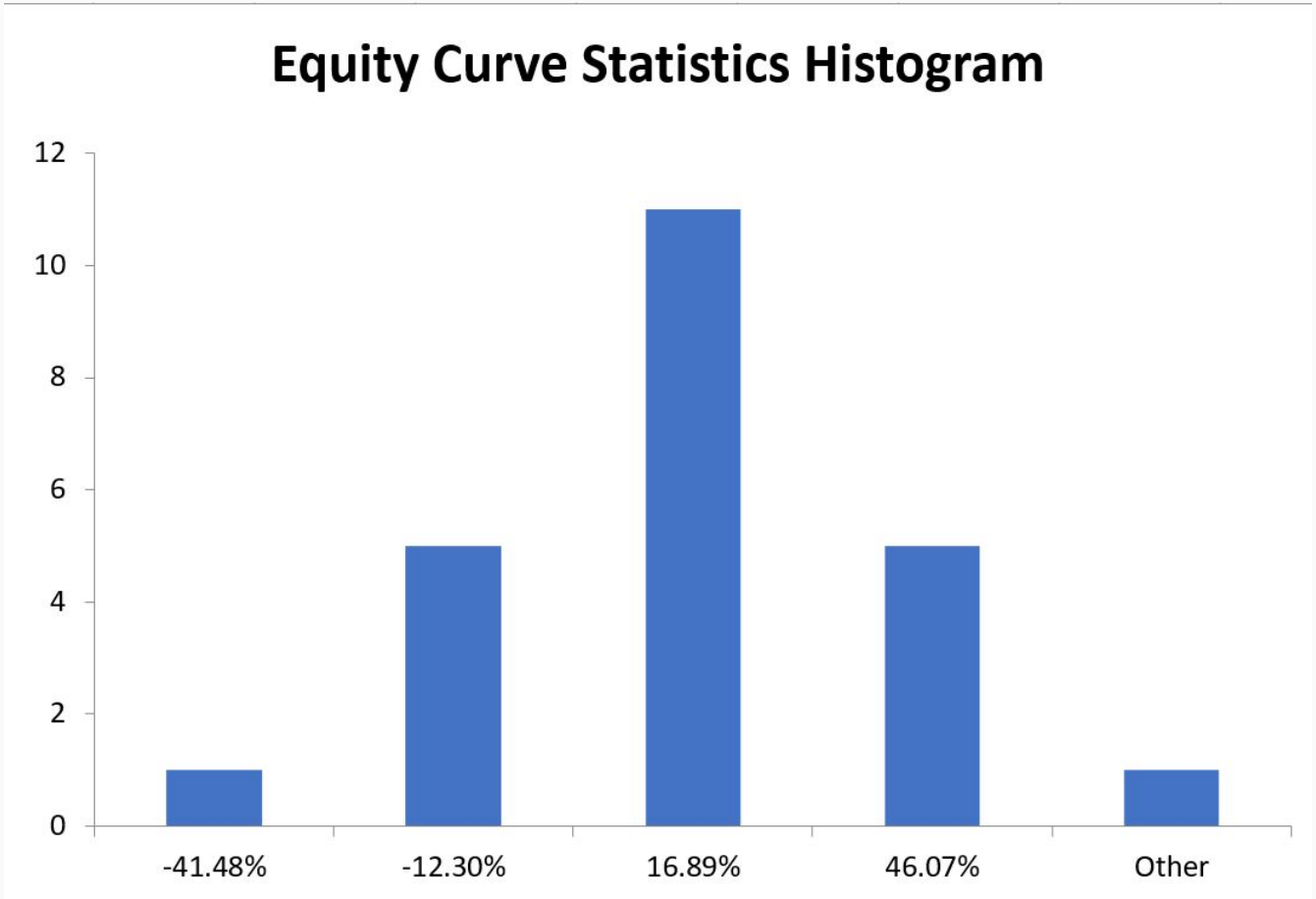
Sample Test (XB 06-10): In Sample Optimization

In Sample Performance Result
Channel Length: 500
Stop Percent:0.05

Net Equity	$241,397.125
Net Profit	$141,397.125
Worst drawdown	$34617.812
Average drawdown	$103991.03
Net profit to worst drawdown	4.084
Average Net Profit	$141,397.125
Sharpe Ratio	5.46%

Series Time Start: 2006/10/02 07:25
Series Time End: 2010/10/04 07:25

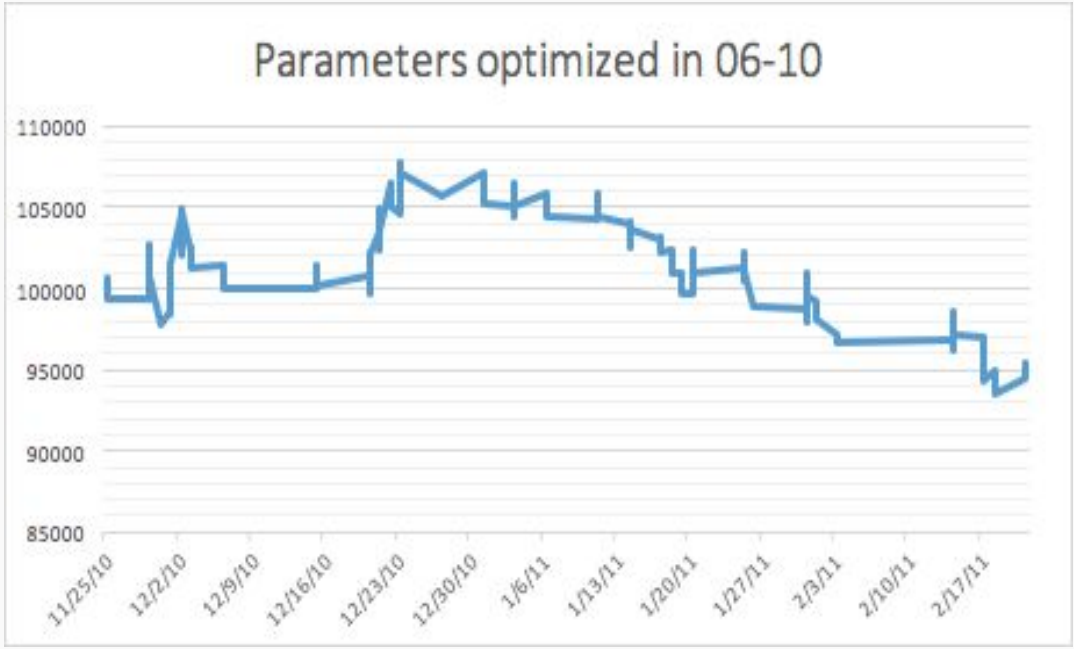
Equity Curve Statistics - XB (4 year 3 months in-sample)



Return	*Frequency*
-41.48%	1
-12.30%	5
16.89%	11
46.07%	5
Other	1

XB 3m Out of Sample Equity Curve

- The optimal parameters obtained in the four year period 06-10:
  - Stppct: .005
  - Chnlen: 500
- This Equity Curve shows both negative and positive portfolio position, indicating that the trading strategy is neutral



Section F
Conclusion

Conclusion

- Border Search: We notice that some of our optimal parameters are on the border (e.g. channel length at 500), maybe next time we can explore this properties more
- The difference between in-sample and out-sample test can be significant.
- Limitation of R Programming Language
- Advantage of other Programming Language
  - C++
- Thanks to all my teammate!!!