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

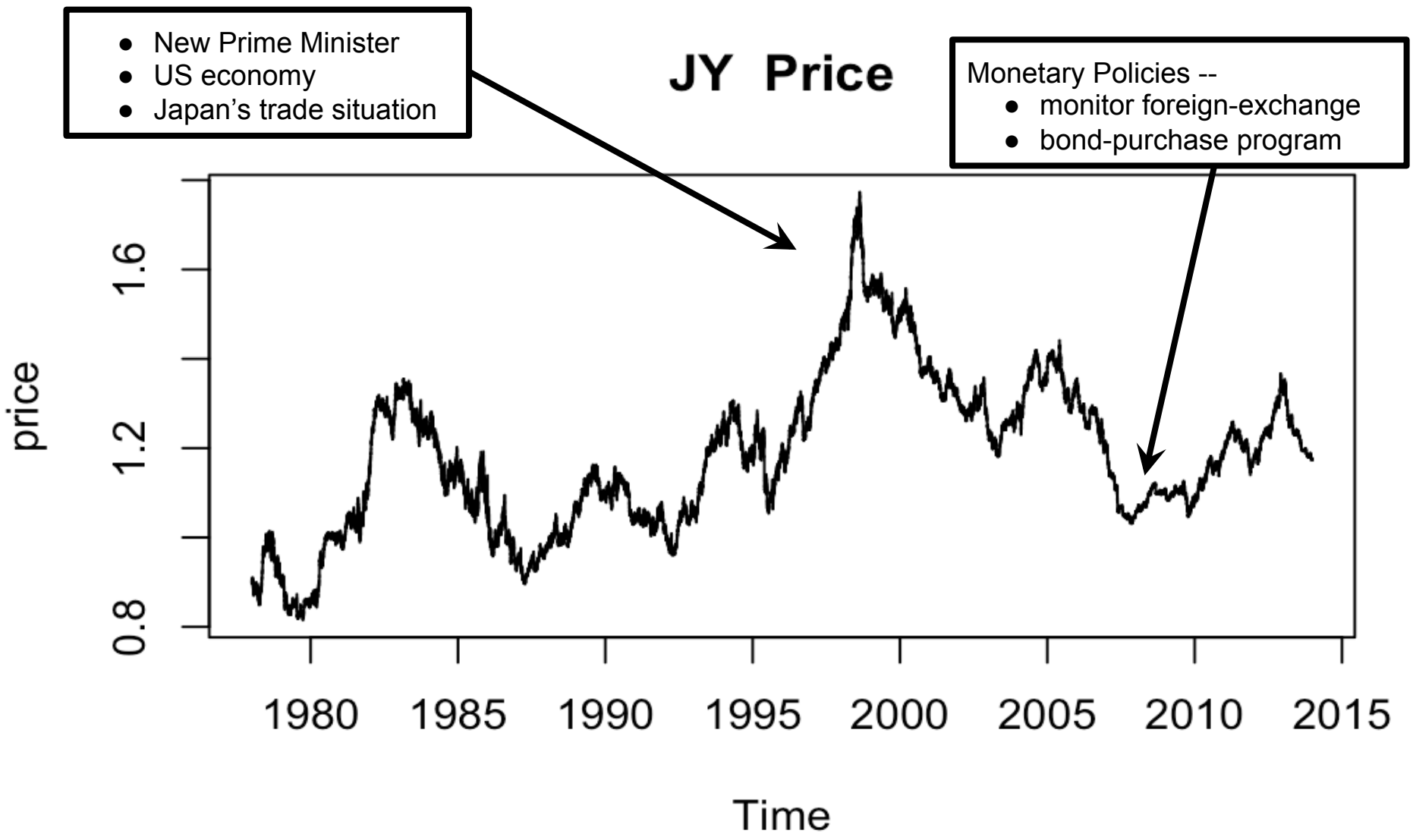
- USD
- Tick value: $6.25
- Tick Size: 0.005
- Trading Hour: 7:20a.m. - 2:00p.m. CST

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

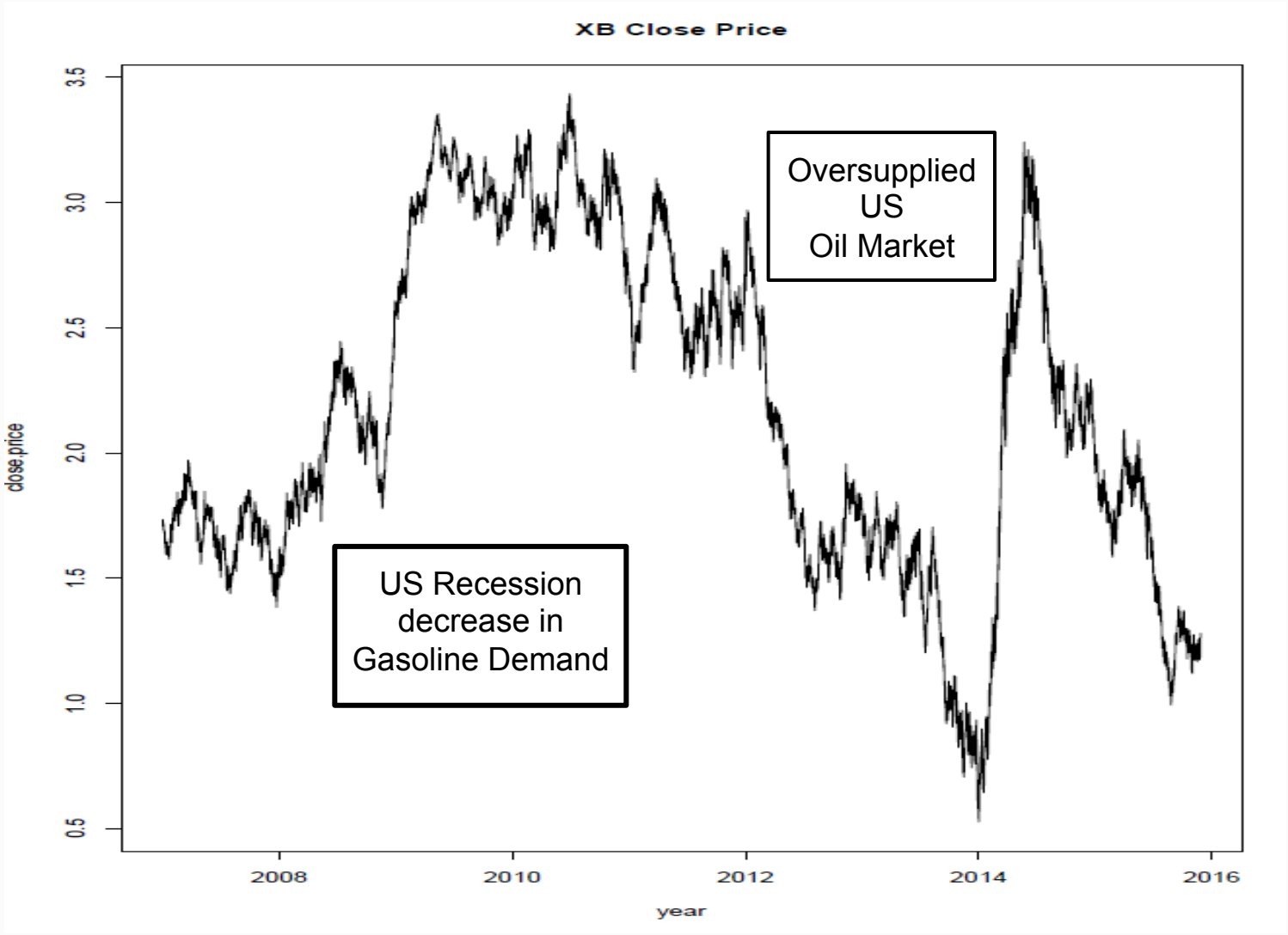
- USD
- Tick value: $4.2
- Tick Size: 0.01

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

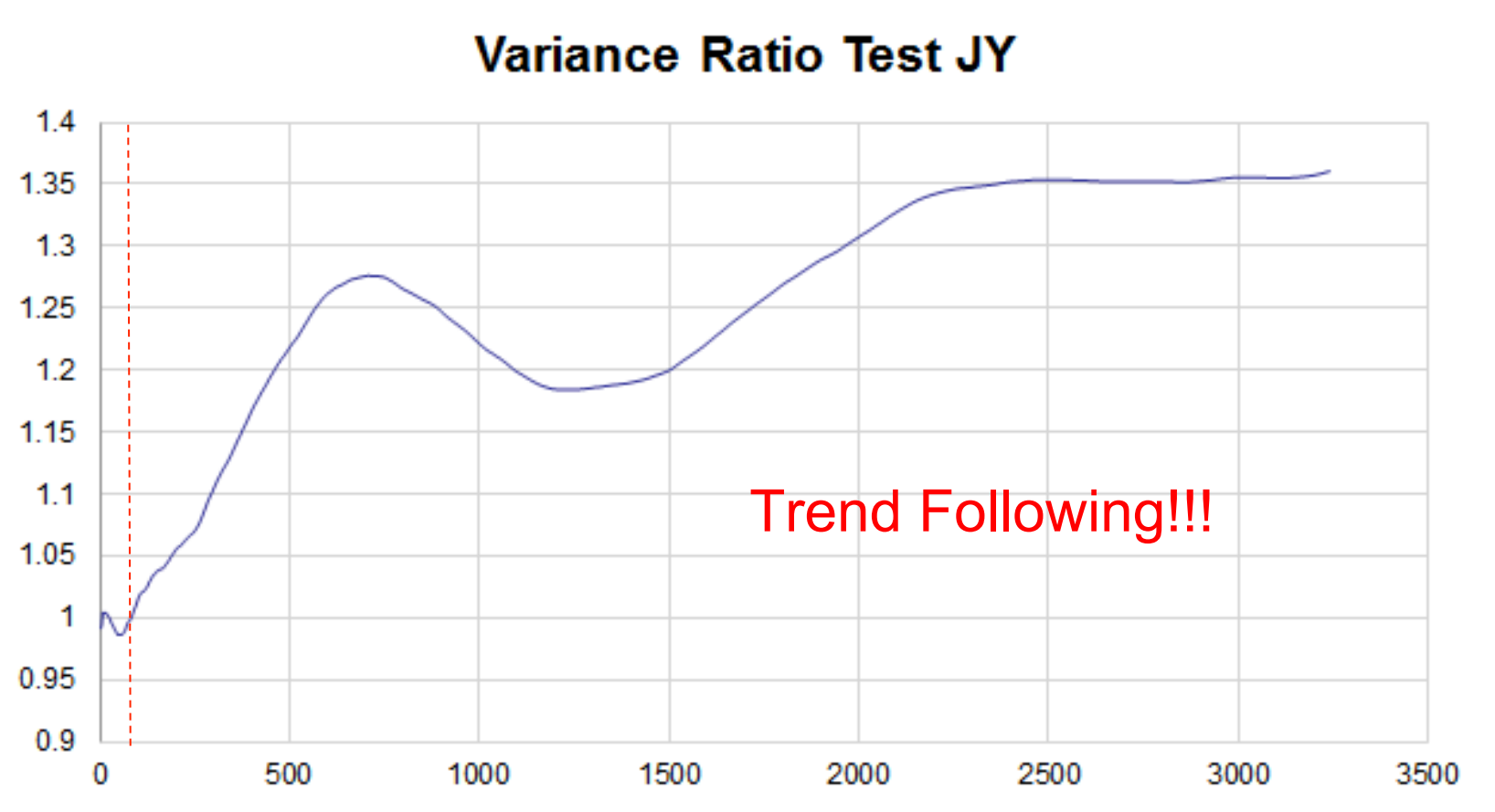
- A measure of the randomness of a return series.
- Variance ratio for q periods is

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

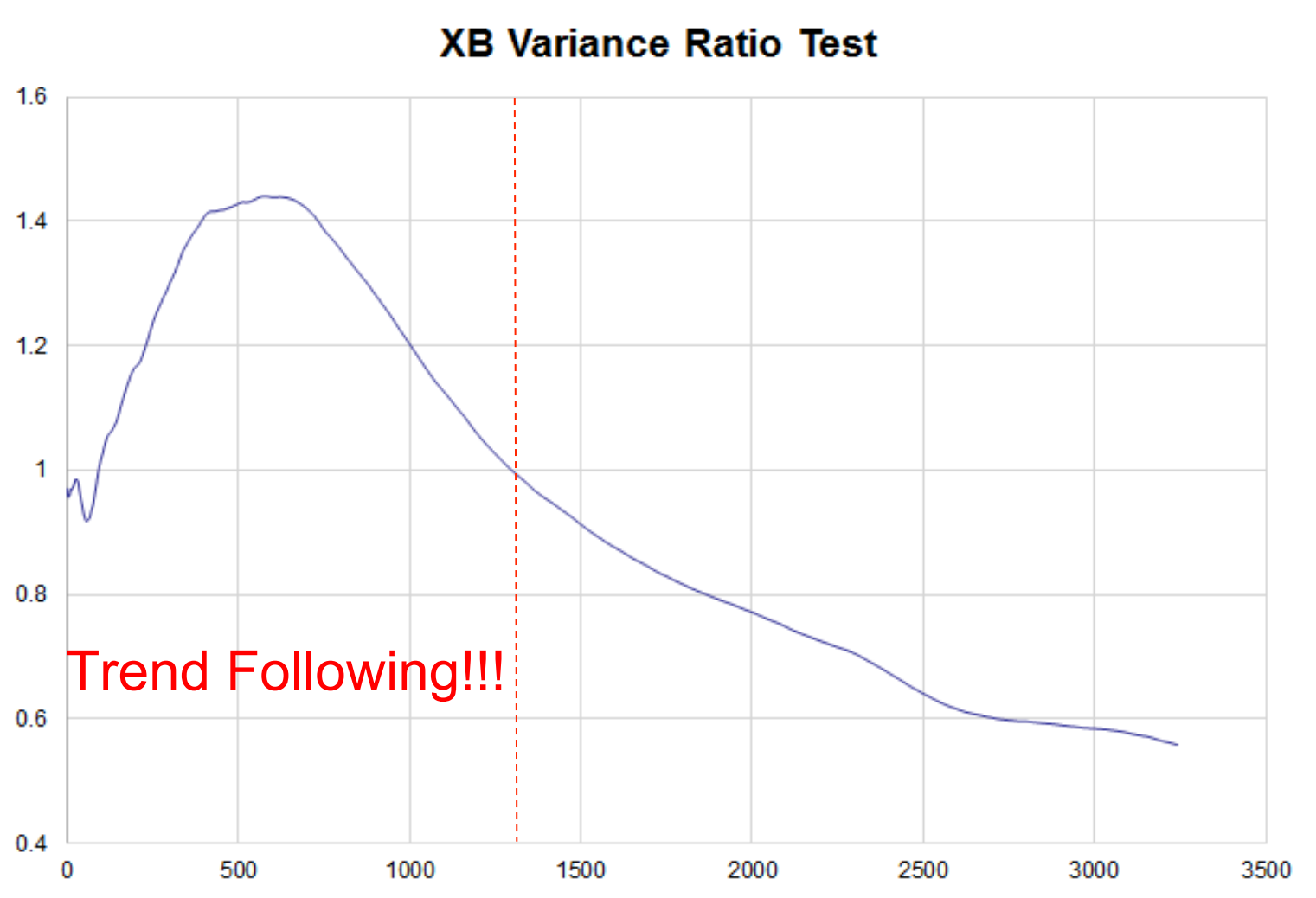
- q is discrete time separation in minutes
- ρ(k) is auto-correlation coefficient of two price changes separated by k minutes

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

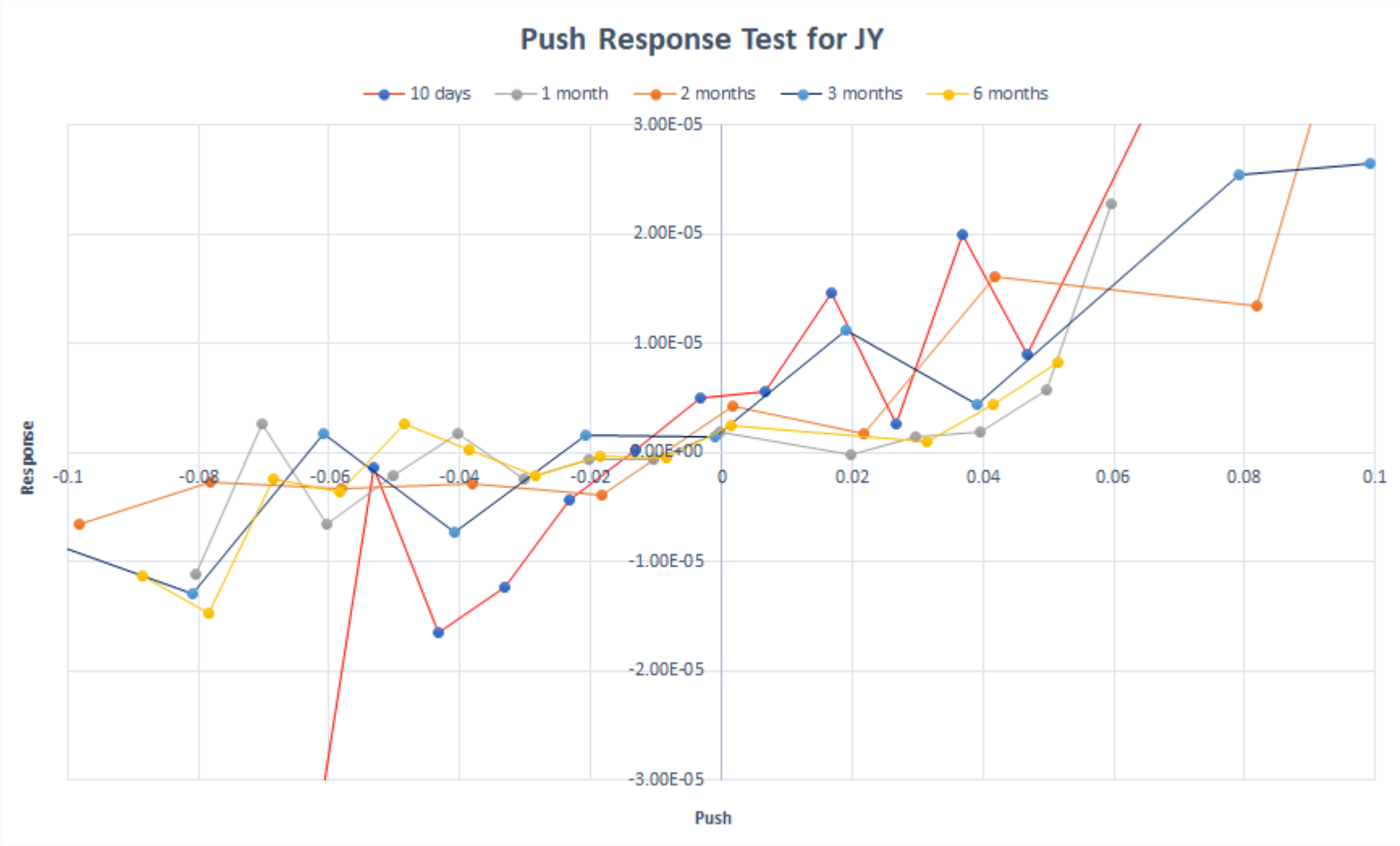
Push = x = price(t) – price(t – τ)

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

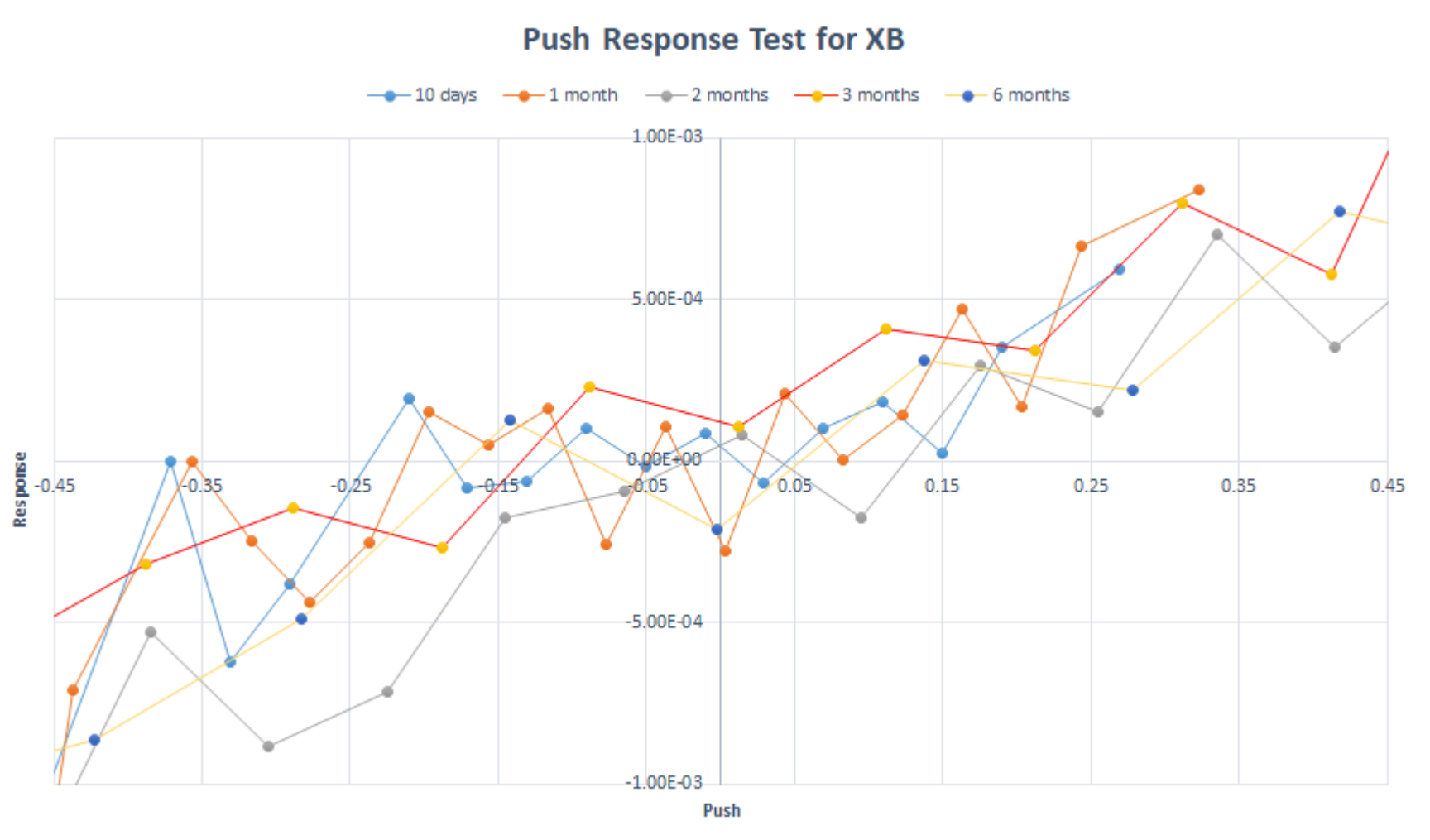
Here, $P(y|x) = \frac{P(x,y)}{P(x)}$ as the conditional mean response to a “push” x

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
- If $c_{new} < c_{old}$: move to the new solution
- If $c_{new} > c_{old}$: *maybe* move to the new solution

at result in an improved solution, whereas Si s worse solutions.

$$a = e^{\frac{c_{old} - c_{new}}{T}}$$

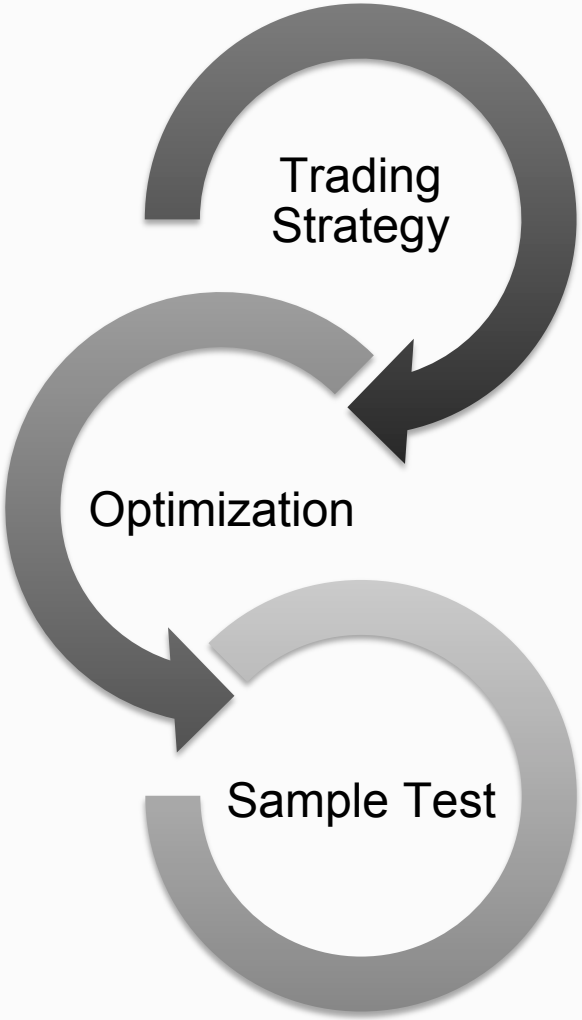
Cons: Although these strategies will speed up the optimization process, they sacrificed the accuracy. They may not reach global optimum, only local optimum, so we use brute force

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

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)))

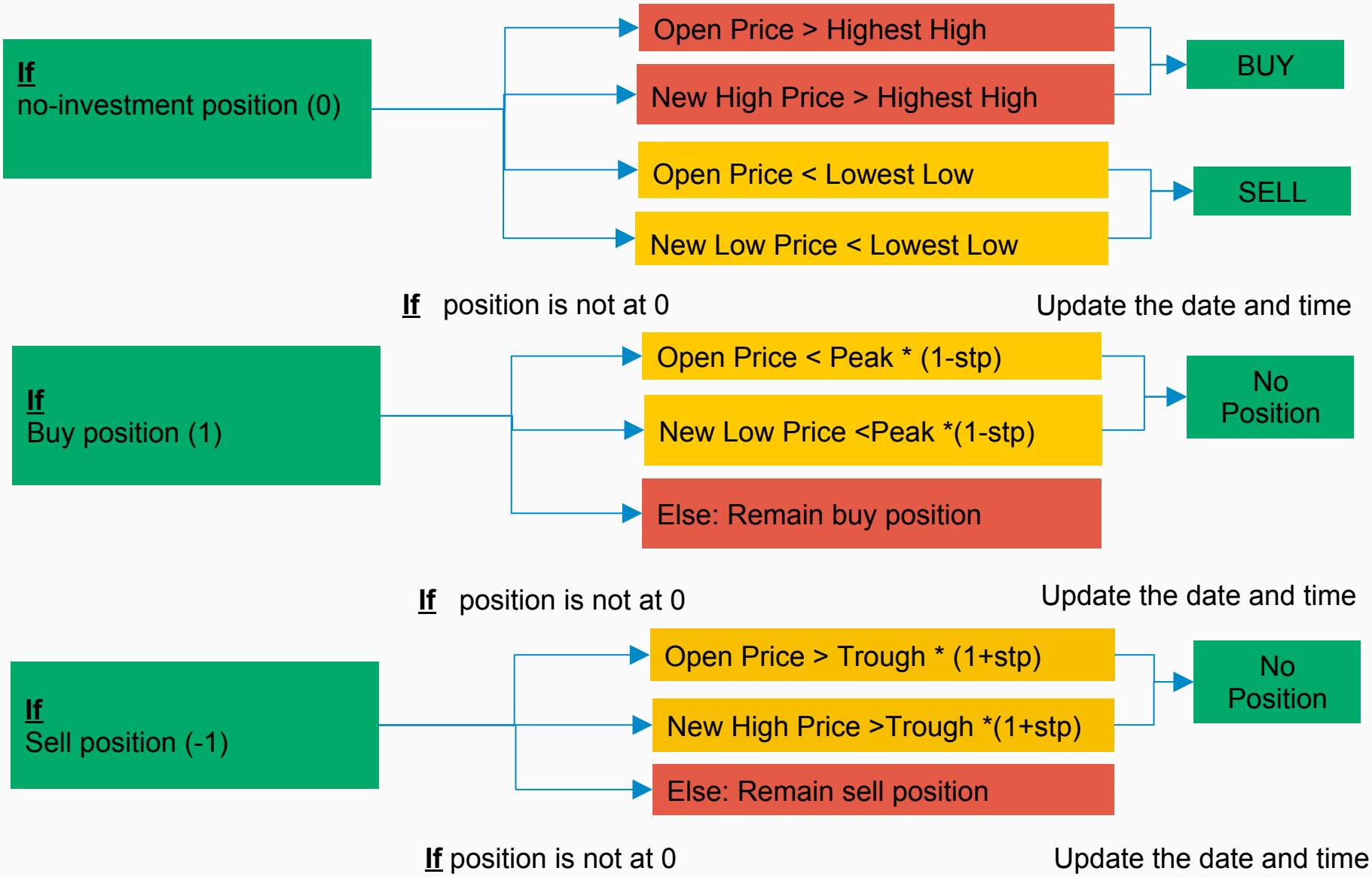
Our code:

```
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

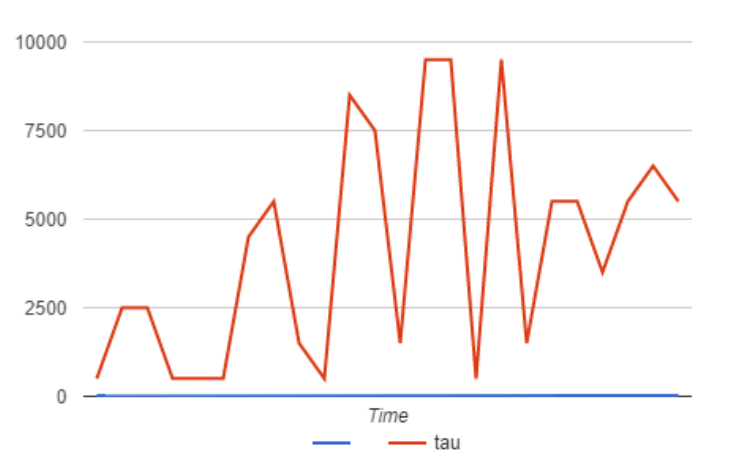
	3 months	6 months	9 months	12 months
4 years	233.82%	225.08%	234.88%	226.85%
6 years	196.17%	195.29%	188.74%	191.59%
8 years	191.83%	191.16%	182.97%	187.71%

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%

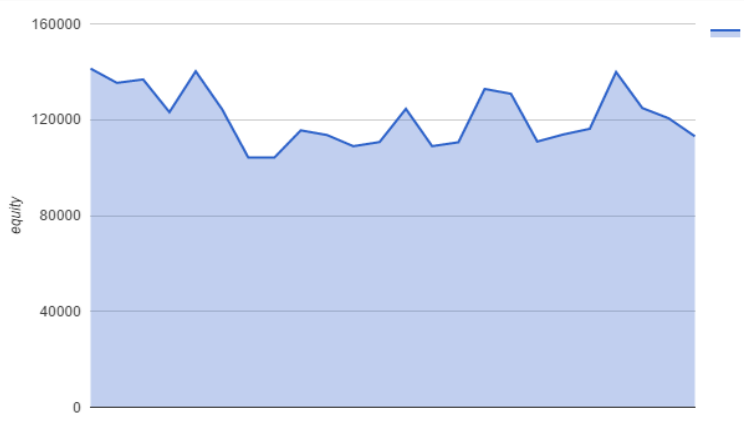
Optimization Result: In-Sample Optimization (JY 4 yr 9 months)

Channel Length

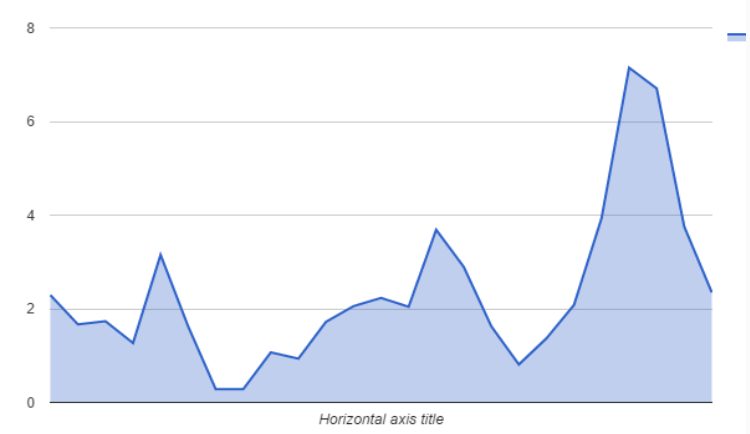


Stop Percent

Net Equity

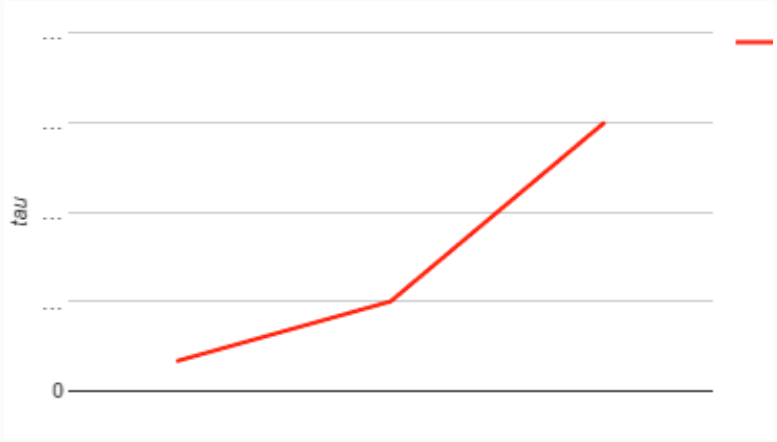


Return on Asset (NPWD)

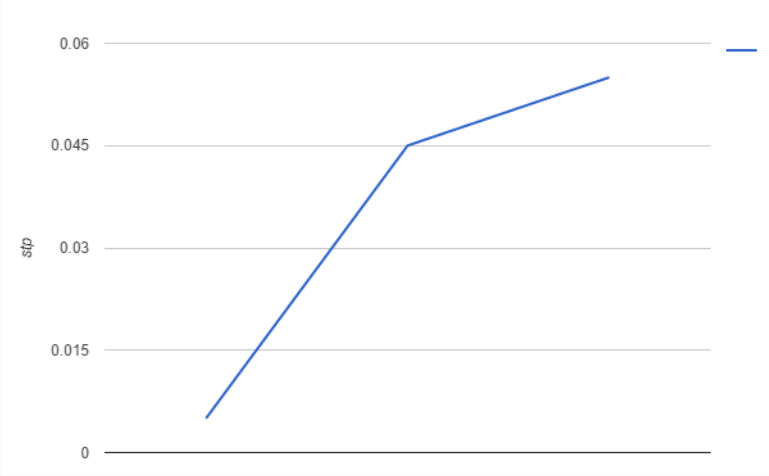


Optimization Result: In-Sample Optimization (XB 8yr 9 months)

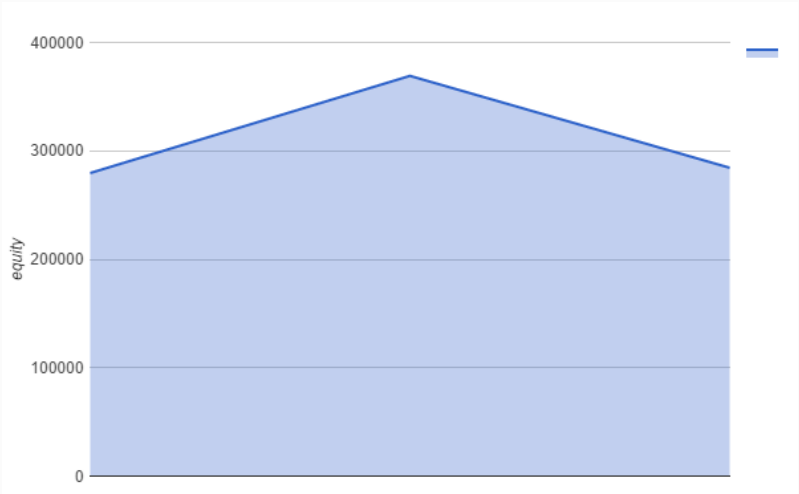
Channel Length



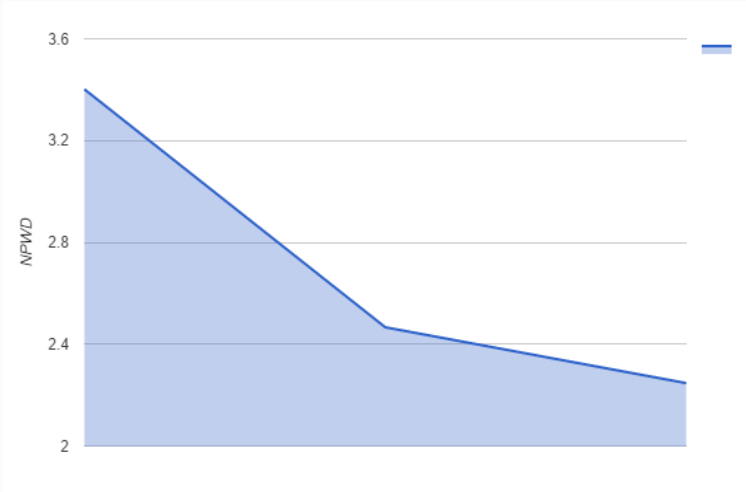
Stop Percent



Net Equity

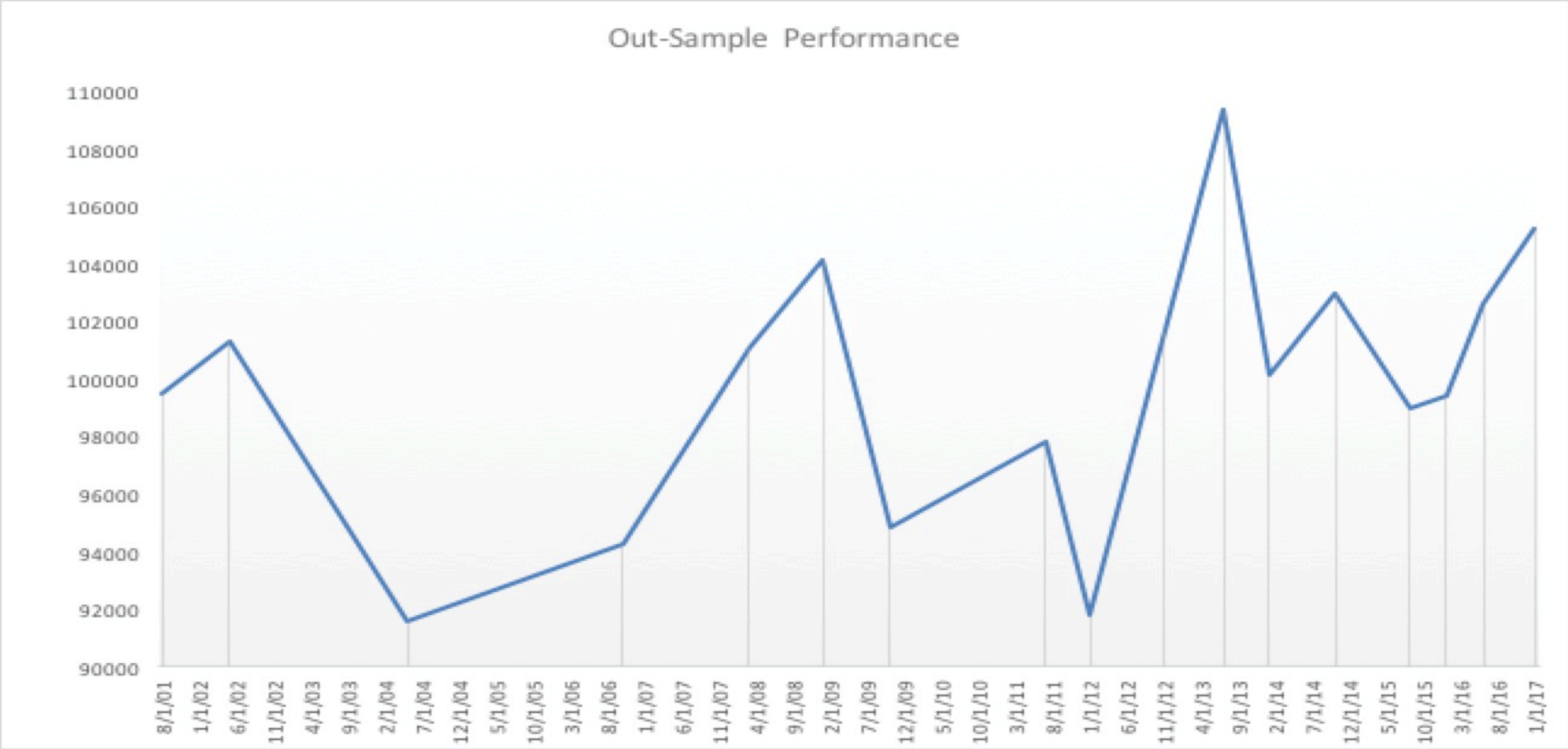


Return on Asset



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

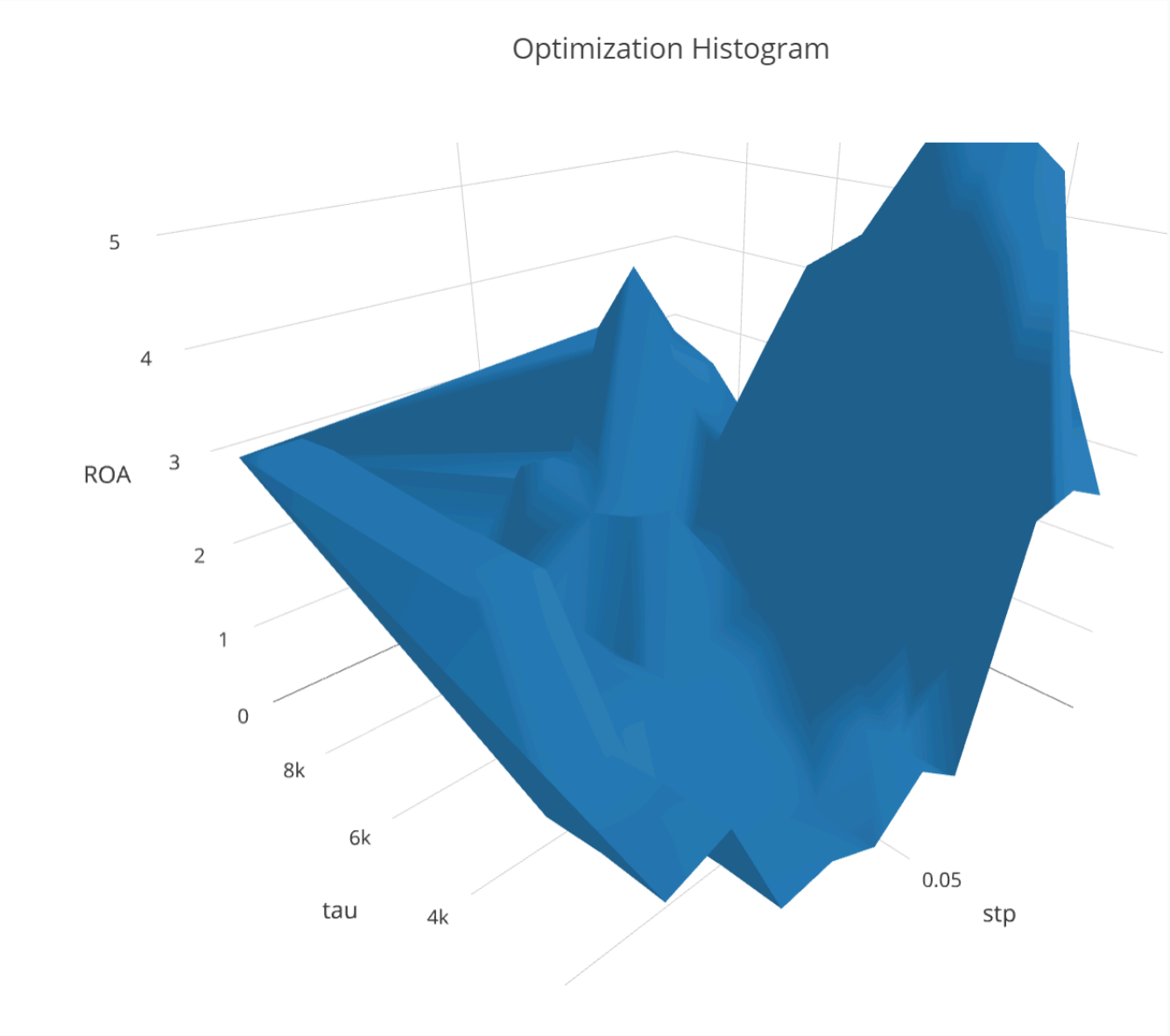
Section E

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



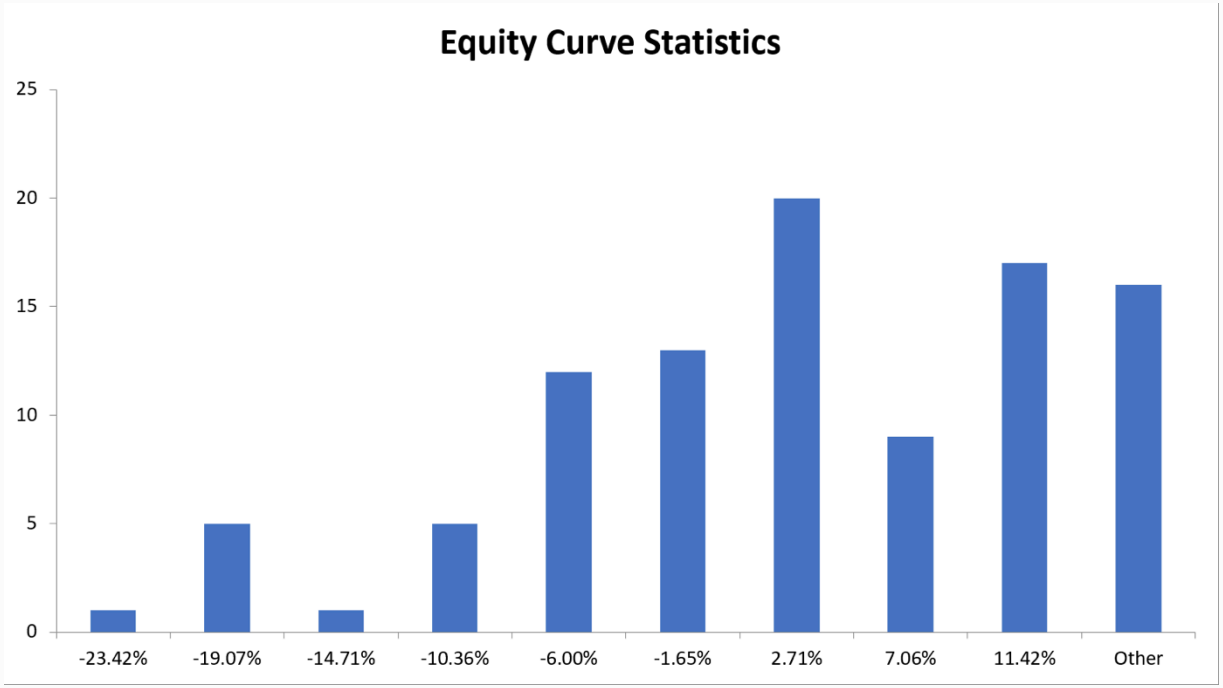
Sample Test (JY 85-89): In Sample Optimization

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%

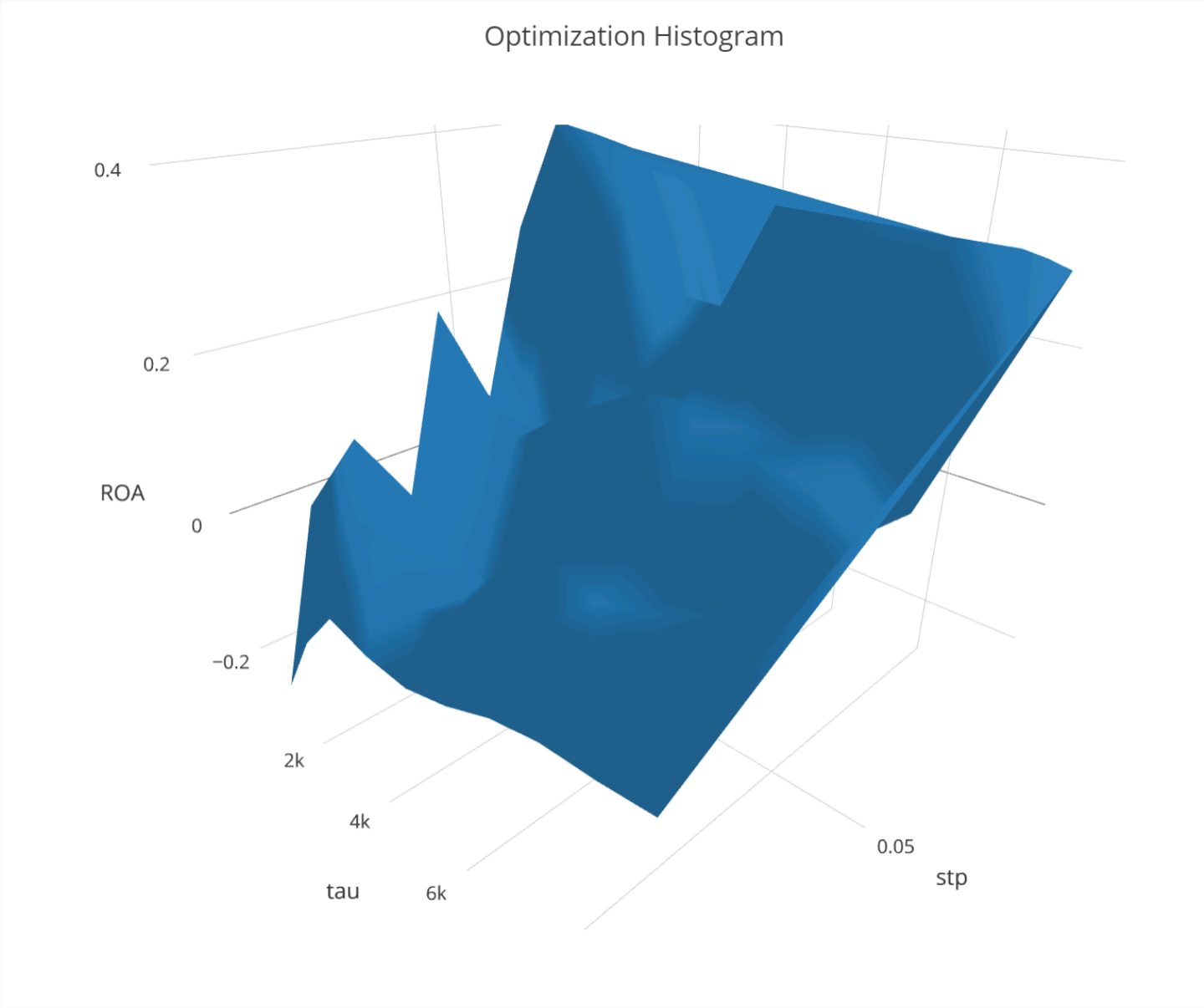
Series Time Start: 1985/01/02 07:25
Series Time End: 1989/01/02 07:25

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



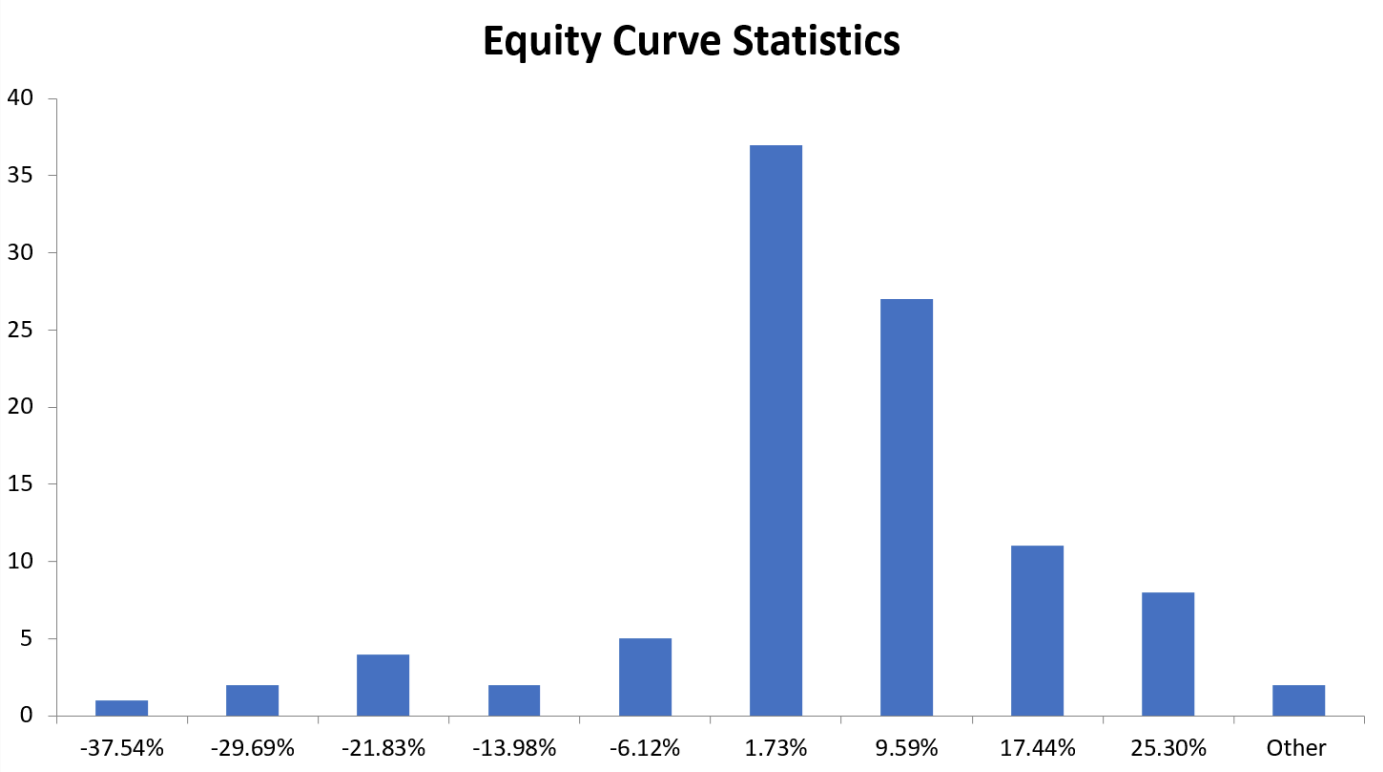
Sample Test (JY 00-04):
In Sample Optimization

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%

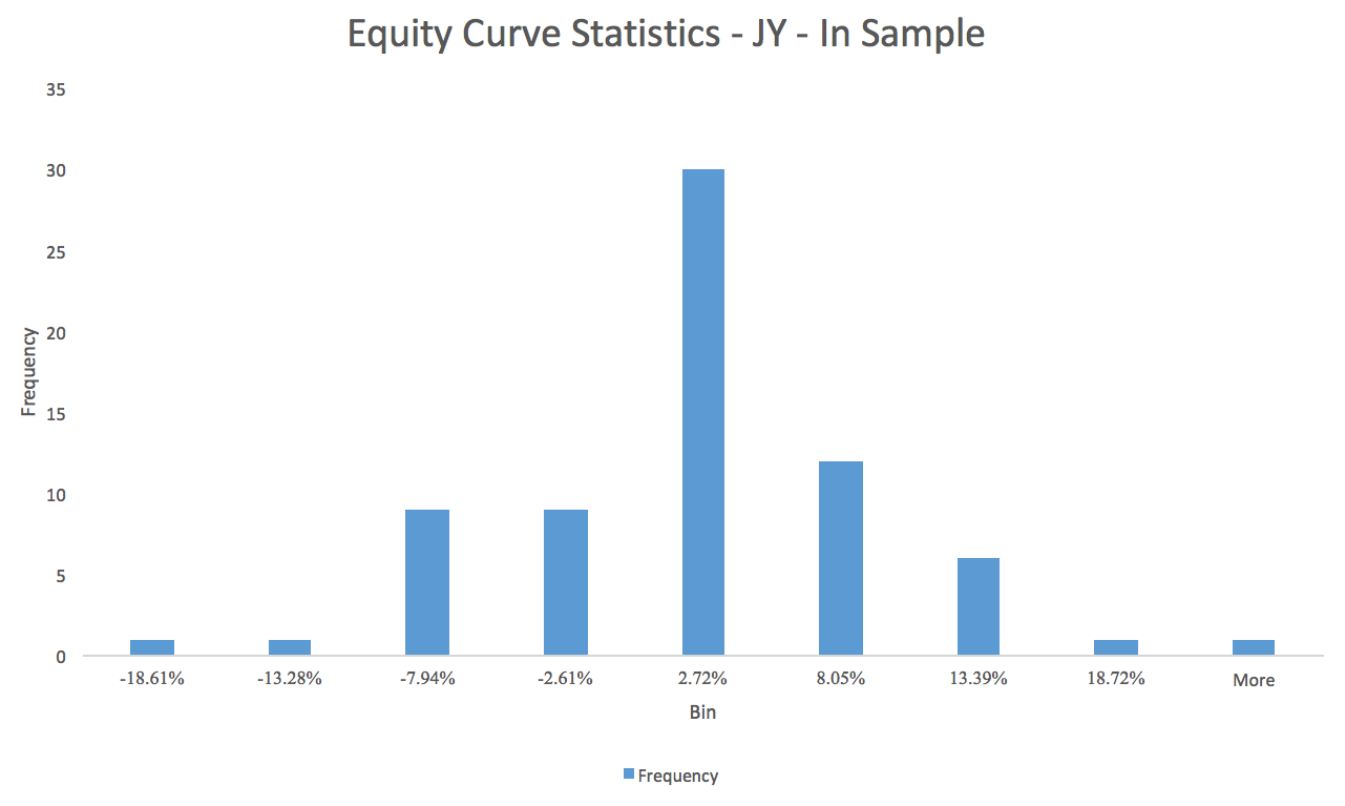
Series Time Start: 2000/01/02 07:25
Series Time End: 2004/01/03 07:25

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%

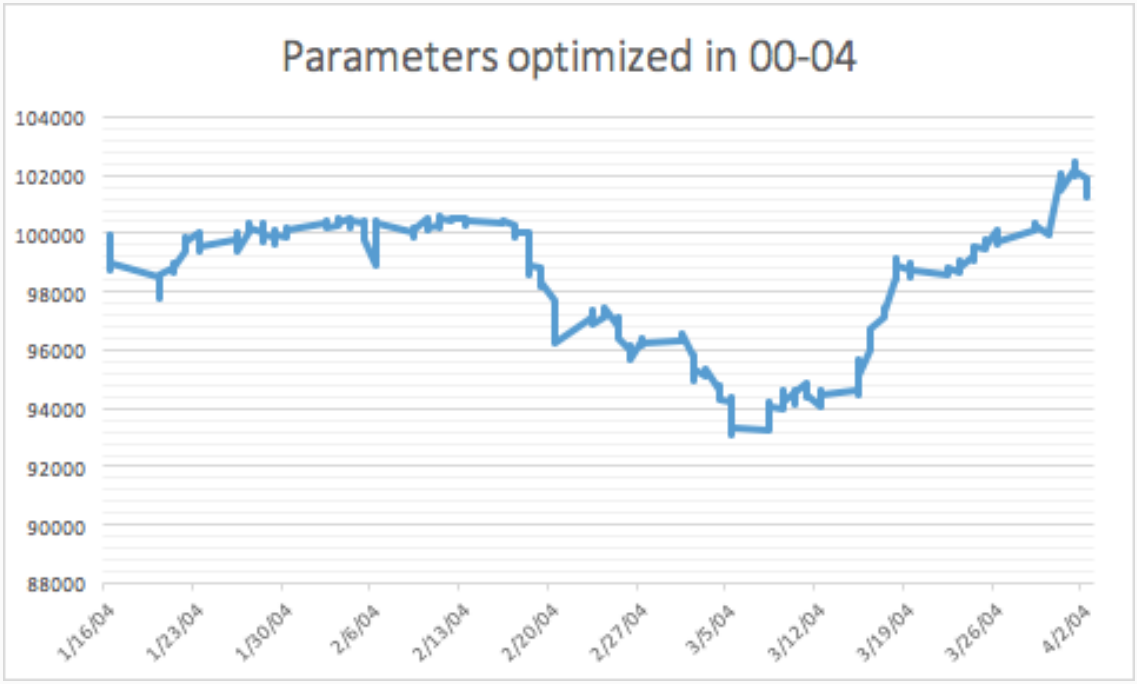
JY 3 month Out of Sample Equity Curve

The optimal parameters obtained in the four year period 00-04:

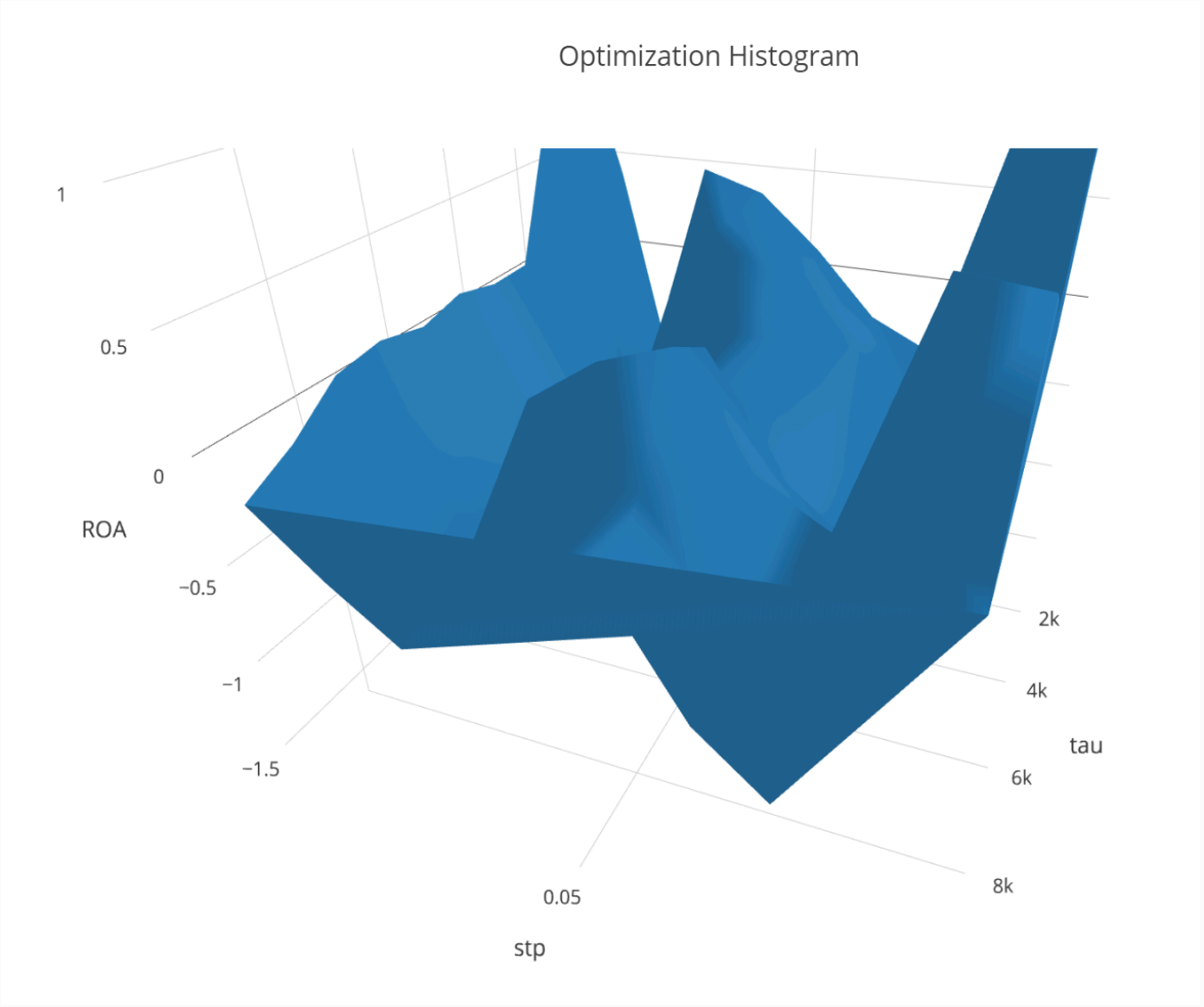
Stppct: 0.075

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



Sample Test (XB 06-10): Optimization Histogram



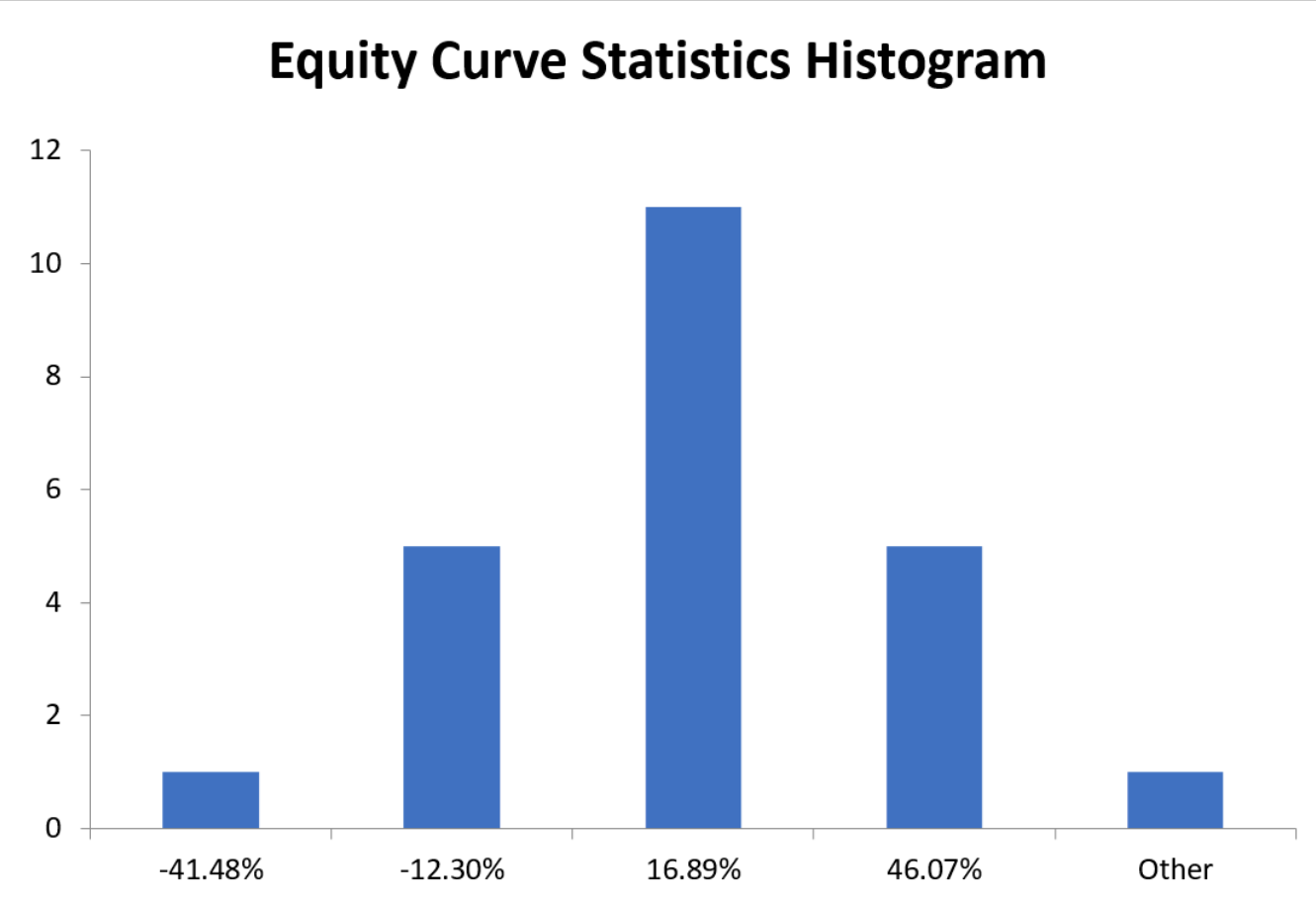
Sample Test (XB 06-10): In Sample Optimization

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

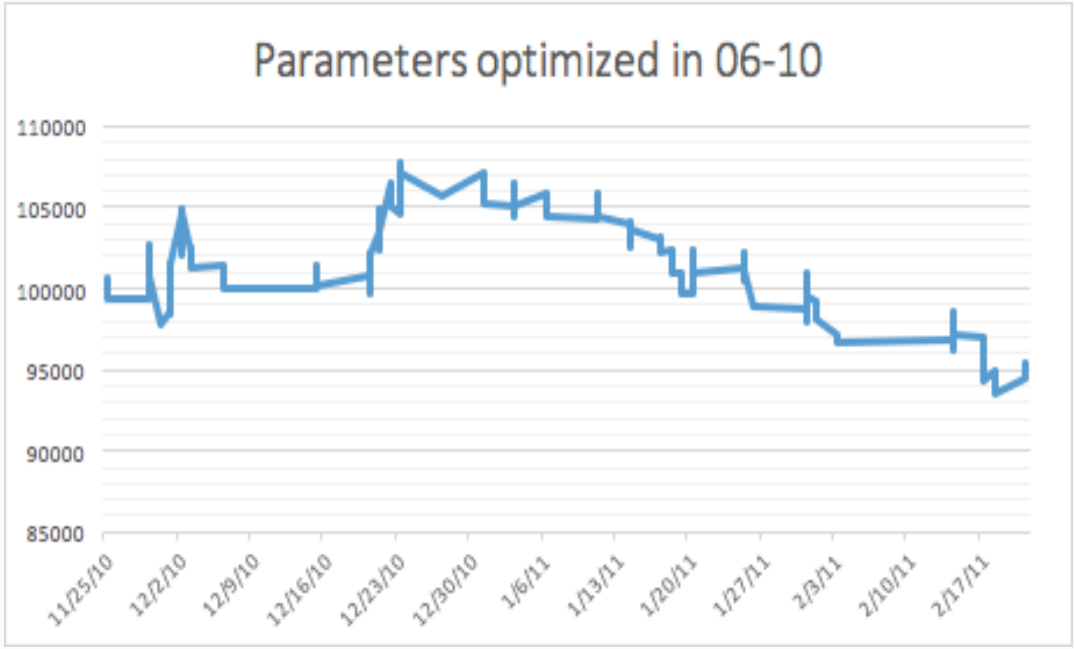
XB 3m Out of Sample Equity Curve

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!!!