LONG-TERM INVESTING WITH DYNAMIC HEDGING
USING A COMBINATION OF STOCKS AND OPTIONS

RO3

Final Year Thesis COMP4091H 2020-2021

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01. Introduction and theory
- Thesis to defend
- Concepts of **option trading** and **algo-investing**
- The Dynamic Hedging strategy for all market condition.

02. Empirical work
- Data collection pipeline design and implementation
- 11 quantified strategies design
- Backtesting engine design and implementation
- Strategy evaluation and discussion

03. Discussion and conclusion
- Comparison with commercial engine
- Limitations / assumptions
- Conclusion
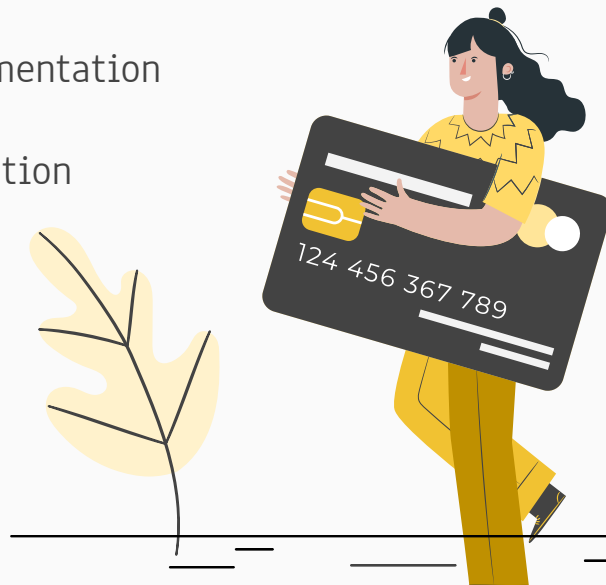
# OI.
INTRODUCTION
AND THEORY

THESIS TO DEFEND

The Dynamic Hedging (DH) strategy proposed in this study is a strategy that can improve return per unit risk so that it is profitable and sustainable in long-term

WHAT ARE OPTIONS?

- Options are **derivatives**.
- Value of options/**Premium** is derived from the properties of the **underlying asset.**
- There are **call** options and **put** options.
- Every option has an **expiration** and a **stike price**.
- **Option holder** can choose to **exercise** the option before expiration to buy/sell the underlying asset from the **option writer**.
- **OTM** = Out of the money | **ATM** = At the money | **ITM** = In the money
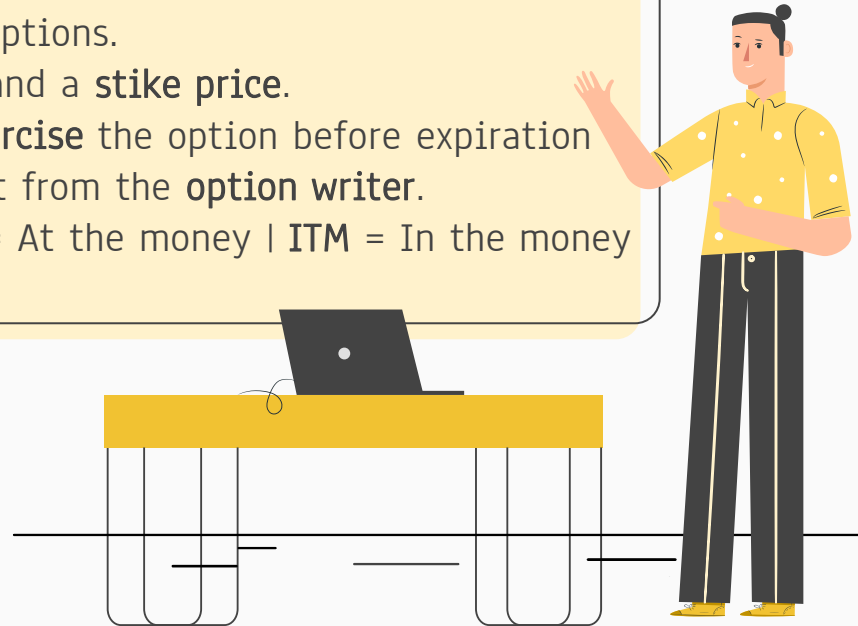
OPTION BASICS
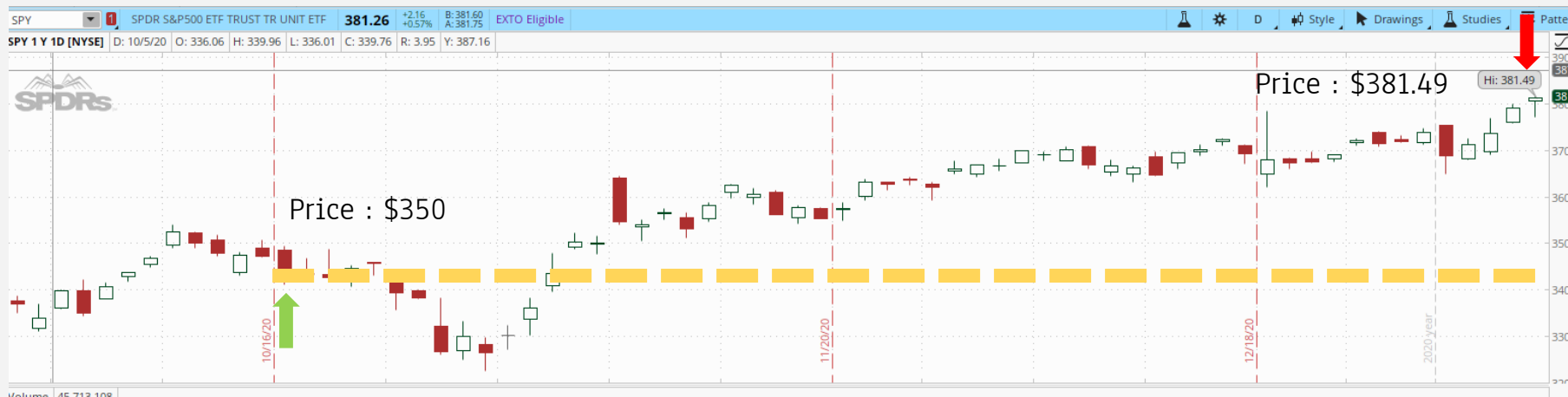
On 16th October 2020, we purchased a S&P 500 ETF (SPY) call option with a strike of $350 expiring on 16th February 2021. We paid a premium of $2002 for this option.

On 18th December 2020, we exercised the call option to purchase 100 shares of SPY at $350 and immediate sold them at $381.49.

Let's do the math!
Net credit = -2002 – 100*350 + 100*381.49 = $1147
ROI = 1147/2002 = 57.3%

ALGO
INVESTING
PROCEDURES

01
DATA COLLECTION

02
STRATEGY DESIGN

03
BACKTESTING

04
EVALUATION

DYNAMIC HEDGING STRATEGY FOR ALL MARKET ENVRIONMENT

#	Components	Descriptions
1	Long Position	A position that gains in value when the underlying asset goes up. E.g. Shares of stock, Bullish options combination
2	Hedge (Short-biased)	A position that gains in value exponentially when the underlying asset goes down. E.g., Long Put option, Put back ratio (short put option plus two long put options)
3	Finance (market-neutral)	A position that gains in value when the underlying asset goes sideways. E.g., Calendar spread, Iron condor (short call spread plus short put spread)
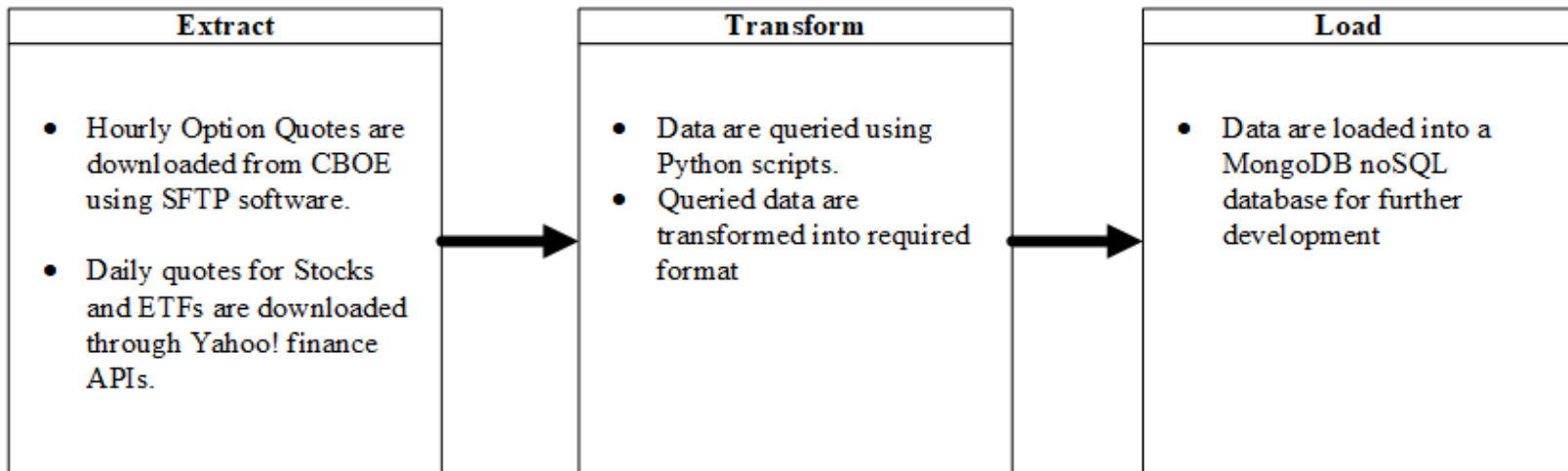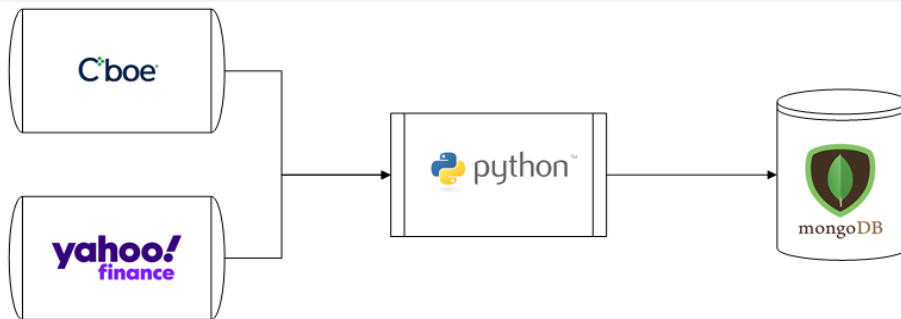
O2.
EMPIRICAL WORK

DATA COLLECTION PIPELINE

Extract	Transform	Load
• Hourly Option Quotes are downloaded from CBOE using SFTP software. • Daily quotes for Stocks and ETFs are downloaded through Yahoo! finance APIs.	• Data are queried using Python scripts. • Queried data are transformed into required format	• Data are loaded into a MongoDB noSQL database for further development

02
STRATEGY DESIGN
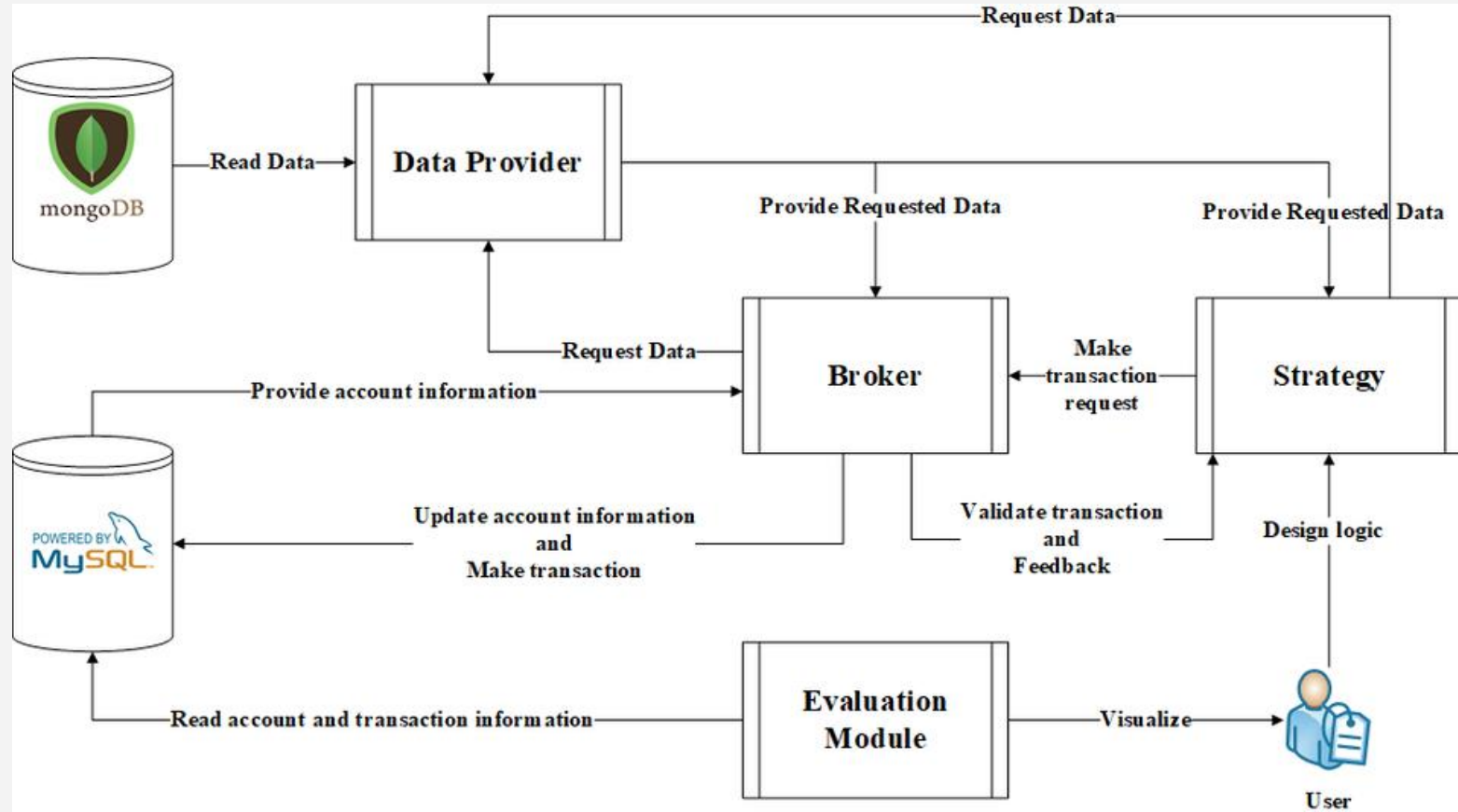
Code	Strategy Nature	Strategy name	Descriptions
LS-1	Long-Biased	Buy and hold	Long stock throughout the test
LS-2	Long-Biased	Revert back to mean	Long stock when the stock is oversold
LO-1	Long-Biased	Long Call options + mean reversion	Long call options when the stock is oversold
SO-1	Short-biased	Long Put options + mean reversion	Short put options when the stock is overbought
SO-3	Short-biased	Tail Risk put	Long 5% OTM put
NO-2	Market-neutral	Short Straddle	Short Call + Short Put + 15% OTM put
NO-2b	Market-neutral	Short Straddle with volatility filter	Short Straddle when VIX < 15
NO-2c	Market-neutral	Short Straddle with shorter DTE	Short straddle weekly.
NO-3	Market-neutral	Short strangle	Short 5% OTM put and call
C-1	Combined	Combined strategy	LS-2 + SO-1 + NO-3
C-2	Combined	Combined strategy	LO-1 + SO-1 + NO-3

$$Sharpe\ Ratio = \frac{Expected\ return - Risk\ free\ rate}{Standard\ deviation}$$

$$Calmar\ Ratio = \frac{Annualized\ return}{Maximum\ drawdown}$$

STRATEGY LS-2:REVERT BACK TO MEAN

Strategy LS-2 follows a technical indicator to determine the timing for entry. If we receive an oversold signal, we will take a long position.

$$IBS(t) = \frac{Close(t) - Low(t)}{High(t) - Low(t)}$$

LS-2 Algorithm

if   IBS(t-1) < 0.2 then

OPEN long Stock

if   IBS(t) > 0.8 then

CLOSE long Stock

LS-2
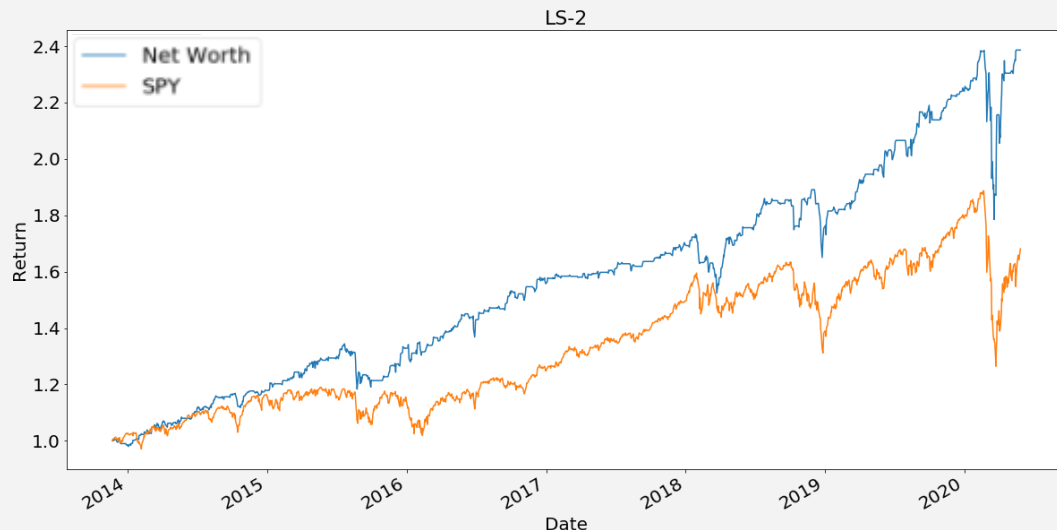
	gtsangtrading_20201114_2324	SPY
Annual Return	14.32%	8.32%
Max Drawdown	-25.14%	-33.00%
Annual Volatility	12.49%	15.16%
Sharpe Ratio	1.135	0.604
Calmar Ratio	0.57	0.252
Omega Ratio	1.376	1.123
Downside Risk	0.086	0.112
Tail Ratio	1.454	0.95
Alpha	0.111	0.0
Beta	0.398	1.0

04
EVALUATION

Strategy LO-1 is derived from Strategy LS-2. We simply replace the stock with options.

LO-1 Algorithm	Trade logic at time t

if   IBS(t-1) < 0.2 then

    OPEN long call option

if   IBS(t) > 0.8 then

    CLOSE long call option

LO-1
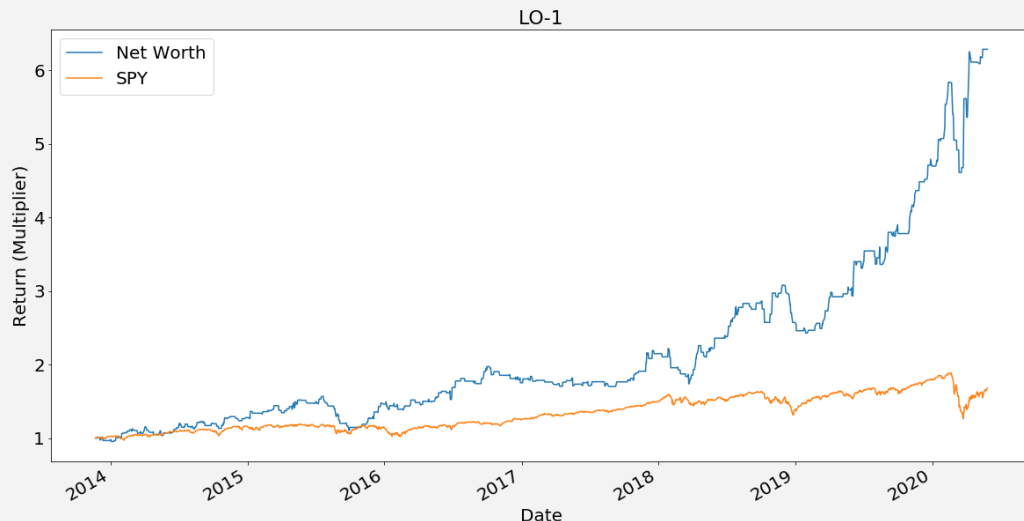
	gtsangtrading_20201115_0121	SPY
Annual Return	32.71%	8.32%
Max Drawdown	−29.56%	−33.00%
Annual Volatility	22.44%	15.16%
Sharpe Ratio	1.374	0.604
Calmar Ratio	1.107	0.252
Omega Ratio	1.517	1.123
Downside Risk	0.14	0.112
Tail Ratio	1.371	0.95
Alpha	0.302	0.0
Beta	0.481	1.0

04
EVALUATION

STRATEGY SO-I: LONG PUT OPTIONS

Strategy SO-1 will open a long put options position if the underlying asset is overbought.

$$RS = \frac{Average\ of\ Upward\ Price\ Change}{Average\ of\ Downware\ Price\ Change}$$

$$RSI = 100 - \frac{100}{1 + RS}$$

SO-1 Algorithm	Trade logic at time t

if   **IBS(t-1) > 0.8 and RSI(2,t) > 90 then**

  OPEN long put option

if   **IBS(t) < 0.2 then**

  CLOSE long put option

SO-1
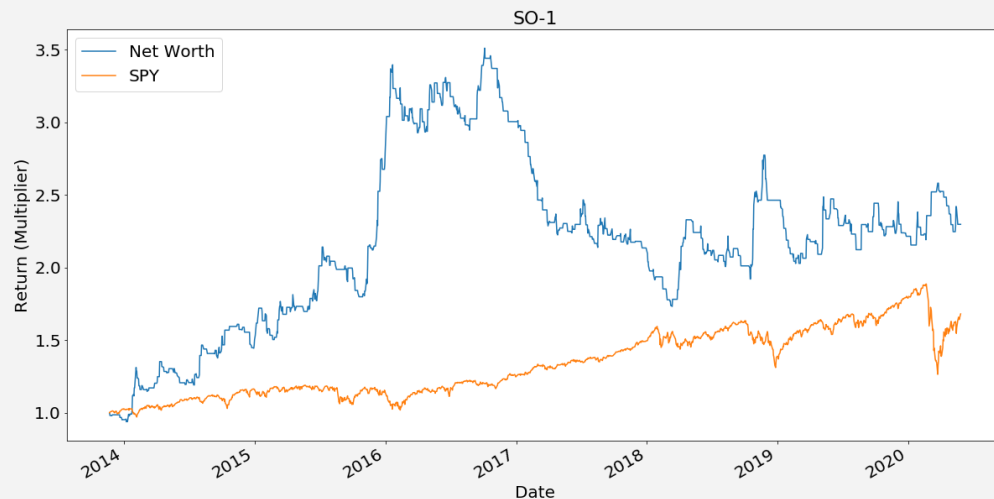
	gtsangtrading_20201115_1447	SPY
Annual Return	13.66%	8.32%
Max Drawdown	-50.67%	-33.00%
Annual Volatility	25.60%	15.16%
Sharpe Ratio	0.626	0.604
Calmar Ratio	0.27	0.252
Omega Ratio	1.199	1.123
Downside Risk	0.143	0.112
Tail Ratio	1.136	0.95
Alpha	0.222	0.0
Beta	-0.439	1.0

04
EVALUATION

STRATEGY NO-2: SHORT STRADDLE
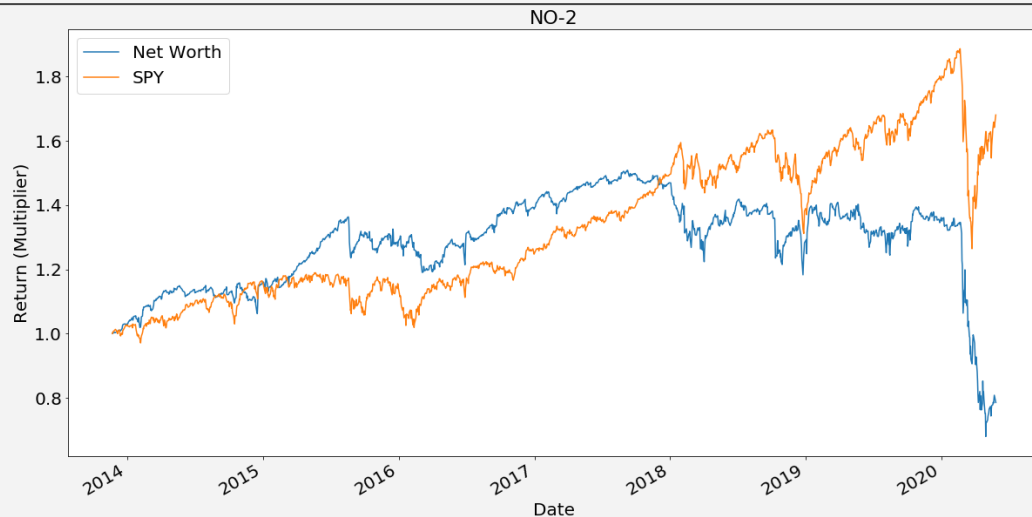
Strategy NO-2 open short straddle positions by selling ATM call and ATM put option every month. To protect against downside losses, we purchase an additional put that is 15% OTM. This strategy is created by Josha Coval and Tyler Shumway in 2000

NO-2

NO-2 Algorithm	Trade logic at time t

if t + 1 == the expiration of the current straddle **then**

    CLOSE old straddle

    OPEN new straddle

    end if

	gtsangtrading_20210102_2202	SPY
Annual Return	-3.65%	8.32%
Max Drawdown	-54.97%	-33.00%
Annual Volatility	17.73%	15.16%
Sharpe Ratio	-0.12	0.604
Calmar Ratio	-0.066	0.252
Omega Ratio	0.972	1.123
Downside Risk	0.138	0.112
Tail Ratio	0.888	0.95
Alpha	-0.037	0.0
Beta	0.177	1.0

04
EVALUATION

STRATEGY NO-3: SHORT STRANGLE

Strategy NO-3 is a short strangle strategy which shorts OTM calls and OTM puts every month.

NO-3 Algorithm	Trade logic at time t

if t + 1 == the expiration of the current strangle **then**

    CLOSE old strangle

    OPEN new strangle

  end if

NO-3
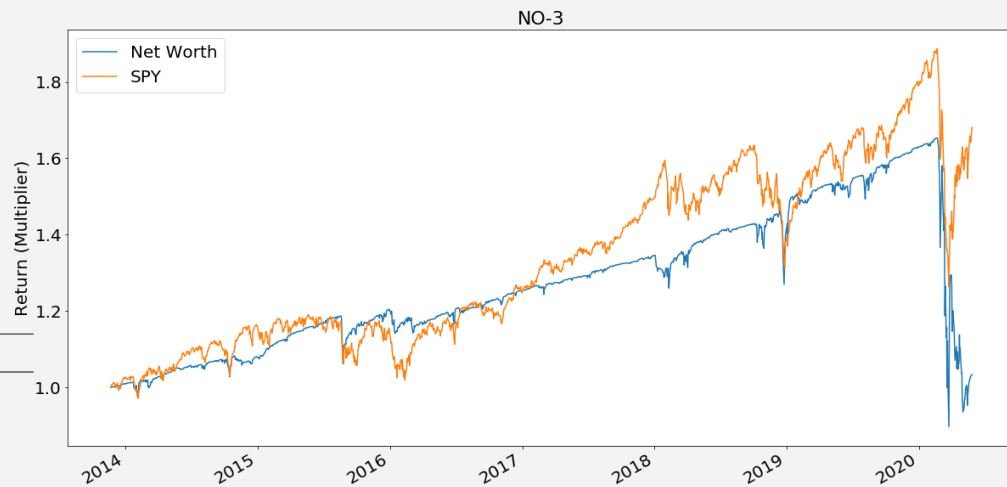
		gtsangtrading_20210103_1907	SPY
Annual Return		0.51%	8.32%
Max Drawdown		-45.75%	-33.00%
Annual Volatility		20.76%	15.16%
Sharpe Ratio		0.128	0.604
Calmar Ratio		0.011	0.252
Omega Ratio		1.054	1.123
Downside Risk		0.148	0.112
Tail Ratio		0.982	0.95
Alpha		-0.017	0.0
Beta		0.48	1.0

04
EVALUATION

Strategy CO-1 is a combined strategy with LS-2, SO-1, and NO-3. The allocation of capital in each strategy is as follows.

Strategy	Weight
LS-1	90%
SO-1	5%
NO-3	2%
Cash	3%

CO-1
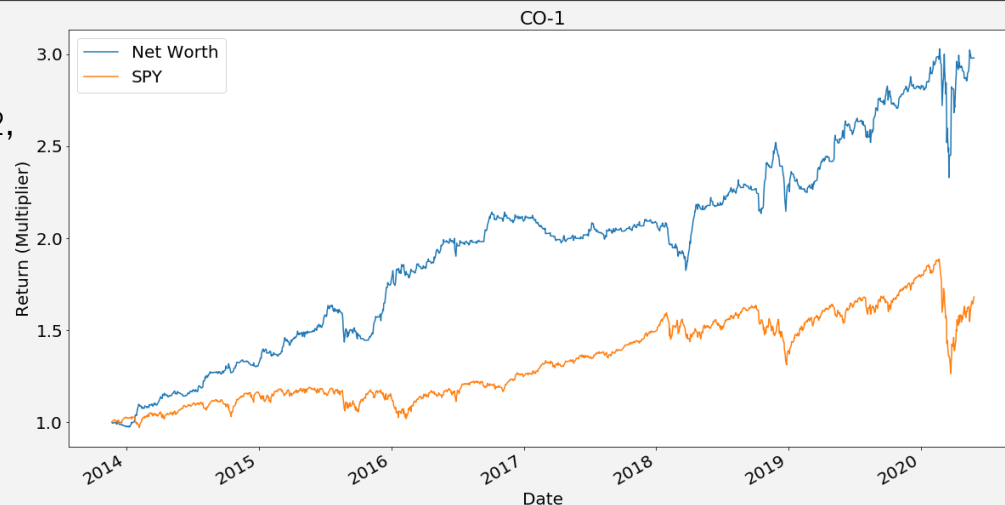
	gtsangtrading_20210107_1520	SPY
Annual Return	18.30%	8.32%
Max Drawdown	-23.13%	-33.00%
Annual Volatility	13.61%	15.16%
Sharpe Ratio	1.304	0.604
Calmar Ratio	0.791	0.252
Omega Ratio	1.347	1.123
Downside Risk	0.09	0.112
Tail Ratio	1.415	0.95
Alpha	0.165	0.0
Beta	0.267	1.0

04
EVALUATION

	CO-1	LS-2	SO-1	NO-3	SPY
Annual return	18.2%	14.32%	13.67%	0.51%	8.32%
Max drawdown	-22.13%	-25.14%	-50.67%	-45.75%	-33.00%
Annual volatility	13.61%	12.493%	25.605%	20.76%	15.16%
Sharpe ratio	1.304	1.135	0.626	0.128	0.604
Calmar ratio	0.791	0.57	0.27	0.011	0.252

04
EVALUATION

Strategy CO-2 is a combined strategy with LS-2, SO-1, and NO-3. The allocation of capital in each strategy is as follows.

Strategy	Weight
LO-1	20%
SO-1	5%
NO-3	2%
Cash	73%

CO-2
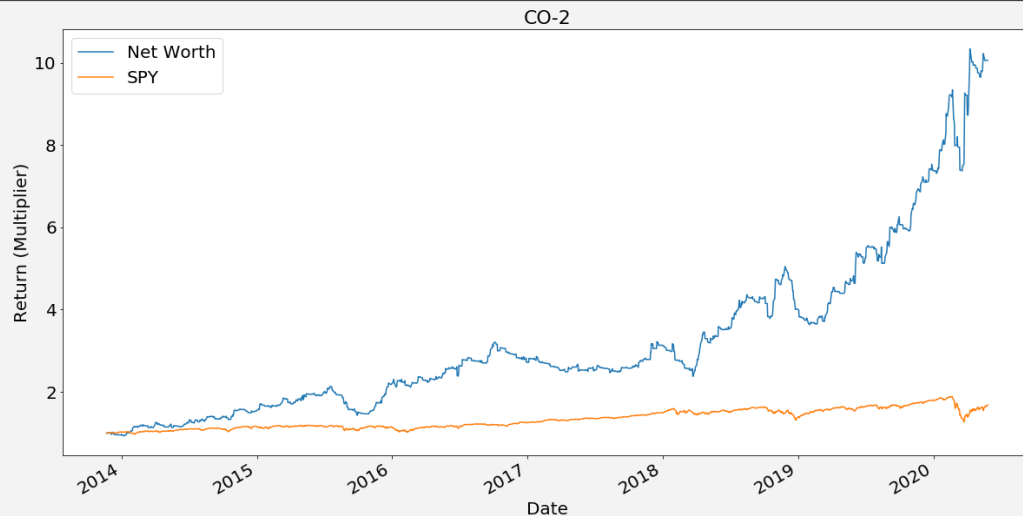
	gtsangtrading_20210107_1547	SPY
Annual Return	42.67%	8.32%
Max Drawdown	-32.74%	-33.00%
Annual Volatility	25.57%	15.16%
Sharpe Ratio	1.519	0.604
Calmar Ratio	1.303	0.252
Omega Ratio	1.447	1.123
Downside Risk	0.158	0.112
Tail Ratio	1.451	0.95
Alpha	0.419	0.0
Beta	0.419	1.0

**04
EVALUATION**

	CO-2	LO-1	SO-1	NO-3	SPY
Annual return	42.67%	32.71%	13.67%	0.51%	8.32%
Max drawdown	-32.74%	-29.56%	-50.67%	-45.75%	-33.00%
Annual volatility	25.57%	22.440%	25.605%	20.76%	15.16%
Sharpe ratio	1.519	1.374	0.626	0.128	0.604
Calmar ratio	1.303	1.107	0.27	0.011	0.252

03.
DISCUSSION & CONCLUSION

COMPARISON WITH COMMERCIAL ENGINE

Criteria	Our engine	Amibroker
Speed	Slow	At least 3000 times faster than our engine.
Functionality	Supports backtesting equity and options	Only supports backtesting equity data Supports optimization, Monte-Carlo simulation
Data source	Only from CBOE	Supports multiple data sources, including Yahoo Finance, eSignal, IQFeed etc.
Interface	Programming interface with methods to access the engine	Graphical User interface
Statistical insight	Provides 10 standard financial metrics.	Provide standard financial metrics and tools for optimization, Monte-Carlo simulation, and walk-forward analysis.
Usability	Scripting with Python	Scripting with Amibroker Formula Language (AFL)

LIMITATIONS / ASSUMPTIONS

01
OVEREXTENDED BULL MARKET

Market has been bullish since 2009.

03
LIMITED TESTING UNIVERSE

We only tested SPY from 2013 to 2020.

05
LACK OF OPTIMIZATION

Strategies are not optimized.

02
SLIPPAGE

Slippage refers to the difference between the expected price of a trade and the price at which the trade is executed. Slippage is not accounted in our engine.
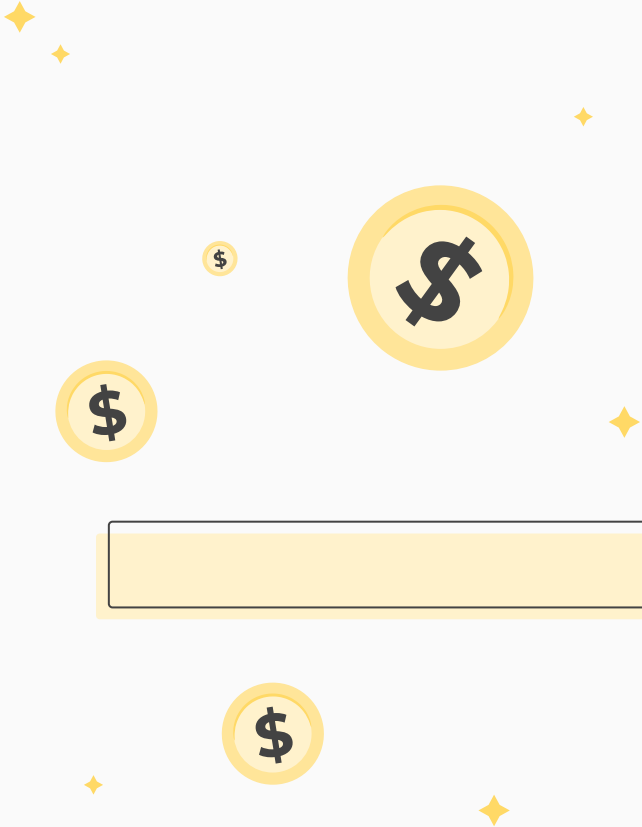
04
LACK OF STRATEGY DIVERSITY

Our long-biased and short-biased strategies are mean-reversion.
No guarantee that this will persist.

06
OVERFITTING

Choosing strategies to construct DH strategy might introduce overfitting risk.

Diversify strategies, Diversify markets

CONCLUSION

Q & A

04
EVALUATION

STRATEGY SO-3: TAIL-RISK STRATEGY

Strategy SO-3 opens a monthly-expired long put options position that is 5% OTM and hold until it expires.
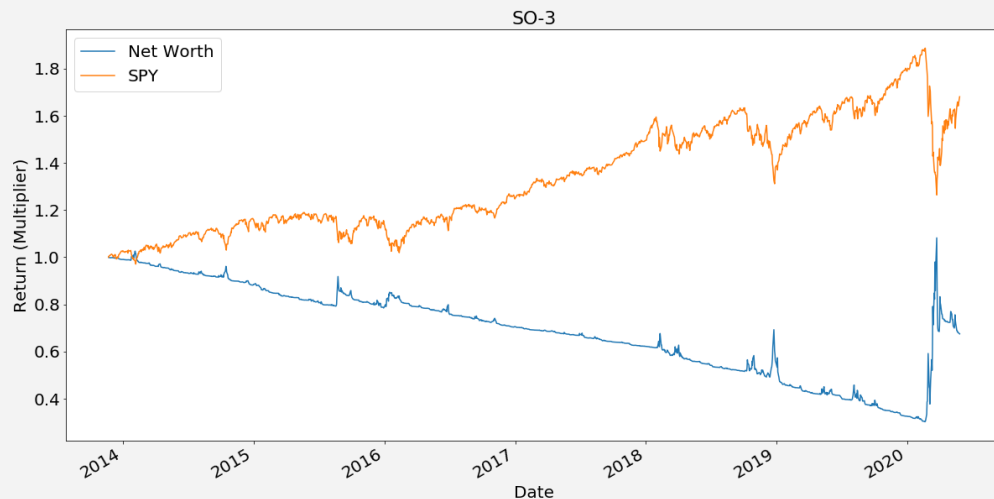
SO-1 Algorithm	Trade logic at time t

if t == the expiration of the current put **then**

    OPEN new put

SO-3

	gtsangtrading_20210103_1830	SPY
Annual Return	−5.88%	8.32%
Max Drawdown	−70.57%	−33.00%
Annual Volatility	36.68%	15.16%
Sharpe Ratio	0.011	0.604
Calmar Ratio	−0.083	0.252
Omega Ratio	1.005	1.123
Downside Risk	0.209	0.112
Tail Ratio	0.846	0.95
Alpha	0.121	0.0
Beta	−1.208	1.0

O4
EVALUATION

Strategy NO-2b open short straddle positions by selling ATM call, and ATM put option every month. To protect against downside losses, we purchase an additional put that is 15% OTM. This strategy only takes a position when the volatility is below 20.

NO-2b

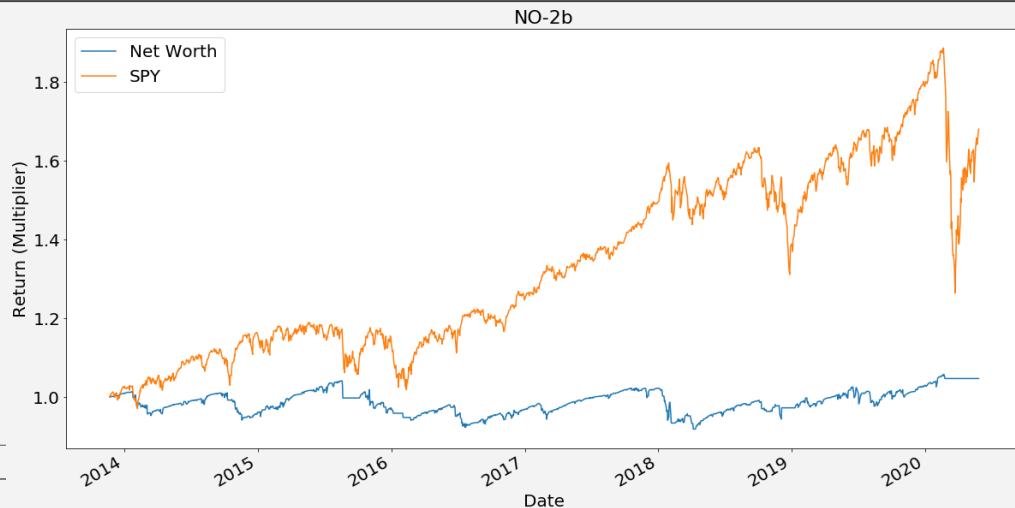| **NO-2b Algorithm**	Trade logic at time t

if $t + 1 ==$ the expiration of the current straddle **and** $\text{VIX}(t) < 20$ **then**

CLOSE old straddle

OPEN new straddle

end if

	gtsangtrading_20210103_2015	SPY
Annual Return	0.71%	8.32%
Max Drawdown	-11.77%	-33.00%
Annual Volatility	6.65%	15.16%
Sharpe Ratio	0.141	0.604
Calmar Ratio	0.061	0.252
Omega Ratio	1.036	1.123
Downside Risk	0.054	0.112
Tail Ratio	0.769	0.95
Alpha	0.007	0.0
Beta	0.028	1.0

04
EVALUATION

Strategy NO-2c open short straddle positions by selling ATM call and ATM put option every month. To protect against downside losses, we purchase an additional put that is 15% OTM. This strategy takes position that is 7 days before expiration.

NO-2 Algorithm	Trade logic at time t

if t + 1 == the expiration of the current straddle **then**
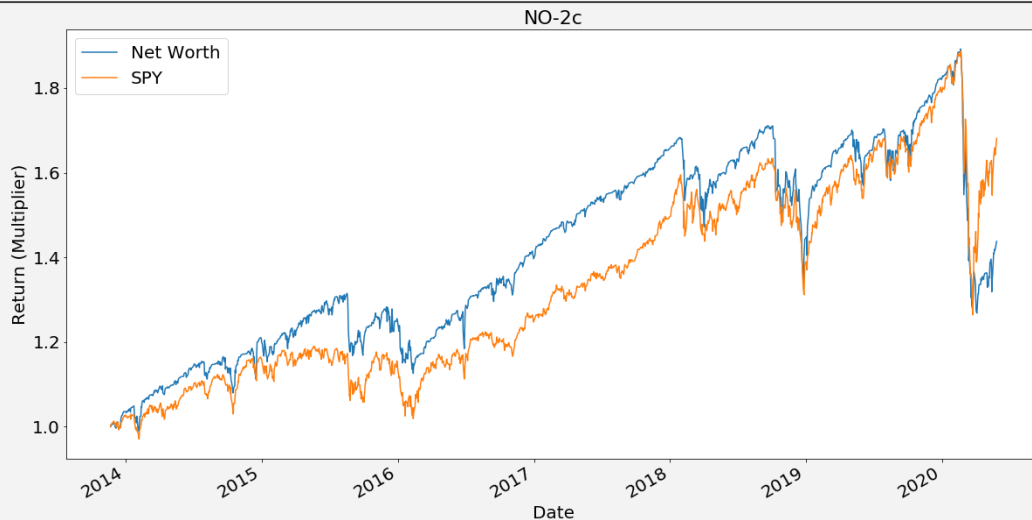
    CLOSE old straddle

    OPEN new straddle

    end if

NO-2c

	gtsangtrading_20210103_1802	SPY
Annual Return	5.75%	8.32%
Max Drawdown	-32.97%	-33.00%
Annual Volatility	14.74%	15.16%
Sharpe Ratio	0.454	0.604
Calmar Ratio	0.174	0.252
Omega Ratio	1.107	1.123
Downside Risk	0.113	0.112
Tail Ratio	0.83	0.95
Alpha	0.018	0.0
Beta	0.531	1.0