2023
Cornell Trading Competition Case Packet

October 14, 2023

Cornell Quant Fund

Proudly sponsored by:

SIG SUSQUEHANNA

HRT DRW Jane Street

OLD MISSION THETA DATA databento

Introduction

Hello and welcome to the 2023 Cornell Trading Competition! We're excited for you to join us at Cornell Tech in New York City. On competition day, you'll have the opportunity to test your case performance live against other competitors and network with Cornell Quant Fund's sponsors and students from across the country!

Our 3 cases this year include Systematic Equities, Options, and Blockchain/Cryptocurrency. **All cases are to be submitted by Wednesday, October 11th and 11:59 PM EST.** Late submissions will not be considered unless you have received prior approval from the event organizers.

We encourage teams to research and assess the qualitative aspects of each case prior to beginning to implement strategies, which is why the official backtester will not be released until Saturday, September 30th. However, if you feel a desire to get an early start, we have specified the format of the output of your functions that we will use in the backtester. Please follow all specifications and submission guidelines within the case, or your submission may not be graded.

Overall prizes will be awarded as follows

1st Overall: $1,600

2nd Overall: $1,200

3rd Overall: $800

Winners of each of the three cases will also be awarded prizes as follows

1st Place: $1,000

2nd Place: $500

3rd Place: $250

+$500 in prizes during the event!!!

While we **HIGHLY SUGGEST** that you submit a strategy to each case in order to be eligible for all prizes, you are not required to do so. Overall prizes will be awarded to the highest overall placement across all three cases. In the event of exact ties, the prize will be split evenly.

Any questions regarding cases should be sent to cornellquantfund@gmail.com

Logistics & Helpful Information

Event Location: Verizon Executive Education Center at Cornell Tech on Roosevelt Island (2 W Loop Rd, New York, NY 10044)

Event Time: October 14th, 2023 from 8:00AM-5:00PM

Breakfast and Lunch will be provided to all competitors!

Parking & Public Transit: We recommend parking in the Motorgate Parking Garage on Roosevelt Island if you are arriving by car. Alternatively, you can take the F-train or the Tram which is accessible on 60th Street in Manhattan.

What to Bring:

- Computer
- Water Bottle
- Competitive Spirit

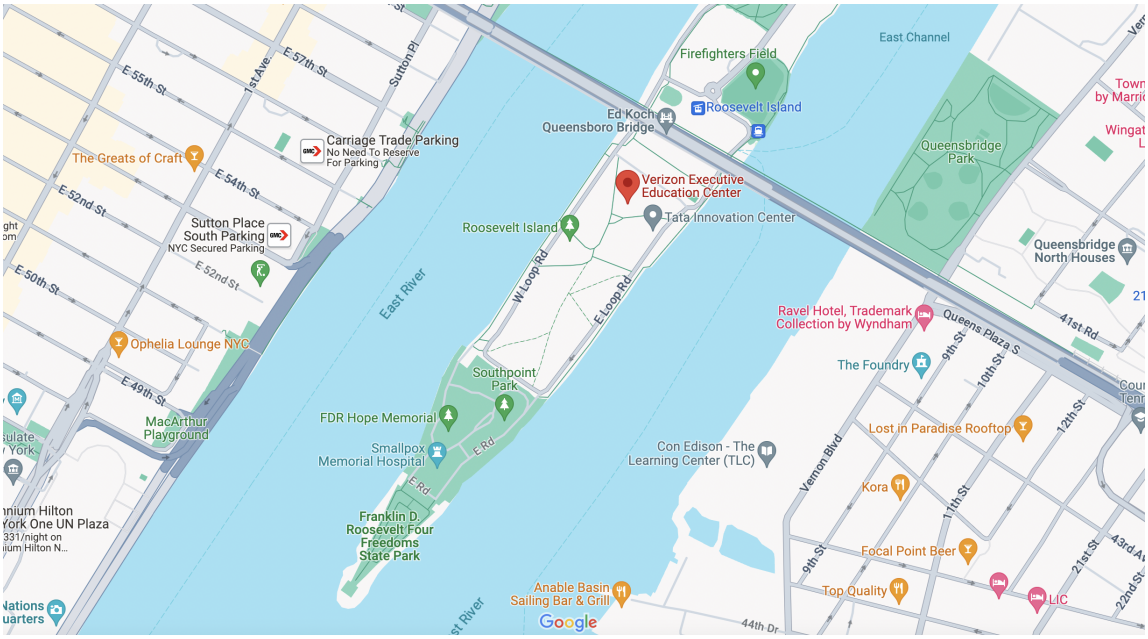
Dress Code is Business Casual

You must attend the in-person event to be eligible for prizes and for travel reimbursements

Information about reimbursement policy can be found here: http://bit.ly/3Zzh6YY

For announcements and FAQ's regarding cases, please see: https://bit.ly/3rtxcGU

Event schedule will be released as the competition date approaches.



Case I

Systematic Equities

1 Introduction

In this case study you will be tasked with creating a Global Equity Market Neutral Fund. What are market-neutral strategies? Market-neutral strategies are strategies that are designed to be independent of market direction. These market-neutral portfolios have both long (investor buys the stock with the hope the price will increase) and a short position (where the investor hopes the price of the stock will decrease).

Equity Market Neutral (EMN) funds should be uncorrelated to traditional equity returns. EMN strategies are known to reduce portfolios overall risk and improve risk-adjusted returns. There are many different ways to create long/short portfolio diversification's. One popular example of being market neutral is in sector long/short this. This where you focus on company specifics rather than market trends. Many portfolios also employ country-industry pair long/short for additional alpha.

If you are curious to read more about market-neutral portfolio offerings here are two:

1. BlackRock Global Equity Market Neutral Fund
2. AQR Equity Market Neutral Fund

2 Case

In this case you will be responsible for creating a global market neutral portfolio (i.e market neutral across all countries). The countries you will be investing in will be emerging markets and developed markets. For each of the five countries in both emerging markets and developed markets, you will be given five equities in every country and will be asked to create portfolio weights that sum to 0 (i.e market neutral position). The emerging market countries we have chosen are: BRA, MEX, IND, CHN, ZAF. The developed market countries we have chosen are: USA, JPN, DEU, GBR, FRA.

Many asset managers and portfolios have limitations on intraday trading – therefore, your portfolio cannot re-balance intraday (i.e you can only change your positions once a day). Additionally, you are not allowed to hold any cash (i.e you must) invest all your capital. The last constraint is that you cannot have more than a 25% turn over between days. One of the main reasons for having a limitation on turnover percentage is to avoid high transactions fees.

3 Example

There is a function we have written in python called `get_data(portfolio)`. This function takes a dictionary which is the portfolio:

```
portfolio = {'BRA': ['PBR','VALE','ITUB','NU','BSBR'],
             'MEX': ['AMX','KCDMY','VLRS','ALFAA.MX','BBAJIOO.MX']}
```

and it returns a multi-index data-frame where the first header is the country, the second is the attributes, and the third is the stock ticker. Here are some of the attributes we have included as an example:

```
Index(['Adj Close', 'Close', 'High', 'Low', 'Open', 'Volume'], dtype='object')
```

You are allowed to use any information available on yfinance to that is not locked behind a paid wall for signal generation.

4 Output

You must write a function that takes the dictionary described above returns a dataframe that takes a portfolio of tickers (the same format above), a start-date and an end-date and returns a portfolio of weights (see the example function in the attached notebook). You must return a dataframe that has the following properties:

1. For every day the portfolio weights sum to 0 (i.e long short across countries)
2. The absolute values of the weights sum to 1.
3. You have less than a 25% turn over day to day.

4.1 Turnover

Let's talk about how we will calcualte turn-over. Let's say we have the following:

1. Day 1: Portfolio weights for assets A, B, and C are $[0.4, 0.3, 0.3]$.
2. Day 2: Portfolio weights for assets A, B, and C are $[0.5, 0.3, 0.2]$.

Let's calculate the absolute change of assets A,B, and C.

1. Asset A: $|0.1| = 0.1$
2. Asset B: $|0.0| = 0.0$
3. Asset C: $|(-0.1)| = 0.1$

Sum the absolute changes for all assets. This will give you the total portfolio turnover for that specific day. Total turnover for Day $2 = 0.1 + 0.0 + 0.1 = 0.2$.

5 Sample Code

In the Jupyter Notebook attached we have the following functions that we will be using to check your results and to download data:

1. `get_data(portfolio)`: returns the multi-index header above with example information that may help you.
2. `simple_strat(portfolio)`: an example strategy that shows how to return weights with the formatting and constraints required.

3. `check_long_short(trading_list)`: checks to see if your portfolio has weights that sum to 0. We have a tolerance of $1e-6$.

4. `check_turnover(trading_list)`: checks to make sure you do not have more than a 25% turnover day-over-day.

6 Evaluation

We will be evaluating you on the back-test based on PNL. We will be taking your profits at the end of the closing of every day and adding that to your cumulative PNL. We will take the final PNL and use this to rank teams and determine winners.

Case II

Derivatives

1 Introduction

In this case, you will algorithmically trade European-style VIX Options and SPX Options according to the movements of the VIX and S&P 500 Indices. Your performance in this case will depend on your ability to generally understand and innovatively utilize the correlations between the various provided assets.

We strongly recommend investing time in understanding the relevant concepts and building a useful model. For the rest of this case description, "options" will refer to European Options.

1.1 Overview of Relevant Concepts

1.1.1 Futures:

Futures are derivative financial contracts that obligate parties to buy or sell an asset at a predetermined future date and price. The buyer must purchase or the seller must sell the underlying asset at the set price, regardless of the current market price at the expiration date. Futures can have various underlyings, from commodities to stock market indices, and are often used by investors for speculating and hedging.

Index-based futures such as VIX futures are priced according to supply and demand of the contracts, which is separate from the VIX value. Hence, the price of VIX futures might be unchanged, or change in the opposite direction, to a change in the VIX Index.

1.1.2 Options:

There are two main types of options: Calls and Puts.

- A Call option gives the holder the right, but not the obligation, to purchase the underlying asset at a predetermined price (the strike price) on a particular date (the expiration date). Purchasing a call therefore represents a bullish bet on the underlying.
- A Put option gives the holder the right, but not the obligation, to sell the underlying asset at a predetermined price on a particular date. Holding a put option is therefore a bearish bet.

In the case of index options such as VIX and SPX options, the underlying asset is either the index (as in the case of the SPX, with the index being the S&P 500), or the corresponding future of the same settlement date (as in the case of VIX options).

The price of options depends on several factors.

1. "Moneyness," or the strike price relative to the current share price

2. Time to expiration
3. Volatility
4. Interest rates

The impact of these factors is summarized by the options greeks:

1. **Delta** (Δ) represents the sensitivity of the option's price to changes in the price of the underlying security.
2. **Theta** (θ) represents the time value decay of an option.
3. **Gamma** (Γ) represents the rate of change of delta relative to the change in price of the underlying security.
4. **Vega** (v) represents the option's sensitivity to implied volatility.
5. **Rho** (ρ) represents the sensitivity of the option's price to interest rates.

1.1.3 VIX and S&P Indices

The VIX Index, known by some as the fear index, has been an important index that a multitude of market participants used in their trading and analysis from equity and derivative traders to even FX and Rates traders. The VIX is representative of "level of expected volatility of the S&P 500 Index over the next 30 days that is implied in the bid/ask quotations of SPX options." (CBOE) Subsequently, the VIX is quite important in determining expected volatility in the market and hence, is used frequently in pricing options and developing trading strategies.

The inverse relationship between the S&P index and the VIX Index has been well documented. Hence, information about the VIX and S&P 500 can be useful to develop trading strategies using both VIX and SPX options. This case requires you to come up with your best strategy for utilizing these links between these assets to maximize your portfolio value.

Links to relevant asset documentation:

- SPX Options
- VIX Options

2 Case

Competitors will be given an initial capital of $1,000,000, and will be asked to trade using the following options:

VIX options: VIX Options, despite being priced on the basis of VIX futures instead of directly upon the index, are cash-settled upon the opening value of the VIX index at the expiration day, which is the 3rd Wednesday of a given month. Each VIX options contract has a multiplier of 100. Hence, for example, an owned VIX call option for a strike price of $20, considering an opening VIX level of 25 on the option's

expiration date, can be exercised for a cash settlement of ($25 − $20) ∗ $100 = $500. Conversely, selling this VIX call option will result in a cash settlement of −$500.

SPX options: Their underlying is the S&P 500 index, and they are also cash-settled using the opening value of the S&P 500 index on the expiration day. Their contract multiplier is also a 100. This case only uses SPX options that expire on the 3rd Friday of a given month.

3 Data

Permitted training data can be accessed here: https://bit.ly/3RxMXax

You are provided with 3 months of VIX options and SPX options TBBO data in the following format:

	ts_recv	instrument_id	bid_px_00	ask_px_00	bid_sz_00	ask_sz_00
0	2023-04-03 13:30:00.212364900	771794296	2390000000	2470000000	526	791
1	2023-04-03 13:30:00.212370044	771794296	2390000000	2470000000	526	791
2	2023-04-03 13:30:00.212370044	771794296	2390000000	2470000000	526	791
3	2023-04-03 13:30:00.656107463	771794651	9223372036854775807	9223372036854775807	0	0
4	2023-04-03 13:30:00.656113330	771794651	9223372036854775807	9223372036854775807	0	0
...	...	...	...	...	...	...

The significance of the columns are as following:

- **ts_recv:** The datetime format timestamp
- **instrument_id:** An identifier for a specific VIX or SPX option. You have also been given 2 instrument id csv files in the case data packet. These two files present a list of all the instrument ids of each type of option, and the specific option they correspond to. This OCC option raw symbol can be read as following:
    1. Root symbol of the underlying stock or ETF, padded with spaces to 6 characters
    2. Expiration date, 6 digits in the format *yymmdd*
    3. Option type, either P or C, for put or call
    4. Strike price, as the price x 1000, front padded with 0s to 8 digits

Hence, SPX 141122P00019500 represents a put on SPX, expiring on 11/22/2014, with a strike price of $19.50.

- **bid_px_00:** The bid price at top level. Price is expressed as a signed integer where every 1 unit corresponds to $1e-9, i.e. $1/1,000,000,000 or $0.000000001
- **ask_px_00:** The ask price at top level.
- **bid_sz_00:** The bid size at top level.
- **ask_sz_00:** The ask size at top level.

You are also given roughly 4 months of VIX and S&P 500 index data (starting from a month before the options data).

4 Rules

Your trading strategy must adhere to the following rules:

- Your orders for buying and selling an option must not exceed the respective ask_sz and bid_sz for that option.
- You can buy or sell an option only until the end of the day prior to the expiration date.
- While you are allowed to trade options with expiration dates beyond the time domain you're running your strategy in, you should not have any open options positions at the end of the time domain that your strategy is tested on. Any open long option positions will be liquidated at 90% their last known bid prices, while an open short position will be liquidated at 110% its last known ask price.
- A trade for an option will be considered to be valid only if there is option data for the datetime at which the trade is being ordered. Remember that as the provided data is in the TBBO format: data for an option is not given at equal time intervals, but rather, at the times a trade was made on that option in that market.

Any trade that tries to violate any of the above rules will be canceled.

You must maintain a minimum margin amount in your portfolio account. This margin amount, which is initialized at 0, will increase when you sell put and call options contracts as following:

1. **Put options:** The premiums of the sold contracts and an additional 10% of the strike price of the option (multiplied by the contract multiplier). Hence, selling a VIX put option with a strike price of 20 for $2 will add an amount of $\$(2 + 0.1 * 20) * 100 = \$400$ to the margin amount
2. **Call options:** The premiums of the sold contracts and an additional 10% of the opening price of the VIX or S&P 500 index (multiplied by the contract multiplier). Hence, selling a VIX call option for $2 on a day when the VIX opened at 15 will add an amount of $\$(2 + 0.1 * 15) * 100 = \$350$ to the margin amount

This minimum margin amount should always be maintained; any trade that tries to violate this minimum margin amount will be canceled.

In addition, please note that any option positions that are in the money on the expiration date will be automatically exercised using the opening price of the indices on the expiration date, with the cash settlement being credited to or debited from your portfolio depending on whether it was a long or short position respectively. When your short positions are settled on the expiration date, the corresponding margin amounts will be freed and available for use in future trades.

Moreover, in case the losses from a short position cross your minimum margin amount, your remaining long and short positions will be randomly liquidated until you meet the minimum margin amount. In case this amount is not met after having liquidated all your other options positions, you will be not allowed to conduct more trades.

5 Output

In testing, your code will be fed a start date, end date, and the 4 csv files for the two classes of options and indices. Your primary strategy function should take these input parameters and output a dataframe in the following format (Note that the trades in this table are fictional):

	Datetime	Option Symbol	Action	Order size
0	2023-09-06 09:10:37.517018	VIX 230906C00018000	B	4
1	2023-09-23 09:10:37.517037	SPX 230923C03765000	S	8
2	2023-09-26 09:10:37.517041	VIX 230926C00018000	B	10
3	2023-09-03 09:10:37.517043	SPX 230519C03765000	B	5
4	2023-09-18 09:10:37.517046	VIX 230918C00018000	B	1
5	2023-09-19 09:10:37.517048	SPX 230519C03765000	B	3

Note the following important points about this data format:

- In the Action column, 'B' and 'S" correspond to buying and selling an option respectively.
- The timestamp must be in datetime format.
- The option symbol must be a string in standard OCC format.

Submissions that do not output a dataframe in this format will not be considered.

6 Evaluation

Competitors will need to submit their python file that outputs the above-mentioned dataframe, and a brief write-up explaining the rationale and working of their trading strategy. Your strategies will be run on a different time interval and submissions will be ranked based on the value of their portfolio at the end of each round.

Case III

Crypto/Blockchain

1 Introduction

This challenge invites participants to develop methodology for simplified high-frequency trading on Bitcoin futures contracts. In order to do this, participants should forecast short term (or long term) momentum. We have amassed a dataset of millions of rows of (semi)high-frequency market data for which you can use to build your model. As there is extremely high trading activity on the bitcoin market, most signals will be temporary and the danger of overfitting is present. Be mindful of these considerations.

2 Case

The complexity of high-frequency trading will be simplified for this case. Rather than maintaining a portfolio of variable size, participants will be limited to three actions per timestep: buy, sell, or neutral. Additionally, at each timestep the position will be exercised (sold and "rebought", or bought back and "resold"), such that price changes are immediately captured.

Predicted Upward Movement (Buy):

- If currently short, cover the short position (returning to neutral).
- Immediately after returning to neutral (or if they were already neutral), go long.
- By the next timestep, regardless of the next prediction, sell the asset to return to neutral before making a new decision.

Predicted Downward Movement (Sell):

- If currently long, sell the position (returning to neutral).
- Immediately after returning to neutral (or if they were already neutral), go short.
- By the next timestep, regardless of the next prediction, cover the short position to return to neutral before making a new decision.

Predicted No Movement (Neutral):

- If currently long, sell to return to neutral.
- If currently short, cover the short position to return to neutral.
- Stay neutral for the next timestep.

Essentially, with this setup, every position gets reset to neutral at the start of each timestep, forcing a "fresh" decision every time. As a result, portfolio size is limited to +1,0,-1. Additionally, the bid-ask spread should also not be a concern: after calculating profits and losses, each participant will be compensated to exactly negate the effects of the bid-ask spread. For instance, if a model incurs a total spread cost of $X over the contest period, $X will be added back to its final profit/loss tally.

This should simulate a very simplified high-frequency trading strategy, without concern of liquidity, transaction costs, latency, spread cost, and other common complicating factors.

As an example, if participants' algorithm/model predicts a short-term increase in price for the next timestep, then they should signal "buy." Here's why:

- Starting from a neutral position at the beginning of the timestep.
- On receiving the "buy" signal, traders would buy/go long on the asset, betting on the price to rise.
- If the prediction is accurate, by the next timestep, they would sell the asset at a higher price than what they bought it for, capturing a profit.
- Regardless of the profit or loss, by the start of the next timestep, the position will be reset to neutral as per the rules.

This would work for long-term increases as well, as downward/upward movement in between the start and end points will cancel out.

The end product of participants' trading algorithm should take provided market data (in .csv form) as input, and output a dataframe with a date column and a position column containing a single value at each time step: 1 (indicating "buy"), 0 (indicating neutral), or -1 (indicating sell):

	DATETIME	POSITION
0	2020-10-14 20:00:00.190657	1
1	2020-10-14 20:00:00.562329	-1
2	2020-10-14 20:00:00.562341	-1
3	2020-10-14 20:00:00.562451	-1
4	2020-10-14 20:00:00.562470	-1
...	...	...
333142	2020-10-15 19:59:59.835140	-1
333143	2020-10-15 19:59:59.835260	0
333144	2020-10-15 19:59:59.835866	1
333145	2020-10-15 19:59:59.835983	0
333146	2020-10-15 19:59:59.907525	0

Participants will start with a neutral position, and the final position will be exercised, if non-neutral. Trading will not be subject to any fees.

3 Data

Permitted training data can be accessed here: https://bit.ly/3PHsr4S

The csv provided covers 2 years of bitcoin futures market data. A description of the columns follows:

ts_event: The server-received timestamp expressed as the number of nanoseconds since the UNIX epoch.

bid_px_00: The bid price at top level. Price is expressed as a signed integer where every 1 unit corresponds to 1e-9, i.e. 1/1,000,000,000 or 0.000000001.

ask_px_00: The ask price at top level. Same unit convention as bid_px_00.

bid_sz_00: The bid size at top level.

ask_sz_00: The ask size at top level.

4 Competition Phase

Participants' algorithms will be run on a backtester using new, unseen Bitcoin trading data. This backtesting period will simulate a period of trading with the algorithm.

5 Deliverables

At the end of the competition, participants will be required to submit:

1. Their Python trading algorithm.
2. A report detailing their trading strategy and the logic of their algorithm.

6 Evaluation

Strategies will be evaluated by the total magnitude change of the portfolio based on trades taken.

For example, in a simple world, consider the case where the futures tick up by $1 each tick for 5 consecutive ticks. If you decide to buy on the first two ticks, sell on the third, and are neutral on the 4th and 5th tick, then your total score will be +$1 (+$2 from the first two ticks, but since you went short the 3rd, you lose $1).