2024 UCHICAGO TRADING COMPETITION

Case Packet & Information

THE UNIVERSITY OF CHICAGO
Career Advancement
Financial Markets

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WELCOME

On behalf of the University of Chicago and the UChicago Financial Markets Program (FM), we are pleased to welcome you to the 12th Annual **UChicago Trading Competition**! Thank you to our FM student case writers & platform developers, and our corporate sponsors for their leadership and support.

This trading competition could not be possible without the generous support of our corporate sponsors. This year's sponsors include: DRW, Belvedere Trading, Chicago Trading Company, Citadel, Flow Traders, Hudson River Trading, IMC, Jane Street, Optiver, Old Mission Capital, SIG, Tower Research Capital, Bridgewater Associates, TransMarket Group, and Two Sigma.

We are delighted to have DRW as a platinum sponsor this year! DRW will host our opening poker event on Friday evening.

The UChicago Trading Competition will be held in-person on Saturday, April 13th at Convene Fulton Market in downtown Chicago. The focus of this event will be algorithmic trading, with two cases covering the following themes:

1. Market Making
2. Portfolio Optimization Asset Return Prediction.

We look forward to seeing the teams in action!

For more information about UChicago Career Advancement, visit our website.

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SCHEDULE OF EVENTS

Friday, April 12, 2024 (all times in CDT)

Location	Time	Topic
W Chicago - City Center *(172 West Adams St, Chicago, IL 60603)*	5:00 - 8:00 pm	Poker Tournament with Platinum Sponsor DRW

Saturday, April 13, 2024 (all times in CDT)

Location	Time	Topic
Convene - Fulton Market *(333 N Green St, Chicago, IL 60607)*	8:00 – 8:45 am	Breakfast / Set up
	8:45 – 9:15 am	Welcome and Agenda Overview
	9:15 – 11:15 am	Case 1: Market Making
	11:15 – 11:30 am	Intermission
	11:30 - 12:00 pm	Overview of Case 1 Q&A with Student Committee
	12:15 - 1:45 pm	Lunch & Employer Career Fair
	1:45 - 2:45 pm	Overview of Case 2 Q&A with Student Committee
	2:45 – 3:30 pm	Awards Presentation
	3:30 - 4:30 pm	Networking Reception with Employers

All sessions are required for participants to be eligible for prize money

PARTICIPANTS

We are pleased to announce that over 150 students across the United States will participate in this year's competition. The following institutions will be represented:

- Amherst College
- Brown University
- California Institute of Technology
- Carnegie Mellon University
- Duke University
- Harvard University
- Johns Hopkins University
- Massachusetts Institute of Technology
- New York University
- Northwestern University
- Princeton University
- Stanford University
- University at Buffalo
- University of California, Berkeley
- University of California, Los Angeles
- University of Chicago
- University of Colorado, Boulder
- University of Massachusetts, Amherst
- University of Michigan
- University of Notre Dame
- University of Pennsylvania
- University of Wisconsin-Madison
- Yale University

AWARDS

Awards will be announced during the awards ceremony. Cash prizes will be awarded to the winning team of each individual case and the top three overall winners based on aggregate scores across all cases. Participants must attend all sessions on Friday and Saturday to be eligible for prize money.

COMPETITION TECHNOLOGY

The University of Chicago Financial Markets Program (FM) is excited to showcase its in-house trading platform X-Change built by senior members of the FM program for the 12th Annual UChicago Trading Competition! Case 1 will be run live utilizing this platform. Case 2 will be run before the competition and results will be played back at the event.

In the next few weeks, you will receive emails detailing instructions on accessing live virtual sessions which will be used to address competitor questions and provide important case and platform updates.

Algorithm Development

Competitors may develop their algorithms in any computing language; however, Python will be the only officially supported language. No other languages will receive explicit support from the case writing team. On the day of the competition, one user from each team will be responsible for manually starting the team's algo at the beginning of each case round.

Additional details on rules and requirements for each round can be found in the case descriptions.

We will use the Ed platform to share updates with participants; all participants will receive an invitation from the platform to join our discussion thread.

Submission Deadlines

Case 1

- Preliminary code submission can be submitted by 12:00pm CDT on Friday, April 5th.
- Competitors will run their bots from a box provided to them on the day of the competition.

Case 2

- Final algorithms **must** be submitted by 12:00pm CDT on Wednesday, April 10th.
- This case will be run in advance of the competition. Teams will not run their algorithms live on the day of the competition. Final scores will be announced on the day of the competition.

CASE 1: Market Making

Introduction

In this case, **you have been tasked to trade five stocks, two ETFs, and a risk free asset**. Your goal is to make as much money as you can, trading against other competitors and the (naive) bots that already exist on the exchange.

Education

ETFs are investment funds that are traded on stock exchanges, similar to individual stocks. They hold a diversified portfolio of assets, such as stocks, bonds, or commodities, and are designed to track the performance of a specific index or sector. In the real world, ETFs offer investors a way to gain exposure to a broad range of assets without having to buy each one individually, and they are known for their low cost.

In the context of ETFs, creation and redemption processes involve entering and unwinding swap agreements to manage the ETF's exposure to the underlying index. Here's a succinct description:

An ETF can be thought of as an agreement between parties on the exchange; one can swap (for a small fee!) between 10 shares of JCR and 3 EPT, 3 IGM, 4 BRV. The forward direction is known as a redemption, and the backward as creation.

- **Creation**: You give 3 EPT, 3 IGM, 4 BRV to the ETF provider. You get 10 shares of the ETF from the provider.
- **Redemption**: You return 10 shares of JCR to the ETF provider. You then receive 3 EPT, 3 IGM, and 4 BDR from the provider.

Note: As a privileged trader, you do not need to hold the exact basket to create or redeem. For example if you create while having no positions, you will then have -3 EPT, -3 IGM, -4 BRV (short positions) and 10 JCR.

Symbology

Risk-Free Asset: JMS
Equities: EPT, DLO, MKU, IGM, BRV
ETF 1 (10 JCR): 3 EPT, 3 IGM, 4 BRV
ETF 2 (10 JAK): 2 EPT, 5 DLO, 3 MKU

Strategic Adaption

In the exchange, you will be competing with a number of other market makers and hitters. Hitters consist of informed participants, typically hedge funds, which possess insights or data that give them an edge in predicting market movements. Uninformed participants are those who trade without access to specialized information.

Potential Strategies

Provide Liquidity: Offer continuous buy (bid) and sell (ask) quotes on the exchange to trade with participants looking to take a position. Your bid quote should be less than your ask quote (why is this?). Hint: think about the difference between your bid and your ask (known as the spread) as payment for taking on risk.

Manage Risk: Monitor and manage your exposure to market movements and potential losses. Note: strategies that produce consistent profits will score higher than those with a similar expected return and higher variance.

Strategic Adaptation: Navigate a market that includes participants that are both more and less informed that you. Consider which participants you want to trade against. Consider how trades you see on the exchange (especially from what looks like smart money) should change your fair value for assets.

Market Impact: Understand how your trades may affect market prices, in terms of pushing prices up or down. Hint: think about how your market impact varies depending on the overall market liquidity.

Case Specifications

Each year will consist of 252 trading days, with 21 trading days per month.

Participants will be provided with the exchange which will be up and running from March 30th, 2024 through the start of the competition. We do not guarantee that the behavior of the market makers and hitters will be the same on the test exchange and during competition day. Nevertheless, we encourage you to use the platform provided to test your strategies.

More information about the exchange will be provided on Ed.

Round Specification & Scoring

The competition will consist of 2 hours of rounds, each 5 minutes long, with **increasing difficulty and increasingly weighted scoring**. Competitors are randomly assigned to an exchange each round through a round robin process to trade against a variety of other market participants.

There will be a settlement price for all assets at the end of each round. Each team's P&L will be calculated using these final prices and added to their cumulative total. Positions do not carry over between rounds.

Difficulty will progress over the rounds, typically through opposing market making **increasing their spreads, decreasing volume, and the distribution of informed hitters increasing relative to uniformed hitters**. Moreover, strategies that generate positive P&L at the start of the competition are expected to continue to generate positive P&L across rounds, but decrease over time. As a result, we want to encourage competitors to adapt as the competition progresses and edges become smaller, as later rounds become weighted more heavily.

We have a **nonlinear grading schema that converts P&L into points**. Strategies that generate consistent positive P&L are expected to do much better than strategies that are high risk/high reward in nature. Similarly, outlier results of both large positive and negative P&L will likely not excessively impact a team's total score. As such, a handful of terrible rounds will not erase a team's chance of overall success, nor will a handful of great rounds assure it.

Note that the practice round will not count towards total points.

Rules

You may take long or short positions in all assets available in a round, subject to risk limits specified below. Exceeding these risk limits will result in the rejection of your entire order.

Risk Limits

As a market maker, your firm stipulates the following risk assets across the tradable assets:

- Max Order Size
- Max Open Order (Size of unfilled order)
- Outstanding Volume (Total volume of unfilled order)
- Max Absolute Position (Sum of long and short positions)

If you exceed any of these positions, all further orders for that contract that exacerbate the risk limits will be blocked by the exchange. Similarly, if any order is rejected by limit, participants are not informed of which limit they breached. **We will release the specific risk limits in a pinned Ed post in advance of the competition. Risk limits are subject to change on the day of the competition.**

Case Materials & Data

Python stub code and settlement price data will be released with the case packet through the UChicago Trading Competition Ed. The basic bot will outline some key functions and exchange syntax for you.

Code Submission

We are requiring a preliminary code submission by **noon (12:00 PM CST) on Friday, April 5th.**

Competitors will however run their bots from a box provided to you on the actual day of the competition.

Questions

For questions regarding Case 1, please post in the UChicago Trading Competition Ed in the "case1" folder. We will regularly check for new messages.

Miscellaneous Tips

In order to be successful in this case (and as a market maker in general), you will need:

1. A model that predicts the "fair value" of the asset you are trading.

- If you know the settlement prices, what is your fair value? If you know a distribution for settlement prices, what is your fair price?
- You have data for previous settlement prices. How does this inform where your fair price is?
- Some of the assets may have some correlations. How may a change in the fair price of one asset affect the fair price of another asset?

2. A market making algorithm that uses the predicted "fair value" to make profitable trades:

- There will be some "smart" and "dumb" money bots on the exchange. Which bots should you want to trade against? Which bots should inform your future expectations of price/settlement price?
- Is it always reasonable to quote symmetrically (in size and/or price) about your predicted fair price?
- What modifications (if any) should you make in the way you trade if the fair price predicted by your model deviates from the mid-price of the market? What if only one side of your quotes gets filled?
- When would it be justified to "cross the spread" to take a position?
- Do you want to hold your positions to settlement? Does this expose you to additional risk?
- Do you want to pay to get out of risk?

3. ETF market making is a delicate task:

- How can you identify arbitrage opportunities in ETF pricing in terms of redemption and creation?
  - Make sure to factor in redemption/creation costs!
- Should you always take both sides of the arbitrage opportunity?
  - Hint: When the ETF and equity prices don't align, it's more likely that the ETF is mispriced.
  - If you're willing to take on more variance, it may be the case that the arb exists because the ETF is mispriced and the equity is fair, so if you do trade the arb, the trade on equity may have been bad.
- When and why would one decide to swap short?

CASE 2: Portfolio Optimization Asset Return Prediction

Introduction

In this case, you are a portfolio analyst tasked with allocating a fund over a ten-year time horizon across six stocks your research team has selected. To aid you, your company has provided you with ten years of historical price data for each stock. Your goal is to develop an algorithm to construct and rebalance a portfolio aimed at maximizing returns while simultaneously minimizing returns variance. The trading begins the day after the last day of data provided.

Education

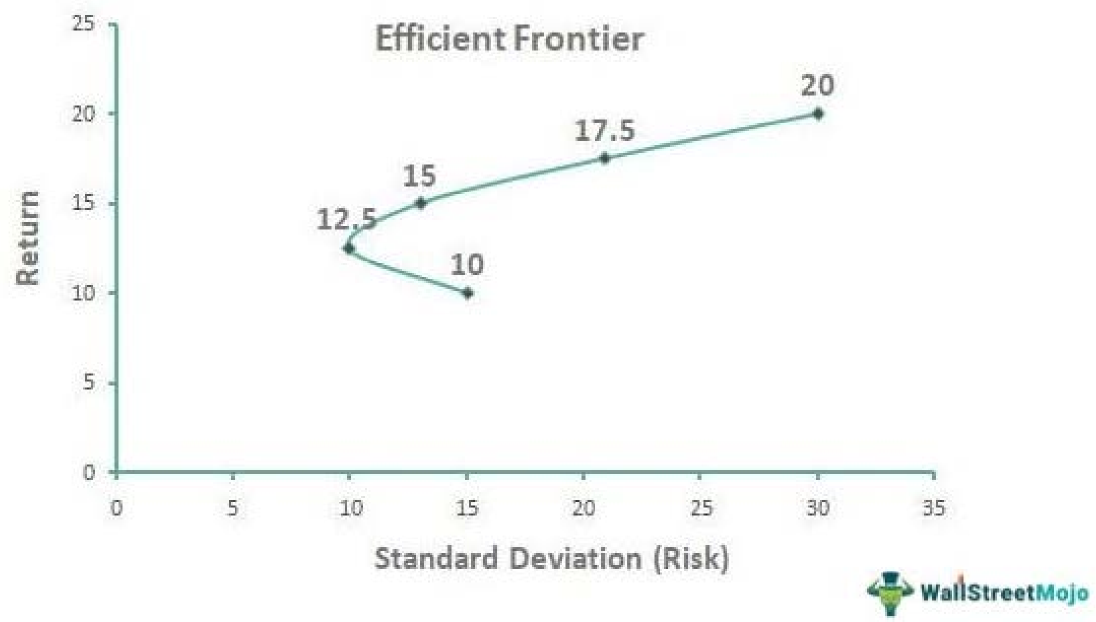
Equal Weight Portfolio

The naive portfolio allocation is giving each stock in your portfolio a weighting of 1/n, assuming n distinct assets. This method assumes that your portfolio's assets aren't correlated with one another, and has many downsides. However, it's relatively straightforward to implement.

We strongly recommend implementing this strategy in your initial explorations of the question. Use this method as a benchmark for future testing; if your new strategies are being outperformed by an allocation of 1/n, we recommend further iterations.

Markowitz

In 1952, Harry Markowitz of the University of Chicago published "Portfolio Selection," which formalized this basic intuition and formed the basis of modern portfolio theory (MPT). Markowitz conceived of an efficient frontier of portfolios that maximize return given a certain level of risk (or alternatively minimize risk given a certain desired return). Along this efficient frontier, the actual portfolio chosen is based on the individual investor's level of risk aversion (high risk aversion = low level of risk, and vice versa). In the absence of exact knowledge on risk aversion, portfolio managers can choose an efficient frontier portfolio based on the specific objectives given to them by their clients or firms.



Obviously, in order to implement a Markowitz portfolio, investors need some estimate of expected return and an estimate of risk. Additionally, we need some way to estimate the correlations, or covariances, between the returns of the different assets. Intuitively, a portfolio where all asset returns are highly correlated should have more risk than one with the same weights and risks for each individual asset but where all the asset returns are uncorrelated due to the fact that in the former case, one asset losing a large portion of its value means the entire portfolio likely will while this is not true in the latter case. Indeed, we see that the variance of returns in a portfolio (a measure of risk) is given by:

$$\begin{bmatrix} w_1 & \cdots & w_n \end{bmatrix} \begin{bmatrix} \mathrm{Var}(r_1) & \mathrm{Cov}(r_1, r_2) & \cdots & \mathrm{Cov}(r_1, r_n) \\ \mathrm{Cov}(r_2, r_1) & \mathrm{Var}(r_2) & \cdots & \mathrm{Cov}(r_2, r_n) \\ \vdots & \vdots & \ddots & \vdots \\ \mathrm{Cov}(r_n, r_1) & \mathrm{Cov}(r_n, r_2) & \cdots & \mathrm{Var}(r_n) \end{bmatrix} \begin{bmatrix} w_1 \\ \vdots \\ w_n \end{bmatrix}$$

where w_i refers to the weight of the ith asset in the portfolio, r_i refers to the return of that asset, and n refers to the number of assets in the portfolio. While we can reasonably estimate variances and covariances of asset returns based on historical data, empirically, historical returns have not been a strong predictor of future expected return and large covariance matrix estimates tend to be numerically unstable, leading to practical difficulties in implementing a Markowitz portfolio. Since the development of MPT, investors and researchers have looked for new ways of dealing with this problem.

Risk Parity Allocation (RPA)

One approach to portfolio allocation is to simply ignore expected returns when determining how to allocate assets in a portfolio. The most naive way of doing this would be to simply find the portfolio with the lowest predicted risk, but this would simply be to invest in a risk free asset, and the return offered by such a portfolio would not entice many investors. What we want instead is a way to have a portfolio full of risky assets where more weight is given to those with lower risk. This can be done by ensuring that every asset's risk contribution to the portfolio is equal, meaning that less risky assets have more weight than riskier ones in order to equalize the risk contribution. Here, risk contribution is calculated as:

$$\frac{w_i (\sum \mathbf{w})_i}{\sqrt{\mathbf{w}^T \sum \mathbf{w}}}$$

where w is the column vector of weights, and ∑ is the variance-covariance matrix from the previous equation (not a summation of w). In this calculation, assets that are uncorrelated with the rest of the portfolio contribute less to risk than correlated assets with the same risk level, which is intuitive since a drop in the value of an uncorrelated asset does not contribute as much to overall losses for the portfolio as would a correlated asset. As it has been shown that asset volatilities and correlations are relatively stable over time, historical risk contribution can be used as a reliable estimate for risk contribution.

Case Specification & Rules

The exchange trading platform will **not** be used for this case. Teams are expected to develop their strategies using our Python stub code and submit their code before the competition.

We will run each competitor's portfolio allocation algorithm on a test dataset with data generated by the same process as the data you are given; **this test dataset will immediately follow the period in the training dataset.**

There will be one round, the results of which will be computed prior to the competition and played back during the competition as if unfolding in real time. As such, you must submit your final code to the case writers beforehand.

In each timestep, asset prices will be provided and teams will submit portfolio allocations among the available assets for that period. **Your algorithm should submit a new vector of weights every day.** These allocations will be in the form of weights on each stock: weights can be positive, negative, or zero in each timestep, but **your weights must be in the range [-1, 1]. Note the absolute magnitudes of your weights don't matter if the relative magnitudes are the same since we are grading on Sharpe. We only place limits for simplicity of grading. For more details ask on Ed**. We assume there are no exchange fees or bid-ask spreads in the market and no liquidity concerns to deal with in allocating your portfolio.

You may use any packages (and any programming language) to study the training data we will provide, but the submitted portfolio allocation code must be in Python and will be restricted in dependencies. The environment used to run submitted competitor code will be Python 3.10 and will only have the NumPy, pandas, scikit-learn, and SciPy packages installed (alongside base Python). Although advanced and/or complex machine learning techniques are interesting to study and are valuable to learn, they are not the focus of this case and are not required for the purposes of solving this case.

We strongly advise that you test your submission using a similar environment on your local machine before submitting your final code; submitted code that does not compile or that fails to run for any time step will be disqualified for this case and the team that submitted it will receive 0 points. Before final submission, there will be an opportunity to test if your code compiles and runs properly (note that the Sharpes yielded from this test will not be indicative of what your actual Sharpe ratio will be).

Scoring

Teams will be ranked based on their annual daily **Sharpe ratio** over the 10-year test period on the daily return percent series of the portfolio. Normally, we calculate the Sharpe ratio based on the excess return series rather than just the return series, but for our purposes we will assume that the risk free rate means relatively constant and can be ignored. The team with the highest Sharpe ratio will receive 40 points, the next highest will receive 39 points, etc.

Case Materials & Data

Python stub code and training data will be released along with the case packet and additional supplementary resources through the UChicago Trading Competition Ed.

We are requiring the final code for this case to be submitted by **11:59 PM CST on Wednesday, April 10th.**

- Note that this is different from Case 1, as we will be computing the results of this round prior to the competition.
- Code submitted past this deadline will not be accepted, and we reserve the right to disqualify any competitors who submit incomplete code or miss this deadline.

Again, we strongly advise that you test your submission in a Python 3.10 environment with only NumPy, pandas, scikit-learn, and SciPy installed before submitting your final code.

Miscellaneous Tips

1. Analyze returns, not prices. Prices of stocks tend to be non-stationary processes, but returns are generally stationary. Analyzing returns series will be more fruitful for your strategies than analyzing price series.

2. Don't test strategies on the same data you train them on. Strategies will likely perform well on data your model has already seen - what's relevant is how well the strategy performs on data the model has not yet seen. You should not necessarily expect that your strategy will perform as well out-of-sample as it will in-sample; holding out a portion of your training data to test on (or running any other procedure to test on new data) is strongly advisable to get a more accurate sense of how successful your strategy will be.

Questions

For questions regarding Case 2, please post in the UChicago Trading Competition Ed in the "Case 2" folder.

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