

CFRM 523 Syllabus

Advanced Trading Systems

Benjamin Hansen

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1 Course Description

This course will provide a detailed research process and tools for replicating, assessing, conceptualizing, and developing systematic trading strategies. Students will apply their knowledge in hands-on projects to replicate and evaluate existing research and to create and evaluate a new strategy model.

Development of systematic trading strategies should follow a highly scientific and repeatable process. This course will start by reviewing categories of systematic strategies, drawing out patterns followed throughout the industry.

We will demonstrate a repeatable process for evaluating ideas, constructing hypotheses, building each of the strategy components, and evaluating and improving the strategy at each step. Students will use the Python to replicate academic research and evaluate the claims made in papers. Students will also construct a non-trivial strategy from scratch, evaluate the power of each of its components, and examine the likelihood of overfitting. The strategy will be documented and presented in lieu of a final exam.

The first half of the quarter will focus on the structure of quantitative strategies, and on the different types of strategies used in production by trading firms and asset managers. The second half of the quarter will focus on more advanced techniques for model evaluation, feature engineering, and using modern methods such as machine learning, as well as practical application of these skills to strategy building.

Throughout the class, we will be doing project work to apply the learned skills. Projects are designed to mimic as closely as possible the day-to-day research activities of working strategy quants, so that students will have practical experience building, testing, and evaluating quantitative models.

2 Learning objectives

Upon successful completion of this course students will be able to:

- Articulate the major classes of trading strategies and explain what market behavior different classes of strategies seek to exploit.
- Evaluate and Replicate research results presented in academic papers on trading system development or analytical techniques applicable to trading strategies.
- Create, evaluate, backtest, and optimize their own non-trivial quantitative trading strategy in Python (or other appropriate language, with consultation)

3 Instructor

Benjamin Hansen

Benjamin Hansen is the lead quantitative researcher at Rotella Capital Management, one of the early fully systematic trading firms. He is the portfolio manager of Polaris, the flagship global macro program with a 33-year track record, as well as the firm's machine learning commodities program. At Qdeck, a fintech spinoff of Rotella, his signals in equities, futures, and cryptocurrencies are being used by RIAs, allocators, and hedge funds. The tools he has built on the platform provide a scientific approach for RIAs to understanding risk reward of particular allocations. He received his Ph.D. in Mathematics from the University of Groningen, where he studied infinite random graphs embedded in the hyperbolic plane. His peer-reviewed research also extends to spectral properties of environmental time-series. He has worked with numerous organizations on problems in pricing, forecasting, and classification.

bthansen@uw.edu

4 Course Approach

We will start by answering questions or providing clarification on issues submitted to the instructor in advance which are of general interest or have not been answered already on the course site.

Then we will have a lecture followed by another question session focused on the lecture and readings for that class period.

Questions can be submitted in advance or asked in class. The greater the time between the questions submitted and the start of class is positively correlated with the detail of the response.

We will then move to an interactive session focused on further clarification and the individual project work. Students will be encouraged to discuss what they are working on in their project, and collaborate with peers. Because each student's strategy or paper will be different, an open mode of communication between students about their projects is encouraged. Questions about student projects will be addressed in a manner designed to benefit all students in the class in their projects by targeting common patterns for problems and solutions raised by the question.

Depending on availability, we may have guest lectures by experts in the field.

5 Prerequisites

As CFRM 522 has not been offered for several quarters, this requirement is waved. However, the caliber of projects is expected to be of the "Advanced" level. A working knowledge of Python and trading related packages such as backtrader and ta-lib will be required. Course work will also reference packages such as statsmodels and sklearn among others, but prior knowledge of these packages should not be necessary. Analytical techniques will be briefly covered in lectures, and covered in full in the suggested readings. Specific analytical techniques and packages will vary widely across student projects. Students should understand that they will likely need to self-study package examples or online references for specific analytical techniques to complete their projects.

6 Projects

The major portion of the grade for the class will come from two projects designed to mimic the activities of working strategy quants. Students will have two individual projects to complete over the quarter. The final deliverable for both projects will include a Collab notebook or jupyter notebook which includes both

written commentary and all the code necessary to produce the analysis. Intermediate deliverables will help guide the student, and make sure that they are progressing towards a completed analysis, in much the same way that an analyst would confer with management and colleagues during the course of an analytical project. Both projects will allow students to choose from a suggested topic list, or propose another appropriate paper or strategy model as the basis for their project. Two students will not be allowed to work on the same paper, though many papers or strategies will be related (they may share citations or techniques, for example) and could provide leverage from coordination. Students will present progress on their projects in class periodically throughout the quarter as appropriate to keep everybody on track. In a working quantitative role you would regularly present your work to your peers for feedback and suggestions.

Midterm Project: Paper Replication The first project will replicate an academic paper. Analysis of new trading system hypotheses often starts when an analyst or their management reads something interesting, providing the seed of a new idea. The analyst needs to first replicate the paper, since most papers do not publish data and code. After replicating the paper, the results need to be analyzed to determine whether the model or results are credible, and how the analysis of the paper can be improved. No two students will share the same paper. This will allow students to openly assist each other on project approach, code problems, etc. in a manner that is more realistic to a real environment, where colleagues would be contacted for ideas and assistance.

Final Project: Strategy Development The second project will apply the process learned in class to create a new strategy from scratch. It will start from identifying constraints and objectives, proceed through hypothesis generation and test plans, and move to creating and evaluating each component of the strategy. Finally, the strategy will be tested for data snooping, look ahead biases, and overfitting.

7 Schedule

Planned Schedule of lectures, readings, and deadlines:

Date	Week	Topic	Readings	Project Work
3/25	1	Course Introduction Introduction to Replication Projects Replicating Published Research	classes of strategies replication essay	start reviewing project ideas
ASAP				choose project paper
3/27	1	Formulating and Testing Hypotheses Classifying Strategies	strategy dev. essay, Narang Chap 3, Ilmanen 1-1.3 (intro)	precis of research paper, literature review
4/1	2	Strategy Styles - Momentum and Trend Strategy Styles - Mean Reversion and Statistical Arbitrage	Ilmanen Chap 14	project draft with detailed hypothesis tests
4/3	2	Strategy Styles - Liquidity Provision (Market Making) Strategy Styles - Proprietary Trading Strategy Styles - Factors	Hasbrouck Chap 1-3 Ilmanen Chap 5 (optional 8-12)	project draft, working main idea replication
4/8	3	Structure of Quantitative Strategies Constraints, Benchmarks, and Objectives	Narang Chap 1-2 strategy development essay and FAQ	incl. results of hypothesis tests

Date	Week	Topic	Readings	Project Work
4/10	4	Indicators Signals	strat essay, Tomasini Chap 2-3	incl. extensions and more tests
4/15	4	Rules		
4/17		Project Due		final replication submission due
4/22	5	Introduction to Strategy Projects	strategy development essay and FAQ,	start reviewing project ideas
4/24	5	Parameter Optimization Walk Forward Analysis	^essay, Tomasini Chap 4 ^essay, Pardo Chap 5,6,11, Tomasini Chap 5-6	Project precis and Literature Review Due
4/29	6	Analyzing Strategies via Monte Carlo Detecting and Compensating for Overfitting		Submit initial working code and write up
5/1	6	Introduction to Machine Learning in Trading		Submit writeup including refined code
5/6	7	Machine Learning II - Feature Engineering	Kuhn and Johnson, Hastie et. al., Peixeiro	Code should include results of testing
5/8	7	Machine Learning III - Common Model Patterns		Code should include walk forward
5/13	8	Evaluating Whole Strategy Performance		Code should include overfitting tests
5/15	9	Managing Capital and Positions		Refine project
5/20	9	Common Mistakes		Refine project
5/22	9	TBA		
5/29	10	Final class of CFRM 523, student presentations		Finalize project
5/31		Project Due		Final strategy submission due

For spring quarter 2024, the dates of instruction are March 25, 2024 to May 31, 2024. Grades are due by 5pm on June 11, 2024.

The readings above should be reviewed by students in approximately this order. Students may find reason to ‘jump ahead’ to a later readings in order to better cover a topic for their projects. Questions on the lectures may be submitted at any time via email or Canvas. Questions submitted more than 24 hours in advance of a scheduled class period are more likely to merit formal/structured responses, rather than ad-hoc or informal responses during class. The interactive class periods (Lectures) are from 4:00pm to 5:20pm, Seattle time, on Mondays and Wednesdays.

All class periods will be recorded and made available on the course website. We will have no class on Monday, May 27th, in observance of Memorial Day.

8 Required Texts

The required texts should all be available electronically from the university library or online at the URL’s included here (or on Canvas). You should not need to purchase textbooks for this course, unless you like having paper copies.

Ilmanen, Antti. 2011. *Expected Returns: An Investor's Guide to Harvesting Market Rewards*. John Wiley & Sons.

Narang, Rishi K. 2013. *Inside the Black Box: A Simple Guide to Quantitative and High Frequency Trading*. John Wiley & Sons.

Pardo, Robert. 2008. *The Evaluation and Optimization of Trading Strategies, Second Edition*. John Wiley & Sons.

Peterson, Brian G. 2017. *Developing & Backtesting Systematic Trading Strategies*.
https://www.researchgate.net/publication/319298448_Developing_Backtesting_Systematic_Trading_Strategies

Peterson, Brian G. 2016. *Research Replication*.
https://www.researchgate.net/publication/319298241_Research_Replication

Peterson, Brian G. 2023. *Classes of Strategies*.
https://braverock.com/brian/strategy_type_bibliography.html

Tomasini, Emilio, and Urban Jaekle. 2009. *Trading Systems*. Harriman House.

Hasbrouck, Joel. 2004. *Empirical market microstructure*
<https://www.acsu.buffalo.edu/~keechung/MGF743/Readings/Hasbrouck's%20book.pdf>

Kuhn, Max, and Kjell Johnson. 2020. *Feature Engineering and Selection: A Practical Approach for Predictive Models*. CRC Press.
<http://www.feat.engineering/>

Peixeiro, Marco. 2022. *Time Series Forecasting in Python*. Simon and Schuster.

Supplementary Reading

Supplemental texts will be referred to in the lectures, and referenced by other readings, but no readings will be required from these texts. Whether a student should own these texts will in part be influenced by your career goals, or the types of analysis you choose to do for your projects.

Please see the file *Supplemental Reading* on Canvas for the most current list of supplemental readings, as Ben will add sources periodically.

For several lectures, there may be long-form lecture notes and code for the examples presented in the lectures available on the course site. If there is nothing posted, or if you want deeper information on a specific lecture, please don't hesitate to ask. Student projects will require extensive additional reading. Required project reading will be determined by the paper or strategy chosen, and demonstrating understanding of your project-specific supplementary readings will be a key part of your grade.

To be perfectly clear, you won't have time to read all the material during the quarter. The readings for this class are core texts if you want to be a working strategy quant, and contain a wealth of knowledge about the various models and techniques you need to be successful in this field. You will need to read material relevant to your projects first, and reference other materials to help you develop your thought processes and code for your projects, as you would in replication and strategy projects in a professional setting. Students who show more familiarity with the readings, and add more references to their projects, generally do better in the class, as they are taking initiative to learn and apply knowledge to their replication and strategy projects.

9 Office Hours

Ben office hour is currently scheduled for Tuesdays from 5-6PM PST. (this is subject to change based on class preference). Chats via all common platforms (Hangouts, Zoom, Teams, etc.) will also be supported.

Times outside the listed Office Hours times will be considered on a case by case basis. Office hours should be utilized for private matters not suitable for interactive class/lecture periods or unsuitable for email.

Students are encouraged to network with and collaborate with their classmates, and the instructor will be available for appointments as well.

Ben will answer emails and text chats as expeditiously as possible, typically within 2-4 hours during the day, and early in the morning if the inquiry comes in overnight. Please don't get hung up on a project step for fear of asking a question. You wouldn't do it in a job, so don't hold back here.

If all of the above isn't sufficient for you to get feedback, please let me know, and we'll work something out.

10 Grading

A major portion of the grade in the class will be driven by measuring engagement. Participation in class, on the class forum, and interacting with other students will also be assessed, as these skills are a requirement for a working quant. In particular, students will need to document 6 examples of assisting other classmates (for example: Substantial constructive feedback on other's work, creating Python functions used by others, creating unit tests that verify shared function correctness.) Grading will also include the project deliverables, which will be graded based on rubrics which will be shared with each project. The final grade will be determined as follows:

Assessment	% of final grade
Paper Project	40%
Strategy Project	40%
Participation	20%
Total	100%

Policy on late assignment/project submission

No late midterm/final project submissions will be accepted. Extenuating circumstances (documented medical issue or death in the family) will be handled on an individual basis. Assignments are targeted to help you make progress on your projects. Failure to keep up with the assignments will likely result in lower project grades, as it will be difficult to cover all the project steps if you do not do all the interim steps. The projects reflect significant, non-trivial, outlays of research, reading, coding, and writing time, and can not reasonably be completed in a marathon before the due date. Assignments are not graded other than 'submitted'. Ben will comment on assignments either where it seems that it will help student progress, or where students have asked specific questions.

11 Learning technology

Canvas learning management system

The Canvas learning management system is the central means of interaction and participation during the course.

- news and announcements
- general discussion forum with other students and instructor
- links to recorded lectures
- lecture slides
- assignment posting

Students should feel free to openly collaborate on project techniques in the general discussion forum for instructor and peer responses and discussion. Zoom office hours will be conducted via Zoom Web Conferencing.

12 Policy on University Sanctioned Accommodations

We are committed to an inclusive and equitable academic environment. This commitment extends to University sanctioned accommodations for medical, disability, or religious reasons.

Washington state law requires that UW develop a policy for accommodation of student absences or significant hardship due to reasons of faith or conscience, or for organized religious activities. The UW's policy, including more information about how to request an accommodation, is available at Religious Accommodations Policy. Accommodations must be requested within the first two weeks of this course using the Religious Accommodations Request form.