Master of Science in Quantitative Finance

COURSE CODE: **QF632**
COURSE TITLE: **Financial Data Science**

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COURSE AREA
Quantitative Finance

GRADING BASIS
Graded

COURSE UNIT
1 CU

FIRST OFFERING TERM
Academic Year: 2025
Academic Term: April

COURSE DESCRIPTION
This course empowers students to harness the transformative potential of data science in finance, offering a dynamic introduction to tools that decode market trends, enhance investment decisions, and craft intelligent trading strategies. Tailored for those eager to merge analytical rigor with financial innovation, the curriculum focuses on translating data into strategic insights through accessible, real-world applications. Students will explore how machine learning techniques—from predictive modeling to adaptive decision-making systems—can uncover hidden opportunities in markets, forecast asset returns, and optimize portfolios for better risk-reward outcomes.

Students will apply Python to build models mirroring real financial scenarios through collaborative projects and case studies. The course demystifies complex algorithms, teaching students to articulate why certain methods excel in specific contexts, such as identifying trading signals or balancing portfolio risk. This approach ensures learners not only master how tools work but also why they matter in fields like asset management or trading. By bridging data science and finance, the course prepares students for careers where AI and automation are reshaping the industry.

(Note: While Python is used in homework and projects, the final exam assesses understanding of concepts and will not test coding ability.)

LEARNING OBJECTIVES

This course equips students to bridge machine learning innovation with financial decision-making, preparing them to address real-world challenges in investments and trading. By the end of the course, students will be able to analyze the role of ML/AI in solving critical finance problems, from optimizing portfolios to managing risk, and articulate how these tools create value in fast-paced markets. They will gain the ability to implement, test, and refine models using industry-relevant datasets, ensuring their solutions are both technically sound and aligned with business goals.

Students will master core applications of ML/AI in finance, including designing portfolio optimization strategies that adapt to market conditions and leveraging advanced techniques like deep reinforcement learning to automate trading decisions. They will learn to identify limitations of traditional financial models and apply ML-driven approaches to overcome challenges such as forecasting volatility, detecting market anomalies, or balancing risk-return trade-offs. Emphasis is placed on interpreting model outputs clearly, ensuring results can be communicated effectively to stakeholders with varying technical backgrounds.

Finally, the course fosters the ability to critically evaluate model performance in real-world scenarios. Students will practice translating raw data into actionable strategies, troubleshoot common pitfalls in ML-driven financial systems, and justify methodological choices based on ethical, practical, and economic considerations. These skills prepare graduates to contribute meaningfully in roles requiring data-driven investment analysis, algorithmic trading, or fintech innovation, where explaining why a model works is as vital as its technical execution.

ASSESSMENT METHODS

The key assessment components are as follows:

1. **Individual Assessment –** **60% of total**, consisting of
    a. Class Participation 20%
    b. Final Exam 40%

2. **Group Assessment:** **40% of total**, consisting of:
    a. Group homework and final project. 40%

INSTRUCTIONAL METHODS AND EXPECTATIONS

With reference to the above, assessments cover both the individual (60%) and group (40%) levels.

Individual Assessment (60% of total): this assessment is measuring the level of interest, creative thinking, the desire to learn and accumulate knowledge continuously.

Group Assessment (40% of total): The class will be grouped into teams, and the main purpose is to evaluate the capacity to add value through working in groups, and socializing ideas constructively. A high emphasis of the grading process is set on actual project participation and final presentation, expressed in the form of a startup presentation based on an advanced investment or risk management methodology designed by each team.

The grading criteria for the presentation are:

- suitability and quality of content,
- analytical and inference abilities of ML models used
- level of understanding of the practical purpose of the project and presentation,
- teamwork,
- ability to answer questions posed.

There will be a 2-hour closed-book final exam. Students are allowed to bring an A4 double-sized cheat sheet. Basic calculator is allowed.

ACADEMIC INTEGRITY

All acts of academic dishonesty (including, but not limited to, plagiarism, cheating, fabrication, facilitation of acts of academic dishonesty by others, unauthorized possession of exam questions, or tampering with the academic work of other students) are serious offences. All work (whether oral or written) submitted for purposes of assessment must be the student's own work. Penalties for violation of the policy range from zero marks for the component assessment to expulsion, depending on the nature of the offence.

When in doubt, students should consult the course instructor. Details on the SMU Code of Academic Integrity may be accessed at http://www.smuscd.org/resources.html.

ACCESSIBILITY

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SMU strives to make learning experiences accessible for all. If you anticipate or experience physical or academic barriers due to disability, please let me know immediately. You are also welcome to contact the university's disability services team if you have questions or concerns about academic provisions: included@smu.edu.sg. Please be aware that the accessible tables in our seminar room should remain available for students who require them.

EMERGENCY PREPAREDNESS FOR TEACHING AND LEARNING (EPTL)

Where there is an emergency that makes it infeasible to have classes on campus, classes will be conducted online via WebEx or Zoom, with no disruption to the schedule. During this semester some students may have to take part of the course online due to Covid-19 situation. Instructions and arrangements are provided by the programme office. Your attendance will also be noted if you are doing the class online.

CLASS TIMINGS

The course is taught in one 3.0-hour session per week over ten weeks.

RECOMMENDED TEXT AND READINGS

- Quantitative Trading Strategies with Python, Apress, 2023, Liu Peng
- The Statistics and Machine Learning with R Workshop, Packt, 2023, Liu Peng
- Bayesian Optimization: Theory and Practice Using Python, Apress, 2023, Liu Peng
- Quantitative Risk Management with Python, Apress, Liu Peng, upcoming in 2025
- Generalization in Deep Learning, CRC, Liu Peng, upcoming in 2025
- Deep Reinforcement Learning for Portfolio Optimization, CRC, Liu Peng, upcoming in 2025

SMU SINGAPORE MANAGEMENT UNIVERSITY MASTERS

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WEEKLY LESSON PLAN

WEEK	TOPICS
1	**Introduction to Financial Data Science** • Key applications of ML/AI in finance: trading, asset pricing, risk management. • Introduction to Python for finance • Setting up environments and collaborative coding norms. • *Homework:* Explore a financial dataset (e.g., stock prices) and perform basic analysis.
2	**Data Preprocessing and Feature Engineering** • Cleaning noisy data: missing values, outliers, and normalization. • Time-series feature engineering: rolling averages, volatility measures, technical indicators. • Case study: Preparing data for a momentum trading strategy. • *Group Project Kickoff:* brainstorm project ideas and work on project proposal.
3	**Foundational ML Models in Finance I – Linear Regression** • Applying linear regression to financial problems. • Linear regression for return prediction. • *In-class Exercise:* Predicting asset returns using common factors. • *Homework:* Build a factor model and implement a stock-picking strategy.
4	**Foundational ML Models in Finance II – Logistic Regression** • Applying logistic regression to financial problems. • Logistic regression for default risk prediction. • *In-class Exercise:* Building a credit risk model to predict probability of default. • *Homework:* Build a classification model for market regime detection.
5	**Portfolio Optimization with ML** • Understanding modern portfolio theory. • Mean-variance optimization.

	• Using ML for asset return prediction in portfolio optimization. • *Homework:* Assessing the impact of estimation error in common portfolio strategies.
6	**Advanced Techniques I – Tree-Based Models** • Decision trees, random forests, and gradient boosting for finance. • Applications: Predicting asset returns for portfolio optimization.
7	**Advanced Techniques II – Neural Networks** • Fundamentals of deep learning and neural network architectures. • Applications in finance: pattern recognition, feature extraction, and forecasting. • Case study: building a simple neural network model to identify market trends. • *Homework:* Assessing the impact of model complexity in common portfolio strategies.
8	**Deep Reinforcement Learning in Trading Strategies** • Q-learning and policy gradients for portfolio optimization. • Case study: Building a DRL-based trading agent.
9	**Model Evaluation and Explainability** • Techniques for evaluating machine learning models in finance. • Techniques for model explainability (SHAP, LIME). • Case study: Backtest a strategy and present results.
10	**Course Review and Final Team Presentation**