THE UNIVERSITY OF HONG KONG
FACULTY OF BUSINESS AND ECONOMICS

PhD Course Syllabus

Course Code/Title: **[Course Code] IIMT6017**

Research Methodologies in Business Analytics

Course Description: This is the core course that prepares PhD students in Business Analytics for their research career. It offers a broad overview of classical and advanced statistical methods with a focus on intuition, methodology and necessary theory for deeper understanding. It covers four main topics: (i) Time series models, including stylized features of asset returns, ARIMA models, GARCH models and continuous-time financial models; (ii) High-dimensional penalized least squares, where we start from introducing methodologies including Elastic Net, Dantzig selector, SCAD penalty etc, and numerical algorithms including least angle regression, coordinate descent, proximal gradient method, ADMM etc, and then moves to in-depth discussions of some theoretical properties of the penalized least squares; (iii) Factor model and risk management, where we will discuss large covariance learning, graphical models, PCA and projected PCA, multifactor pricing models, portfolio allocation and risk management from a statistical point of view; (iv) Non-parametric regression, where the main focus is on splines, projection estimators, adaptive estimation and minimax lower bound. The majority (about 60%) of the course will focus on methodologies related with business analytics, while along the way, one will pick up probability tools and interesting theory (about 40%) on model selection, statistical inference and decision optimality.

Course Objectives:

1. Give a comprehensive overview of statistical methods for business analytics.
2. Introduce commonly used statistical methodologies and models for research and applications.
3. Provide students with knowledge and experience in conducting analysis for big and high dimensional data.
4. Enable students to implement all relevant methods.

Pre-requisite:

Assessment: See below for details.

Remarks: All PhD courses are non-credit-bearing and will be assessed on a pass/fail basis.

Course Learning Outcomes (CLOs)	Aligned PLOs*				
On completion of this course, students should be able to:	1	2	3	4	5
1. Understand big picture of statistical methods in business analytics.	✓			✓	✓
2. Critically evaluate state-of-the-art researches that align with the course topics.	✓			✓	✓
3. Able to analyse big and high dimensional real-world data.		✓	✓	✓	✓

4. Able to conduct research work in statistics and business analytics.	✓	✓	✓	✓	✓

***Programme Learning Outcomes (PLOs) for Research Postgraduate Programme:**

1. Demonstrate critical understanding, at an advanced level, of up-to-date knowledge and research methodology of a particular field
2. Implement effective academic and personal strategies for carrying out research projects independently and ethically
3. Contribute original knowledge in response to issues in their specialist area
4. Communicate research findings at a diverse range of levels and through a variety of media
5. Evaluate one's own research in relation to important and latest issues in the field

COURSE DETAILS *(subject to change at instructor's discretion)*

Year / Semester: TBA

Time / Venue: TBA

Instructor: Dr. Weichen Wang

I. Teaching and Learning Activities

In-class and Out-of-class Activities *(e.g. lectures, papers reading, writing proposal)*	Expected hour	% of student study effort
1. Interactive lectures	48	40
2. Homework assignments	48	40
3. Reading course materials and papers	24	20
Total	120	100%

II. Assessment

Assessment Components *(e.g. assignments, proposal, presentation, examination)*	Weight	CLOs to be assessed				
		1	2	3	4	5
1. Class participation	10%	✓	✓		✓	✓
2. Homework assignments	40%	✓	✓	✓		✓
3. Final exam	50%	✓	✓	✓		
Total	100%					

Students will be assessed based on the following performance standards:

Course Grade	Performance Standard
Pass	• Participate actively in class discussions • Demonstrate good understanding of the course materials • Complete homework assignments with excellent solutions • Show the ability to carry out innovative and rigorous research
Fail	Students fail to satisfy two or more points listed above.

III. Course Content and Tentative Schedule

Tentative Teaching Schedule

Topic 1: Time series models

- Stylized features of asset returns
- ARIMA for modeling return dynamics
- GARCH for modeling volatility dynamics
- Continuous-time financial models

Topic 2: High-dimensional penalized least squares

- Folded-concave penalties: Ridge, Lasso, SCAD, Elastic Net, Danzig selector etc.
- Numerical algorithms: LARS, coordinate descent, proximal gradient, ADMM etc.
- Theoretical properties: L0 vs L1 penalty, selection consistency, prediction errors

Topic 3: Factor model and risk management

- CAPM and multifactor pricing models from statistical perspective
- Portfolio allocation and risk assessment
- Large covariance estimation and graphical models
- Statistical factor models, PCA, and projected PCA
- Applications on community detection, topic model, matrix completion, ranking etc.

Topic 4: Nonparametric regression

- Projection estimators for functional estimation and their risk performance
- Minimax lower bound, adaptive estimation and minimax optimality

IV. Required/Recommended Readings

- Fan, J., Li R., Zhang, C. and Zou, H. (2020) Statistical Foundations of Data Science. Chapman and Hall/CRC.
- Casella, G., and Berger, R. L. (2021). Statistical Inference. Cengage Learning.
- Fan, J. and Yao, Q. (2015). The Elements of Financial Econometrics. Science Press, Beijing.
- J.Y. Campbell, A.W. Lo and A.C. MacKinlay (1997). The Econometrics of Financial Markets, Princeton University Press.
- Tsay, R.S. (2010). Analysis of Financial Time Series (Third edition), John Wiley & Sons.
- Friedman, J., Hastie, T., and Tibshirani, R. (2001). The Elements of Statistical Learning (Vol. 1, No. 10). New York: Springer series in statistics.
- Bühlmann, P., and Van De Geer, S. (2011). Statistics for High-dimensional Data: Methods, Theory and Applications. Springer Science & Business Media.
- Tsybakov, A. B. (2008). Introduction to Nonparametric Estimation. Springer Science & Business Media.

V. Course Policy

The University Regulations on academic dishonesty will be strictly enforced!

An orderly learning environment is extremely important for this course. Disruptive behaviors are absolutely unacceptable. Academic dishonesty includes cheating, plagiarism, unauthorized collaboration, falsifying academic records, and any act designed to avoid participating honestly in the learning process. Any such dishonesty will result in an F grade.

Attendance of the class is required and essential. All exams are required and there will be no make-up exams. Missed exams will receive a grade of zero.

No late assignment will be accepted. Missed homework will receive a grade of zero. Each student must produce his or her own homework to be handed in and graded, although communications and discussions are allowed.