Master of Science in Analytics

Course Syllabus

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TA/Grader: TBD

Time Series Analysis and Forecasting
MSCA 31006
Section 01 - Monday 6-9 p.m. CST
Section 03 - Friday 6-9 p.m. CST
Spring 2022
Location: In-person

COURSE DESCRIPTION

Time Series Analysis comprises methods for making predictions based on previous records. This course provides students a foundation on applied time series analysis and forecasting. Some of topics to be covered include Autoregressive Integrated Moving Average (ARIMA) models; exponential smoothing models; time series regression models; spectral analysis; ARCH and GARCH, transfer functions and state-space models. The theoretical topics will be illustrated with the analysis of different data sets using R.

PREREQUISITES

MSCA 31007: Statistical Analysis

COURSE MATERIALS

Required: None
Optional:

1. (FPP) Hyndman, R. and Athanasopoulos, G. *Forecasting: Principles and Practice*. 2nd Edition, OTexts. 2018.
2. (MJK) Montgomery, D.C., Jennings, C.L. and Kulahci, M. *Introduction to Time Series Analysis and Forecasting*. 2nd Edition, Wiley, 2015.
3. (TSA) Cryer, Jonathan D. and Kung-Sik Chan. *Time Series Analysis with Applications in R*. 2nd Edition. Springer, 2008.
4. Shumway and Stoffer. *Time Series Analysis and its Applications. With R Examples.* 2nd Edition. 2006
5. Wei William W. S. *Time Series Analysis: Univariate and Multivariate Methods*, 2nd Edition, Pearson, 2005.
6. Hamilton, J. D. *Time Series Analysis*, 1st Edition, Princeton University Press, 1994.

SOFTWARE

R

LEARNING OBJECTIVES

Time series analysis is essential to the modern data scientist/analyst; therefore, a comprehensive knowledge of time series analysis is valuable to many real-life data analytics applications. The objectives of this course are:

- Provide essential theoretical foundations of time series analysis.
- Support the theoretical topics with numerous examples.

EVALUATION

Grades for the course will be based on the following:

Class participation and in Class quizzes:	30%
Assignments:	7 X 6% = 42%
Final Project:	28%
Total:	100%

GRADING SCALE

A =	93%–100%
A- =	90%–92%
B+ =	87%–89%
B =	83%–86%
B- =	80%–82%
C+ =	77%–79%
C =	73%–76%
C- =	70%–72%
F =	0%–69%

WEEKLY QUIZZES

Following each session, students will be given an online quiz to complete within 48 hours via Canvas. Students have a single attempt to complete each quiz, and there is no time limit once they begin the quiz. The best eight out of ten quizzes will be selected for the final grade.

FINAL PROJECT

For the final project, the students will be asked to form multiple groups of 5 students (depending on the class size). Utilizing the knowledge acquired during the course, each group will be asked to locate a time series dataset and apply some of the techniques discussed in the course (or other techniques if the team thinks it is necessary) on the located data set. During session #10, each group will be given 10-15 minutes to orally present their project and answer possible questions. Each group member is asked to explicitly state his or her contribution to the project.

Groups should be formed, and a topic selected by the end of the 4th session of the quarter. The list of group members and topics should be emailed to the instructor for final approval and to verify no replication in the selected projects (*first come, first served*). In addition, a brief project proposal (up to 150 words) that describes the nature of the dataset and problem statement should be sent to the instructor and the TA.

Some helpful guidelines:

- The dataset should be approximately stationary or made easily stationary by appropriate transformations.
- The dataset is not too small (at least 100 observations).
- Try to identify a time series that particularly interests you.
- Please avoid datasets related to forecasting financial data. (e.g., Stock-price data)
- Compare forecasting from at least three model categories (e.g., Regression, ARIMA, Exponential smoothing)

Possible project outline:

1. Introduction: Includes problem statement and objective of your project.

2. Data: Elaborate on the data used in this project with detailed description of all attributes, source of data, missing observations, etc. Describe any steps you followed to prepare the data.
3. Experimental results and Analysis: Execute algorithm (plots, ACF, PACF, Spectral Analysis, hypothesis testing, etc.), discuss results with appropriate details.
4. Model Selection: Select final model based on selection criteria and evaluate forecasting metrics and accuracy.
5. Conclusion and Future work: Summarize your work and draw specific conclusions from the overall final project. Describe next steps to continue working on this project. (i.e., how the model forecasting can be improved)

The students will be graded based on the following criteria:

- Presentation
- Problem Statement and Assumptions
- Derived Solution
- Results
- Future Work

ATTENDANCE

This course will meet weekly in person. Your attendance is required and paramount to your success in this class. You are allowed to miss at most two sessions, provided that you make arrangements with the instructor in advance.

If available, at the discretion of the instructor, remote access to the class meeting or access to a recording of the class meeting may be provided. You should discuss with your instructor regarding joining the session remotely or utilizing the recording of the session prior to missing the meeting, if possible. If available, recordings may also be provided for reference after attendance for all students.

Students who may need long-term accommodation should contact their Dean of Students at mailto:psd-dos@lists.uchicago.edu.

REMOTE ACCESS AND COURSE RECORDINGS

This course is optimized for an in-person experience, but under some circumstances your instructor may choose to provide you access to recordings of the session or the option to join remotely. If an instructor provides you with a recording or a link to join remotely:

- Do not record, share, or disseminate any course sessions, videos, transcripts, audio, or chats.
- Do not share links for the course to those not currently enrolled.
- Any Zoom cloud recordings will be automatically deleted 90 days after the completion of the recording.

LATE WORK

All assignments must be submitted to this course's Canvas site on the due date. If you turn in an assignment late, 50% credit will be deducted from the total score for each day after the deadline. Assignments turned in more than one week late will not receive credit. In the case of unexpected events, you must contact the instructor before the

assignment due date in order to receive a grace period. Students can only receive up to 1 grace periods in the course.

REQUESTING REASONABLE ACCOMODATIONS

The University of Chicago is committed to ensuring equitable access to our academic programs and services. Students with disabilities who have been approved for the use of academic accommodations by Student Disability Services (SDS) and need a reasonable accommodation(s) to participate fully in this course should follow the procedures established by SDS for using accommodations. Timely notifications are required in order to ensure that your accommodations can be implemented.

Please follow accommodation implementation instructions provided by the disability liaison in the division after you have completed the SDS procedures for requesting accommodations.

You may want to begin by reading through the information published on this website https://disabilities.uchicago.edu/. Contact SDS at disabilities@uchicago.edu or 773-702-6000, if you are interested in requesting disability accommodations.

ACADEMIC HONESTY & PLAGIARISM

It is contrary to justice, academic integrity, and to the spirit of intellectual inquiry to submit another's statements or ideas of work as one's own. To do so is plagiarism or cheating, offenses punishable under the University's disciplinary system. Because these offenses undercut the distinctive moral and intellectual character of the University, we take them very seriously.

Proper acknowledgment of another's ideas, whether by direct quotation or paraphrase, is expected. In particular, if any written or electronic source is consulted and material is used from that source, directly or indirectly, the source should be identified by author, title, and page number, or by website and date accessed. Any doubts about what constitutes "use" should be addressed to the instructor.

Academic Honest and Plagiarism:
https://studentmanual.uchicago.edu/academic-policies/academic-honesty-plagiarism/
https://internationalaffairs.uchicago.edu/page/honest-work-and-academic-integrity-plagiarism

Copyright: http://www.lib.uchicago.edu/copyrightinfo/

STUDENT HEALTH PACT

All students on campus are required to adhere to the guidelines in the UChicago Health Pact in order to create a safe environment in the classroom. This entails:

- Wearing a face covering or mask covering your nose and mouth in University facilities when required by the University, unless you are not required to wear a face covering or mask because you have received an accommodation;
- Keeping a face covering with you at all times in the event it is needed regardless of COVID-19 vaccination status;
- Washing your hands with soap and water frequently for at least 20 seconds, or using alcohol-based hand sanitizer when soap and water is not available, throughout the day and before and after in-person interactions with others.

The complete text of the UChicago Health Pact along with additional information about

COVID-19 protocols can be found here.

REPORTING COVID-19 RELATED CONCERNS

If you believe that a required COVID-19 safety policy or practice is not being followed, you should report the incident to your supervisor, academic leader, or via the University of Chicago Accident Incident Reporting (UCAIR).

REPORTING COVID-19 EXPOSURE OR A CONFIRMED CASE

Individuals who are tested positive for COVID-19, have COVID-19 related symptoms but have not tested positive or have tested negative, been exposed to a COVID-19 positive person and are currently asymptomatic, or recently traveled are to follow the University's Protocol for Addressing Confirmed or Suspected COVID-19 Exposures.

According to the protocol, any University community member who has a confirmed case, symptoms, or exposure must promptly self-report via C19HealthReport@uchicago.edu and cooperate with the Contact Tracing Team.

COURSE SCHEDULE

Summer, Autumn, Winter, and Spring quarters are 9 weeks of instruction, with the 10th week for assessment or course rescheduling. Refer to the university's academic calendar at www.uchicago.edu/academics/calendar/ for quarterly start and end dates.

Important Note: Changes may occur to the syllabus at the instructor's discretion. When changes are made, students will be notified via email and in-class announcement.

Session #	***Session Topic***	***Learning Objectives***	***Textbook Reading***	***Assignments Due***
1	Introduction	• Class Introduction and Syllabus overview • Notations and Conventions • Autocorrelation function • Stationarity and non-stationarity • White noise • Random walk	FPP (1 – 2) MJK (1 – 2) TSA (1 – 2)	None
2	Time Series Decomposition	• Univariate and multivariate regression modeling • Time Series Smoothing (Moving Average / Exponential) • Holt Winters Method	FPP (5 – 7) MJK (3 – 4) TSA (3)	Assignment #1
3	ARIMA Models	• Data transformations and differencing • Box-Jenkins ARMA and ARIMA models • Invertibility • Model Specification	FPP (8) MJK (5) TSA (4 – 6)	Assignment #2
4	Model Estimation and Diagnostics	• Parameter Estimation • Model Diagnostics • Seasonal ARIMA Models	FPP (8) MJK (5) TSA	Assignment #3

			(7,8,10)	
5	Forecasting	• Points Forecast • Prediction Intervals • Forecasting evaluation & accuracy	FPP (8) MJK (2) TSA (9)	Assignment #4
6	Cross-Validation Methods and State Space Models	• Cross-Validation Methodologies • Bootstrapping • Bagging, Random Forest and Boosting • Model selection uncertainty • State Space Models • Bayesian Structural Time Series (bsts) models	MJK (2) FPP (7, 8)	Assignment #5
7	Multivariate time series models and long memory models	• Vector Autoregressions (VAR and VARIMA) • ARMAX and Regression with ARMA errors • Long memory ARIMA models and ARFIMA	FPP (9) MJK (7) TSA (12)	Assignment #6
8	Spectral Analysis & Transfer Functions	• Spectral Analysis • Multi Seasonality & TBATS model • Transfer Functions • Intervention Analysis	FPP (9) MJK (6) TSA (11, 13)	Assignment #7
9		• Cointegration • Recurrent Neural Network (RNN) • ARCH/GARCH models • Time Series Analysis with Python		None
10	Final Project	Reserved for final projects		Final project slides are due Monday prior to Session 10