STATS 4A03/6A03 - Time Series

Winter 2020

Course Webpage: Avenue to Learn (A2L) - Stats 4A03/6A03

Course information including announcements, handouts, lecture slides and R code, assignments, solutions, tests and project information, term grades, useful links, etc., will be available on the course webpage. You are expected to check it regularly.

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Office Hours (HH 204): Mon, Thu 13:30-14:20, or by appointment

Teaching Assistant: Nikola Počuča

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Office: Hamilton Hal 214, ext. 23414

Nik will be marking homework, assist with projects, and hold review sessions for tests and the final exam. Time permitting, Nik may be available for extra help outside the scheduled review sessions. The primary time to get help is during the instructor's office hours.

Email Communication. When emailing either the instructor or the TA please include 'STATS 4A03' or 'STATS 6A03' in the subject line.

Class Meetings: Mon 12:30-13:20, Tue 13:30-14:20, Thu 12:30-13:20, in HH 109.

Course Description

Calendar Description

Stationary, auto-regressive and moving-average series, Box-Jenkins methods, trend and seasonal effects, tests for white noise, estimation and forecasting methods, introduction to time series in the frequency domain. This course includes a scientific communication component.
Prerequisites: STATS 3A03, 3D03

Course Objective

Time series analysis is concerned with data consisting of time-ordered sequences of measurements on some phenomenon of interest. These type of data are common in many areas, including business (weekly interest rates, daily closing stock prices), climate (daily high and low temperatures, annual amount of precipitation), agriculture (annual crop and livestock production figures, annual export sales), public consumption (hourly provincial hydro demand, yearly garbage amount produced by

a city), and many others. Unlike most other statistical data, time series data show correlation over time, we call it autocorrelation. In addition, data often show trends such as linear, polynomial, seasonal and sinusoidal patterns.

Using a systematic approach, we will learn how to extract information about the characteristics of phenomena that generates a time series, how to model the stochastic mechanism that gives rise to an observed time series, and how to forecast the future values of a series based on its history.

Upon successful completion of this course, the students will be able to perform the following tasks.

(a) Produce, interpret and explain time plots, including identification of trends, seasonality and variance behaviour for a time series dataset.

(b) Calculate, plot and interpret autocorrelation functions.

(c) Fit time series models such as ARMA (autoregressive moving average) and ARIMA (autoregressive integrated moving average) to data and interpret the results.

(d) Carry out forecasts from time series data and interpret and explain the results.

(e) Handle the numerical calculations and plotting using statistical software such as R.

A **tentative** breakdown of the topics to be covered in class can be found on the course webpage.

Goals for Student Learning

- Through time series model construction and analysis, students should develop the ability to think critically and creatively about stochastic processes, and the ability to use computational technology to generate additional perspectives and insights in understanding these processes.

  Discipline specific goals include:

  - Appreciate the key features that describe a time series and perform relevant analyses and computations on series.
  - Understand some of the important stochastic processes used in time series modelling, and the properties of these models.
  - Appreciate and apply key concepts of parameter estimation and forecasting in a time series context.

- By participating in the group project, students should enhance their research and scientific communication skills, cultivate confidence in their own mathematical knowledge and skills, and develop a desire for continuous and independent learning.

Resources

Textbook

J.D. Cryer and K.-S. Chan, *Time Series Analysis: With Applications in R*. 2nd Edition, Springer Science & Business Media, 2010.

The textbook is freely available in electronic format (ebook) at the McMaster Library:
HTTP://libaccess.mcmaster.ca/login?url=http://dx.doi.org/10.1007/978-0-387-75959-3

The course will cover most of the material in the following chapters of the text:

1. Introductory Examples (Ch. 1)
2. The Main Concepts (Ch. 2)
3. Trends in Time Series (Ch. 3)
4. Models for Stationary Time Series (Ch. 4)
5. Models for Nonstationary Time Series (Ch. 5)
6. Parameter Estimation for Time Series (Ch. 7)
7. Forecasting (Ch. 9)

Software

The computing work will be done in R, a free statistical software downloadable for Mac, Windows, and Linux from The R Project for Statistical Computing webpage at https://www.r-project.org.

You are strongly advised to download and install the software at your earliest convenience.

Course Assessment and Evaluation

Assignments (20%)

There will be **four homework assignments**, which are mandatory and count towards 20% of your course grade. The assignment questions will be posted on Avenue one week before their due date. The due dates are **tentatively** scheduled as follows:

Assignment 1 - due Thursday, January 16, 2020

Assignment 2 - due Thursday, January 30, 2020

Assignment 3 - due Thursday, February 27, 2020

Assignment 4 - due Thursday, March 26, 2020

The exact due dates will be announced in class and posted on the course webpage. **Completed assignments are to be submitted to Crowdmark before 11:59 PM on the day they are due.** Submit a single pdf document containing your text and code. A sample homework assignment in acceptable format will be available on the course webpage under "Sample Homework".

MSAF can be used for **only one** homework assignment during the term, and in that case the weight of the missed assignment will be redistributed to the other homework assignments.

While **collaborative work** on assignments is allowed, **each student has to write up the solutions for the assigned problems on their own and in their own words.** Copying with minor changes (e.g. with symbols changed, or with slightly different wording) from solutions prepared by another person, publication, or website, in whatever format, will be dealt with as an act of plagiarism.

Group Projects (15%)

You will be invited to form groups of two or three students. Each group will select a dataset from a list that will appear on the course website, or request approval for an alternative dataset. You will study this dataset and present your findings, as a group, in a **written report** and through a **poster presentation**. The due dates for the project deliverables are **tentatively** set for April 2–7, 2020. Detailed information about project expectations will be provided during the lectures. Using a real-world dataset, you will

(1) select class of time series models that is appropriate to the observed data and propose a model based on statistics computed from data as well as on any additional knowledge of the subject matter in which data arises;
(2) fit the model to data by finding the best possible estimates of the model's parameters from the observed series;
(3) assess critically the quality of the proposed model by testing how well the assumptions reflect the given data;
(4) for unsuccessful models, redefine the model, steps (1)–(3), based on the inadequacies found;
(5) use a successfully developed model to forecast future values and interpret the results.

You will have to use R to carry out the model building and analysis, and you will have to clearly document and discuss the steps (1)–(5) outlined above. You will receive a mark proportional to your individual contribution to the project, and failing to participate in a project will result in the grade zero. Projects that are not submitted/presented on their due date will also be graded as zero, unless proper documentation is supplied.

Tests and Exams (65%)

There will be **two midterm tests**, during class time, and **one cumulative final exam** during the April exam session. The midterms are **tentatively** scheduled as follows:

Midterm 1 - Thursday, February 6, 2020, between 12:30-13:20 in HH 109 and TSH B106

Midterm 2 - Thursday, March 12, 2020, between 12:30-13:20 in HH 109 and TSH B106

The exact time and location of the midterm tests and the final exams will be announced in class and posted on the course webpage. Only the McMaster Standard Calculators, **Casio fx-991 MS** or **Casio fx-991 MS Plus** are allowed during midterm tests and the final exam.

Evaluation and Grading

The formula of the course grade is the higher of the two following grading schemes:

Grading Scheme A	
Assignments ($4 \times 5\%$)	20%
Project	15%
Midterm tests ($2 \times 15\%$)	30%
Final Exam	35%
Total	**100%**

Grading Scheme B	
Assignments ($4 \times 5\%$)	20%
Project	15%
Midterm test (best of two)	15%
Final Exam	50%
Total	**100%**

I reserve the right to change the weight of any portion of this marking scheme. If other formulas are to be considered, your final grade will not be less than the result of the scheme given above.

Please note! Once the final exam is written, the final grade cannot be adjusted to take into account any special situation.

MSAF

In the event of an absence for medical or other reasons, students should review and follow the Academic Regulation in the Undergraduate Calendar

"Requests for Relief for Missed Academic Term Work".

In most cases, missed work or tests will be addressed by reweighing the remaining work or tests. If you must miss a lecture, it is your responsibility to find out what was covered. The best way to do this is to borrow a classmate's notes, read them over, and then ask your tutor or instructor if there is something that you do not understand.

Academic Integrity

You are expected to exhibit honesty and use ethical behaviour in all aspects of the learning process. Academic credentials you earn are rooted in principles of honesty and academic integrity.

Academic dishonesty is to knowingly act or fail to act in a way that results or could result in unearned academic credit or advantage. This behaviour can result in serious consequences, e.g. the grade of zero on an assignment, loss of credit with a notation on the transcript (notation reads: "Grade of F assigned for academic dishonesty"), and/or suspension or expulsion from the university.

It is your responsibility to understand what constitutes academic dishonesty. For information on the various types of academic dishonesty refer to the *Academic Integrity Policy*, located at `http://www.mcmaster.ca/academicintegrity/`
The following illustrates only three forms of academic dishonesty:

1. Plagiarism, e.g. the submission of work that is not ones own or for which other credit has been obtained.

2. Improper collaboration in group work.

3. Copying or using unauthorized aids in tests and examinations.

On-line Elements

In this course we will be using e-mail, Avenue to Learn (A2L), and the Crowdmark platform. Students should be aware that, when they access the electronic components of this course, private information such as first and last names, user names for the McMaster e-mail accounts, and program affiliation may become apparent to all other students in the same course. The available information is dependent on the technology used. Continuation in this course will be deemed consent to this disclosure. If you have any questions or concerns about such disclosure please discuss this with the course instructor.

Academic Accommodation of Students with Disabilities

Students who require academic accommodation must contact *Student Accessibility Services (SAS)* to make arrangements with a Program Coordinator. Academic accommodations must be arranged for each term of study. *Student Accessibility Services* can be contacted by phone 905-525-9140, ext. 28652 or e-mail `sas@mcmaster.ca`. For further information, consult McMaster University's policy for *Academic Accommodation of Students with Disabilities*.

Academic Accommodation for Religious, Indigenous and Spiritual Observances (RISO)

Students requiring academic accommodation based on religious, indigenous or spiritual observances should follow the procedures set out in the *RISO policy*. Students requiring a RISO accommodation should submit their request to their Faculty Office normally within 10 working days of the beginning of term in which they anticipate a need for accommodation or to the Registrar's Office prior to their examinations. Students should also contact their instructors as soon as possible to make alternative arrangements for classes, assignments, and tests.

Disclaimer: Extreme Circumstances

The instructor and university reserve the right to modify elements of the course during the term. The university may change the dates and deadlines for any or all courses in extreme circumstances (e.g., severe weather, labour disruptions, etc). If either type of modification becomes necessary, reasonable notice and communication with the students will be given with explanation and the opportunity to comment on changes. It is the responsibility of the student to check their McMaster email and course websites such as McMaster Daily News and/or A2L during the term and to note any changes.

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