ECON 853: Time Series Econometrics
Department of Economics, Queen's University
Winter 2018

1 Contact Information

Course web page: `http://www.econ.queensu.ca/faculty/morin/econ853w2018/`

Instructor: Lealand Morin
Office Hours: TBD
Office Number: Dunning Hall 216A
Email Address: `morinl at econ.queensu.ca`

Teaching Assistant: Raphaelle Gauvin-Coulombe
Office Hours: Wednesdays, 11:30-1:00
Office Number: Mackintosh-Corry Hall A425
Email Address: `gauvinr at econ.queensu.ca`

2 Class Times and Locations

Times: Fridays, 10:00 - 11:15, 11:30 - 1:00.

Typically, lectures will alternate between a theoretical and a practical focus. The location will depend on the content of lectures (check the course web page):

- Hand-Purvis Conference Room, Dunning Hall, Room 213 (for theoretical discussion).
- Dunning Hall Computing Lab, DUN 350 (for practical applications).

3 Description

This is a course in applied time series analysis and predictive modeling. The objective is to learn the tools of time series econometrics and apply them in practice. The topics of the course include univariate and multivariate stationary time series models (ARMA and VAR models), forecasting, spectral analysis, univariate and multivariate non-stationary time series models (trending data, unit roots, cointegration) and conditional heteroskedasticity (ARCH and GARCH). If time permits, the course might cover topics such as the Kalman filter, regime switching and ARFIMA models. Throughout the course, parallels will be drawn between classical theory and methods of predictive analytics used in industry.

To reflect the developments of modern analytics, we will consider techniques of model validation to ensure a convincing presentation. While it is enough of a challenge to make

an empirical discovery, it is another matter to demonstrate convincingly that the result will hold up in the future. In addition, the preparation of data will be given particular emphasis, since all of the subsequent analysis depends on the data on which it is built. To this end, developments in industry will be referenced throughout the course that focus on techniques of model risk management.

Since a major component of the course involves empirical analysis, it requires experience with modern tools of computing. The main programming language for the course is R, which is a popular open-source language for statistical computing. However, students with strong backgrounds in other languages might still prefer to do some work in their language of choice.

This is supplemented by tools for software version control, such as GitHub, and the basics of cloud computing, which is a valuable skill set to develop. From the first day of class, the course materials will be available through a GitHub repository. Assignments will be uploaded to this medium and can be annotated remotely, with feedback from the instructor, and with appropriate controls for students' privacy, of course. Students will leave this course with a working knowledge of modern tools of statistical software development that will facilitate excellence in future empirical work, regardless of their career ambitions.

4 Evaluation

The main requirement for this course is a final project, which is divided into two parts. You are to work in teams of two to find data, perform empirical analysis and produce a formally written report. More detailed guidelines will be given as the course progresses but no two projects will be the same. You are encouraged to follow your interests and decide on a course of action well suited to your project. The choice of topic is flexible and creativity will be rewarded. Be advised that you should form teams and choose a topic early. Ideally, you will have a good idea of what you will do while working on the first assignment.

Assignment: Exercises in model fitting (25%).
In this assignment, you practice fitting models to samples of data, both generated from random numbers and from the real world. The emphasis will be on techniques of model fitting while illustrating common difficulties when analyzing real data.

Project 1: Preliminary analysis of *your* data (35%).
In this project, you take a first look at your data, beginning with summary statistics and graphical analysis. You will perform an analysis of autocorrelation, stationarity and ARMA model fitting. The goal is to get familiar with your data and be in a position to make informed decisions about your final project. Emphasis is on communicating your results with formal academic writing. The format of the project should include headings such as Introduction, Model, Data, Results, and Concluding Remarks to look like an academic paper or a report for an employer.

Project 2: Final paper (40%).
Continue your first project by analyzing the data further and produce formal written documentation of the procedures and results. Examples of topics include (see next section) multivariate techniques such as VAR or cointegration, or time varying volatility (ARCH), the Kalman filter, endogenous regime switching, etc. You also have the option to consider other time series and predictive modeling techniques not covered in the course.

The objective of the report is to document a careful empirical analysis. While the creativity of the topic is valued, emphasis will be placed on producing a convincing piece of analytical work. It is important to choose an empirical strategy that addresses your question and is suited to the data that are available. In addition, your results should be adequately tested and validated to allow you to present your empirical results with confidence.

5 Course Content

- The Modeling Process
- The Tools of Empirical Research
- Maximum Likelihood Estimation
- Stationary Processes
- Univariate ARMA models
- Estimation and Inference
- Model Selection and Performance Evaluation
- Vector Time Series
- Unit Roots
- Cointegration
- Fractional Integration (ARFIMA models)
- Spectral Analysis
- Kalman Filter and State Space Models
- Autoregressive Conditional Heteroskedasticity
- Selected Methods for Predictive Modeling

Coverage of the last five items depends on interest and timing.

6 References

6.1 Time Series Analysis

The first group of references form the core of the theoretical concepts in time series analysis.

Hamilton, James, D., 1994, *Time Series Analysis*, (Princeton University Press).
- An authoritative treatment of everything that is time series, from the econometrician's perspective.

Box, G.E.P. and Jenkins, G.M., 1976, *Time Series Analysis: Forecasting and Control*, (Holden-Day Publishers).
- The classic, seminal reference for the tried-and-tested time-series modeling approach. There are also newer editions.

Enders, W., 2004, *Applied Econometric Time Series*, (John Wiley & Sons, Inc.).
- Covers time series applications of interest to economists.

Brockwell, P.J. and Davis, R.A., 1991, *Time Series: Theory and Methods*, (Springer-Verlag).
Brockwell, P.J. and Davis, R.A., 2002, *Introduction to Time Series and Forecasting*, (Springer Science and Business Media).
- A good pair of references for time series analysis not aimed specifically at economic applications.

6.2 Predictive Modeling

These references are recommended to cover many of the practical aspects of statistical model building.

Kuhn, Max and Johnson, Kjell, 2016, *Applied Predictive Modeling*, (Springer Science + Business Media).
- Great overview of the entire model-building process.
- Includes topics such as data pre-processing, model tuning and overfitting, and a substantial list of topics for model performance measurement.
- Presents other topics such as classification methods, tree-based methods and feature selection, which are key parts of the predictive modeler's toolkit.

Provost, Foster and Fawcett, Tom, 2013, *Data Science for Business: What You Need to Know about Data Mining and Data-Analytic Thinking*, (O'Reilly Media, Inc.).
- Focused on processes of data science for answering business questions, which are important regardless of the algorithm you use.
- Covers the entire model-building pipeline within an organization, along with an overview of common techniques, including factors in model evaluation.

Abbott, Dean, 2014, *Applied Predictive Analytics: Principles and Techniques for the Professional Data Analyst*, (John Wiley & Sons, Inc.).
- A business-oriented approach to modeling, with a variety of modeling techniques.
- Covers the entire modeling pipeline, from understanding the business problem to deployment.

Siegel, Eric, 2016, *Predictive Analytics: The Power to Predict Who Will Click, Buy, Lie, or Die*, (John Wiley & Sons, Inc.).
- Storytelling approach to modeling by highlighting key use cases.
- Features popular examples and stories rather than techniques.
- Focused not so much on the 'what' or the 'how' but the 'why'.

6.3 Statistical Learning

The following references are included to provide an expanded menu of topics to choose from. While most of the topics covered in these sources will not be formally treated in the course, you are free to explore them to improve your analysis.

Hastie, Trevor, Tibshirani, Robert and Friedman, Jerome, 2017, *The Elements of Statistical Learning: Data Mining, Inference, and Prediction, Second Edition*, (Springer Series in Statistics).
- Gives a broad treatment of data mining and statistical learning.
- A key academic reference to bridge the gap between traditional topics and modern techniques.

James, Gareth, Witten, Daniela, Hastie, Trevor and Tibshirani, Robert, 2017, *An Introduction to Statistical Learning: with Applications in R*, (Springer Texts in Statistics).
- A junior-level introduction to the above.

7 Statement on Academic Integrity

Academic integrity is constituted by the five core fundamental values of honesty, trust, fairness, respect and responsibility (see `www.academicintegrity.org`). These values are central to the building, nurturing and sustaining of an academic community in which all members of the community will thrive. Adherence to the values expressed through academic integrity forms a foundation for the "freedom of inquiry and exchange of ideas" essential to the intellectual life of the University (see the Senate Report on Principles and Priorities).

Students are responsible for familiarizing themselves with the regulations concerning academic integrity and for ensuring that their assignments conform to the principles of academic integrity. Information on academic integrity is available in the Arts and Science Calendar (see Academic Regulation 1), on the Arts and Science website (see `http://www.queensu.ca/artsci/sites/default/files/Academic_Regulations.pdf`), and from the instructor of this course.

Departures from academic integrity include plagiarism, use of unauthorized materials, facilitation, forgery and falsification, and are antithetical to the development of an academic community at Queen's. Given the seriousness of these matters, actions which contravene the regulation on academic integrity carry sanctions that can range from a warning or the loss of grades on an assignment to the failure of a course to a requirement to withdraw from the university.