Time series and Forecasting methods

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Overview

This course provides the theory and practice of time series analysis. After introducing the basic theory of stationary processes, it describes and presents analytically the Box-Jenkins methodology for ARIMA models. The course introduces the class of conditional heteroscedastic models (ARCH/GARCH), and presents practical time series forecasting techniques. Illustrative examples applying time series models/techniques to actual economic and financial data are also presented using the statistical package R. The empirical analysis consists of (a) unit root testing to exchange rate series and financial series, e.g. stocks and indices, (b) modeling and forecasting financial return series, (c) estimation of different risk measures, (d) performance evaluation of fund investments (e.g. mutual and/or hedge fund returns).

Key Outcomes

By completing the course the students will:

- know the basic concepts of stationary processes
- have learned the ARIMA time series models
- have learned about the time-varying volatility models
- be able to apply the Box-Jenkins methodology in practice
- be able to model and forecast time series data
- know how to implement time series analysis using R

Requirements and Prerequisites

The students should have a basic quantitative background. Specifically, basic knowledge in the fields of statistics will be necessary for this course.

Books

Recommended textbooks:

- Hamilton, James D. *Time Series Analysis*. Princeton, New Jersey: Princeton University Press, 1994.
- Enders, Walter. *Applied Econometric Time Series*. New York: Wiley, 2010.
- Cowpertwait, Paul S.P., and Metcalfe V. Andrew. *Introductory Time Series with R*. New York: Springer Texts in Statistics, 2009.
- Cryer, Jonathan D., and Chan Kung-Sik. *Time Series Analysis with Applications in R.* Springer Texts in Statistics, 2010.

Other Useful textbooks:

- Gujarati, Damodar N. *Basic Econometrics*. New York: McGraw-Hill, 2008.
- Harvey, Andrew. *Time Series Models*. Cambridge: MIT Press, 1993.
- Hendry, David F. *Dynamic Econometrics*. Oxford: Oxford University Press, 1995.
- Pindyck, R.S. and D.L. Rubenfeld. *Econometric Models and Economic Forecasts*. New York: McGraw-Hill, 1991.
- Shumway, Robert H. and David S. Stoffer. *Time Series Analysis and Its Applications with R Examples*. New York: Springer Texts in Statistics, 2011.
- Tsay, Ruey S. *Analysis of Financial Time Series*. New York: Wiley, 2010.
- Wooldridge, Jeffrey. *Introductory Econometrics: A Modern Approach*. South-Western College Publishing, 2009.

- Engle, Robert F. and C.W.J. Granger (eds.). *Long-Run Economic Relationships: Readings in Cointegration*. Oxford: Oxford University Press, 1992.
- Granger, C.W.J. and Paul Newbold. *Forecasting Economic Time Series*. San Diego, CA: Academic Press, 1986.
- Banerjee Anindya, Juan Dolado, J.W. Galbraith, and David F. Hendry. *Co-integration, Error Correction, and the Econometric Analysis of Non-Stationary Data*. Oxford: Oxford University Press, 1993.

Software/Computing requirements

The computational aspects of this course will be implemented in R, a free software environment for econometric and time series models. R can be downloaded at https://www.r-project.org and installed on all types of environments (Windows, Mac, UNIX). We will make use of the data sets available in the "datasets" library of R. Other data sets that will be used in class and/or assignments they will be available in the eclass page of this course.

Grading

There will be a total of 2 homework assignments (given at the units 4, and 5) that will contribute 20% in the final grade. The remaining 80% will be determined by the in class final exam. Please note that one needs to pass the final exam (independently of the grades in the homework assignments) in order not to fail the course.

Course Syllabus

The course comprises of five units of three hours each.

Unit 1: Introduction and Unit root testing

Examples of time series. Basic concepts: Autocorrelation and stationarity. Properties of stationary and non-stationary processes. Unit root testing. Augmented Dickey-Fuller test. Illustration of unit root testing using R to economic and financial data sets. Example 1: Unit root testing to exchange rate series (application and useful conclusions), example 2: unit root testing to financial time series, e.g. stocks and indices (application and useful conclusions).

Unit 2-3: Stationary time-series models

General linear processes. Moving average processes. Autoregressive processes. Mixed autoregressive moving average processes. Properties of ARMA processes. Autocorrelation and partial autocorrelation function. Stationarity. Invertibility. Stationarity through differencing. ARIMA models.

Unit 4: Box-Jenkins methodology

Identification step: the role of autocorrelation and partial autocorrelation function. Estimation step: maximum likelihood estimation. Exact and conditional likelihood. Diagnostic step: residual analysis. Prediction step: minimum mean square error forecasting. ARMA forecasting. Forecasting transformed series. Illustration of applying Box-Jenkins methodology using R. Applications to real economic and financial series: (a) modeling and forecasting financial return series (S&P 500 monthly returns and Johnson and Johnson quarterly data), (b) modeling and forecasting foreign exchange rates (Euro/Dollar exchange rates), (c) modeling and forecasting economic series (GNP deflator series, GDP in EU countries)

Unit 5: Time series models of heteroscedasticity

Characteristics of financial time series. ARCH/GARCH type models. Maximum likelihood estimation. Models diagnostics. Extensions of the GARCH model. Variance prediction. Illustration of estimating

GARCH-type models to financial time series using R. Applications to real financial series: (a) modeling and forecasting financial return series (S&P 500 monthly returns), estimation of different risk measures (e.g Value at Risk), (b) performance evaluation of fund investments (e.g. mutual and/or hedge fund investments).

Participation

In-class participation and contribution is a very important part of the educational process with many benefits:

- Better understanding of the topic under consideration.
- Advancing the discussion by contributing insightful comments and questions.

Please arrive to class on time and stay to the end of the class period. Chronically arriving late or leaving class early is unprofessional and disruptive to the entire class. Turn off all electronic devices prior to the start of class. Cell phones, tablets and other electronic devices are a distraction to everyone.

Assignments

Late assignments will either not be accepted or will incur a grade penalty unless due to documented serious illness or family emergency. Exceptions to this policy for reasons of civic obligations will only be made available when the assignment cannot reasonably be completed prior to the due date, you make suitable arrangements, and give notice for late submission in advance.

Attendance Requirements

Class attendance is essential to succeed in this course and is part of your grade. An excused absence can only be granted in cases of serious illness or grave family emergencies and must be documented. Job interviews and incompatible travel plans are considered unexcused absences. Where possible, please notify the instructor in advance of an excused absence. Students are responsible for keeping up with the course material, including lectures, from the first day of this class, forward. It is the student's obligation to bring oneself up to date on any missed coursework.

Code of Ethics

Students may not work together on individual graded assignments unless the instructor gives express permission. Exercise integrity in all aspects of one's academic work including, but not limited to, the preparation and completion of all other course requirements by not engaging in any method or means that provides an unfair advantage. In any case of doubt, students must be able to prove that they are the sole authors of their work by demonstrating their knowledge to the instructor. Clearly acknowledge the work and efforts of others when submitting written work as one’s own. Ideas, data, direct quotations (which should be designated with quotation marks), paraphrasing, creative expression, or any other incorporation of the work of others should be fully referenced. No plagiarism of any sort will be tolerated. This includes any material found on the internet. Reuse of material found in question and answer forums, code repositories, other lecture sites, etc., is unacceptable. You may use online material to deepen your understanding of a concept, not for finding answers. Please report observed violations of this policy. Any violations will incur a fail grade at the course and reporting to the senate for further disciplinary action.