Time Series

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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 real economic and financial data are also provided 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). The specific topics covered in this course are outlined below.

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).

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.

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 (GDP in EU countries).

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).

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

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.
- 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 statistics, econometrics 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 lab sessions and/or assignments will be available in the eclass web page of this course.

Grading

The evaluation of the students' work is based partly on the final exam and partly on projects. The final exam will contribute 80% to the final mark. Two assignments will contribute 20% to the final mark. Note that one needs to pass the final exam (independently of the marks in the homework assignments) in order not to fail the course.