FAU – School of Business, Economics and Society
Chair of Statistics and Econometrics

Multivariate time series analysis

Summer 2025 – Syllabus

Instructor:
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Office hours: by appointment

Overview: This course is an introduction to commonly used methods in multivariate time series analysis. The course will give students the theoretical knowledge and practical skills to apply the covered techniques in a wide range of empirical applications, mainly in macroeconomics (e.g., identification of monetary policy shocks) and financial econometrics (e.g., jointly modeling the returns of a portfolio of assets).

The course starts with a review of univariate time series issues. Students will learn how to model time series processes using the ARIMA framework. Subsequently, the course covers the basics of multivariate probability distributions and moves on to vector autoregressive (VAR) models. Such models describe the joint behavior of multiple time series. Students will learn how to specify and estimate VAR models and use them for predictive analysis. The course covers in depth the difference between the reduced-form and structural VAR representation. Subsequently, it tackles a range of common methods for the identification of structural shocks in empirical macroeconomics (such as monetary policy shocks or fiscal shocks). It also covers the topics of impulse response function, forecast error variance decomposition, and historical decomposition. Finally, the course covers the basics of multivariate GARCH models, which one can use to describe the volatility of vectors of financial return series.

Students should have solid knowledge of the basics of statistics and econometrics and will profit from prior experience with R or other econometric software packages although we do not require any prior programming skills.

We teach the course over the period April 22nd to July 23rd. Each week, we have two lectures, one exercise session and one video exercise:

Lecture:	Tuesday, 15:00-16:30, room LG 5.154. 22.04., 29.04., 06.05., 13.05., 20.05., 27.05., 03.06., 10.06, 17.06., 24.06., 01.07., 08.07., 15.07., 22.07
Exercise:	Wednesday, 15:00-16:30, room LG 4.109. 23.04., 30.04., 07.05, 14.05., 21.05., 28.05., 04.06., 11.06., 18.06., 25.06., 02.07., 09.07., 16.07., 23.07.

Final examination: tba (by examination office)

Grading: Written exam (60 minutes). Students can improve their grade by doing a replication study during the semester.

Course requirements: Course participants are strongly advised to …

- **Attend.** You can only fully benefit from this course if you attend both lectures and exercises regularly because the course content is highly cumulative, meaning that later topics rely heavily on stuff covered in the previous weeks. VAR models are, for instance, straightforward generalizations of univariate time series models.
- **Prepare.** Ideally, do the assigned readings before the lecture and come to class prepared to discuss them and to ask questions that you have.
- **Follow the website.** I will make course material available through the course website on StudOn. I will also make announcements using this platform.
- **Code.** Your learning gains will be much, much higher if you regularly work on the R assignments, which ask to implement the material that we cover in the lectures. Do not underestimate how much coding an approach helps understanding it!

Course outline

Topic 1:	Properties of time series
Topic 2:	Univariate processes/ARIMA models
Topic 3:	Non-stationary time series and unit root tests
Topic 4:	The basics of vector autoregressive (VAR) models
Topic 5:	Estimation of VAR models
Topic 6:	Predictive Analysis with VAR models
Topic 7:	Structural VAR model
Topic 8:	Impulse response functions, forecast error variance decompositions, and historical decompositions
Topic 9:	Identification of structural VAR models
Topic 10:	Advanced Topics in VAR analysis
Topic 11:	Multivariate GARCH models

Main textbooks:

- Enders, W. (2005) *Applied Econometric Time Series*, Wiley.
- Hamilton, J. D. (1994), *Time Series Analysis,* Princeton University Press, Princeton.
- Lütkepohl, H. (2005), *New Introduction to Multiple Time Series Analysis*, Springer.
- Kilian, L. and H. Lütkepohl (2017), *Structural Vector Autoregressive Analysis,* Cambridge University Press, Cambridge.
- Tsay, R.S. (2002), *Analysis of Financial Time Series*, Wiley.

R Software

R is a free software environment. You can download R using any of the links on the following website: https://cran.r-project.org/mirrors.html.

We recommend that you use RStudio to organize your codes. You can download a free copy of RStudio Desktop here (just use the download button that is most to the left).

We will use the first exercise session to explain how to install R/RStudio and to make sure that it works on everyone's laptop. The first exercise sessions cover the basics of

programming in R. You can also take our online introduction to R on StudOn if you want to prepare.

There are many excellent online courses for learning R available online which you might want to consult if you do have no prior experience with R at all. We recommend the following:

- The book "R Programming for Data Science" by one of the authors of the Coursera course;
- Many tutorials on various aspects of R offered via the swirl project;
- The course "Topics in R Statistical Language" offered by PennState University.

The most important thing to enhance your programming skills and to master the implementation of econometric methods is to write a lot of code.