Course description:
This course covers advanced topics in time series analysis. Topics will include vector autoregression models, vector error correction models, state-space models, dynamic factor models, Bayesian vector autoregression models, count time series, Markov-switching and change-point models, and forecast evaluation.

This course is intended for those who have taken the four-week workshop on Time Series Analysis, the one-week workshop on Time Series Analysis: An Introduction, or the equivalent.

A sound background in time series fundamentals is assumed. The course will make use of basic matrix algebra. The lab component of this course will employ STATA and R. Familiarity with STATA is assumed but a STATA crash course will be provided outside the lecture on day two. If you are unfamiliar with R or STATA, we suggest that you attend one of the many R and STATA tutorial sessions or lectures offered as part of the Summer Program. The use of R will begin in the second half (Prof. Brandt’s portion) of the course but the R lectures offered by the summer program occur in the first half. Therefore, if you're not familiar with R, attend one of these R lectures ahead of time.

Making Contact:

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Assignments and Grading:
Assignments will be given in this course. Assignments will either be daily or every-other-day. The goal of the assignments is to solidify the concepts of each lecture with hands-on work in the lab.
Course outline:

**Day 1.**
Introduction to the course and review of time series fundamentals
- Notation and terminology
- Autoregression, autocorrelation and serial correlation
- Stationarity
- Exogeneity
- Weak dependence
- Trending, cycling and structural breaks
- Instability and integration

**Readings:**
Chapters 1 and 2 of unpublished manuscript, to be provided.


**Day 2.**
Vector Autoregression (VAR) Models – a review of the basics
- The reduced form VAR
- Lag-length selection
- Interpretation
- Robustness checks
- Granger causality

**Readings:**

**Day 3.**
Vector Autoregression (VAR) Models – an extension
- Vector Moving Average representation (VMA)
- Impulse response functions (IRF)
- The Cholesky decomposition
- Orthogonalised impulse response functions (OIRF)
- Forecast-error variance decomposition (FEVD)
- Dynamic multiplier functions

**Readings:**

**Day 4.**
Vector Error Correction Models (VECM) – Part one
- A reminder about cointegration and error correction models
- Applying the logic of cointegration to (VAR) models

**Readings:**

STATA documentation on VECMs – to be provided

**Day 5.**
Vector Error Correction Models (VECM) – Part two
- Lag-length selection
- Rank selection
- VECM identification
- Interpretation
- Robustness checks

**Readings:**

Day 6.
Structural Equation Models
- What are structural equation models?
- Structural Vector Autoregression (SVAR)
- Identifying restrictions
- Structural impulse response functions (SIRF)

Readings:


Day 7.
The State-Space approach to structural models
- The linear state-space model
- Some classical time series models in state-space form
- Controlling for measurement error
- Modelling I(1) processes
- Modelling other non-stationary processes

Readings:

Day 8.
More on the State Space approach
- Estimating state-space models
- The Kalman filter
- Predicting, filtering and smoothing with state-space models

Readings:

STATA documentation on state-space models in STATA – to be provided.
Day 9.
Advanced time series models in state-space form

- Dynamic-factor models
- Vector autoregressive moving average models (VARMA) – if time permits

Readings:


Day 10.
Thinking as a Bayesian

- The intuition to Bayesian state-space models
- Two examples: Time varying coefficients models and Bias Estimation models

Readings:

Day 11.
Bayesian time series models

- Introduction to Bayesian inference
- Bayesian linear regression
- Bayesian dynamic models
- Introduction to MCMC and Bayesian posterior inference
- Role of prior beliefs in model construction

Readings:

**Day 12.**
Bayesian VAR models and their interpretation
- Litterman and Sims-Zha priors
- Other priors
- Bayesian VAR estimators
- Interpreting Bayesian VARs

**Readings:**


**Day 13.**
Bayesian Structural VAR (B-SVAR)
- B-SVAR model construction: from theory to model
- Estimation of B-SVARs
- Comparing B-SVAR models

**Readings:**


Day 14.
Changepoint models -- Frequentist
- Thinking about structural change
- Problem of fitting recursive models for structural breaks
- Changes in mean versus variance
- Inference in structural change models

Readings:


Day 15.
Bayesian Changepoint models
- Chib’s changepoint model
- Relationship between HMMs, changepoints, and regime switching
- Bayesian priors and estimation

Readings:


Day 16.
Markov-switching time series models
- Definition of MS processes and comparison with other models
- Inferential issues in data that vary over regimes
- Choosing priors for MS models.
- Basic MS model estimation and filtering

Readings:

democratization in emerging market countries”. *International Studies Quarterly.*
47(2):203–228.

*Classical and Gibbs-Sampling Approaches with Applications*. MIT Press. Chapters 4 and
9.

**Day 17.**
Practical issues in fitting Markov-switching models
- Bayesian v. frequentist MS estimation
- Choosing the number of regimes
- Regime inference and reporting
- Regime identification under state-relabeling issues.
- Stationarity of MS-AR models

**Readings:**
Celeux, Gilles, Merilee Hurn and Christian Robert. 2000. “Computational and Inferential
Difficulties with Mixture Posterior Distributions.” *Journal of the American Statistical
Association.* 95(451): 957-70.


Fruhwirth-Schnatter, Sylvia. 2001. “Markov Chain Monte Carlo Estimation of Classical and
Dynamic Switching and Mixture Models” *Journal of the American Statistical Association*
96(453) 194-209.

**Day 18.**
Forecasting, evaluation, and model averaging
- Forecast density evaluation
- How to compare forecast densities to observed data
- Scoring rules for model comparisons
- Calibration, discrimination, sharpness
- Methods for forecast evaluation and quality assessment

**Readings:**
Brandt, P. T., J. R. Freeman, and P. A. Schrodt (2011). Real time, time series forecasting of


Diebold, F. X., J. Hahn, and A. S. Tay (1999), Multivariate density forecast evaluation and
calibration in financial risk management: High-frequency returns on foreign exchange.


**Day 19.**

Event count time series
- Building non-Gaussian time series models with conditional filters
- Difficulties with modelling limited dependent variable time series
- Event count time series model
  - PEWMA
  - PAR(p)
  - BaP-VAR(p)

**Readings:**


http://pan.oxfordjournals.org/content/early/2012/03/15/pan.mps001.short


**Day 20.**

Individual meetings

**Readings:**

NA