Time Series Analysis

Spring 2008
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Course: 1 semesters, 3 hours per lecture.

This course focuses exclusively on Time Series Analysis (TSA). Similar to any other filed of economics, intuition and creative ideas constitute the flesh and bone of TSA. I am aiming at equipping the students with proper tools for advanced empirical work and lay the foundation for theoretical research in TSA.

Starting with conventional univariate time analysis, including identification, estimation, diagnostic checking and forecasting of a time series model, I shall close the foundational built up with multiple time series. Unit root and cointegration econometrics makes the second part, and ARCH/GARCH the final part. I shall give an relatively thorough analysis of literatures in these area, starting with functional central limit theorem and ending up with an empirical analysis of Johansen's maximum likelihood methods.

In additional to econometric theory, I also emphasize computational aspects of these complicated econometric techniques. *R*, is the three statistical packages used in this course. Several lab sessions are scheduled.

Textbook
Fumio Hayashi, **Econometrics**, New Jersey:Princeton University Press, 2000
Reference Books:

- G.E.P. Box, G.M. Jenkins and G.C. Reinsel, **Time Series Analysis: Forecasting and Control,** 3rd edition, Prentice Hall, 1994.
- Clive Granger **Forecasting Economic Time Series,** 2nd edition Academic Press 1986.
- Hamilton, James D. **Time Series Analysis**, New Jersey: Princeton University Press, 1994
- Aris Spanos, **Statistical Foundations of Econometric Modelling**, Cambridge University Press, 1986.
- *Johansen, S. (1995) **Likelihood-based inference in cointegrated vector autoregressive models**, Oxford: Oxford University Press
- Helmut Lutkepohl, **Introduction to multiple Time Series Analysis,** 2nd edition, Springer-Verlag 1993

Topics

First semester

1. Introduction to Stochastic Process, Time series and *R* (1 lecture)
2. ARIMA modelling (2 lectures)
3. Theory of Forecasting (1 lecture)
4. VAR and Impulse response analysis (2 lecture)
5. Functional central limit theorem and testing unit root (2 lectures)
6. Cointegration and error correction model (3 lectures)
7.

Softwares

R: freely available at
http://www.r-project.org
bayesm,urca

1 Introduction to stochastic processes

Spanos chap 8

- definition
- memory and heterogeneity
  - stationary
  - Martingale
  - Markov
- Brownian motion
  - derivation
  - nowhere differentiability
  - role in stochastic integral
- ARIMA processes

2. Univariate ARIMA modelling

Granger & Newbold chap 3

- Autocorrelation, partial autocorrelation function, inverse autocorrelation function
- Wold representation theorem
- Random walk model
- General ARIMA model
- Variance stabilization transformation
- Model identification
  - using ACF & PACF
  - using AIC, BIC, & SC criterion
    C.Z. Wei (1992), "On predictive least squares," **The Annals of Statistics, 22**, pp 1-42.
- Estimation
  - method of moment
  - maximum likelihood method
  - nonlinear estimation
- diagnostic checking
  Box-Pierce Q-statistics Box, G.E. & D.A. Pierce (1970) ,"Distribution of residual autocorrelations in autoregressive-integrated moving average time series models," **Journal of American Statistician Association, 52**, 181-192.

3. Theory of Forecasting

Granger and Newbold chap 4

- loss function
- optimal forecast when the parameters are known

- optimal forecast when the parameters are estimated
  C.Z. Wei(1985), "Adaptive predictions by least squares predictors in stochastic regressions with applications to time series," **The Annals of Statistics, 15**, 1667-1782.

- optimal multi-step forecast
  Tiao, G. and D.Xu (1993), "Robustness of maximum likelihood estimators for multi-step prediction–the exponential smoothing case," **Biometrika, 80**, 623-641.

- partial least squares, principal components, ridge regression
  Lin, J and R. Tsay, 2005, "Comparisons of Forecasting Methods with Many Predictors," manuscript.

4. Functional central limit theorem and continuous mapping theorem

Billingsley chaps 1,2 P.C.B. Phillips (1987), "Time series regression with a unit root," **Econometrica, 55**, 277-301.

- functional central limit theorem
  - for iid
  - for mixing processes
- continuous mapping theorem

5. Unit Root Econometrics

- A little history about unit root and cointegration
  - Yule (1927) periodicity of sunspot numbers
  - Box-Jenkins (1976)
  - Dickey-Fuller (1979)
  - Granger (1981)
  - Nelson and Plosser (1982)
  - Granger and Weiss (1982)
  - Engle and Granger (1987)
  - Phillips (1987)
  - Johansen (1988)

- Why does unit root matter ?
  - properties of I(1) vs. I(0)
  - unit root does exist in economic data
- testing unit root
  D.A. Dickey and W. Fuller(1979), "Distribution of the estimators for autoregressive time series with a unit root," **Journal of American Statistical Association, 74**, 427-31.
  D.A. Dickey and W. Fuller (1981), "Likelihood ratio statistics for autoregressive time series with a unit root," **Econometrica 49**, 1057-72.
  N.H. Chan and C.Z. Wei (1988), "Limiting distribution of least-square estimates of unstable processes," **The Annals of Statistics, 16,'**, 367-401.
  - testing unit root without intercept
  - testing unit root with intercept
  - testing unit root with autocorrelated residual
    * Augmented Dickey-Fuller Test (Fuller chap 8)
    * Phillips-Perron Test
  - testing multiple unit roots
  - near unit root
- spurious regression
  C.W.J. Granger and P Newbold (1974), "Spurious regressions in econometrics, ", **Journal of Econometrics, 2**, 111-120.
  P.C.B. Phillips(1986), "Understanding spurious regressions in econometrics," **Journal of Econometrics, 33, 311-34**.
- Statistical inference with integrated regressor

7, VAR and Impulse Response

- VAR
- Impulse response function for stationary series

8. Cointegration

R. Engle and C.W.J. Granger(1987), "Co-integration and error correction: representation, estimation and testing," **Econometrica, 55**, 251-76.
S. Johansen(1988), "Statistical Analysis of Cointegration vectors," **Journal of Economic Dynamics and Control, 12**, 231-254.
S. Johansen (1991), "Estimation and hypothesis testing of cointegration vectors in Gaussian vector autoregressive models, " **Econometrica, 59**, 1551-1580.
S. Johansen and K. Juselius (1990), "Maximum likelihood estimation and inference on cointegration- with applications to the demand for money, " **Oxford Bulletin of Economics and Statistics, 54,** 169-210.
S. Johansen (1992), "Cointegration in partial systems and efficiency of single equation analysis," **Journal of Econometrics**, 52, 389-402.

- definition of cointegration
- economic and statistical meaning of cointegration
- cointegration and error correction model
- estimating and testing cointegration in bivariate system
- estimating and testing cointegration in multivariate system
- empirical examples of cointegration using Taiwan data
- estimating common trend
- threshold cointegration