Quantitative and Statistical Methods II: Introduction to Time Series Analysis

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1 Description

This 20-hour course is an introduction to the theory and application of time series methods in econometrics. Its main objective is to develop the skills needed to do empirical research with time series data sets. Topics covered stationary and non-stationary models as well as univariate and multivariate time series. The course is mainly designed for students who will use time series data in their empirical macroeconomics analysis.

2 Prerequesites

The course assumes familiarity with probability, statistics and econometrics. Good sources for reviewing this material are J. M. Wooldridge "Econometric analysis of cross section and panel data", 2010 MIT Press, and J. H. Stock and M. Watson "Introduction to Econometrics"2007, Boston: Pearson/Addison Wesley. Some notions of programming in Matlab will be useful.

3 Course outline

1. Preliminary concepts: Stochastic process; Stationarity; Autocovariance and autocorrelation function; Partial autocorrelation function; Asymptotic theory for dependent processes.

2. Stationary univariate linear models: ARMA models. Impulse response function. Garch models.

3. Model Selection and Information criteria; Estimation and Diagnostic checking.

4. Non-stationary univariate time series models. Unit root and Trend stationary models; Unit root tests. Small sample bias. Models with structural breaks.

5. Reduced form VAR. Estimation. Impulse response funcions. Granger Causality.

6. Further topics (time permitting): Heterokedasticity and Autocorrelation robust inference. Long memory models.

4 Grading

The final grades will be based on a final exam (60%), and four problem sets (40%).

5 References

The main reference for this course is:

Hamilton, J. *Time Series Analysis.* Princeton: Princeton University Press, 1994.

An excellent source with very up-to-date material can be found in the lectures "What's New in Econometrics-Time Series" delivered by James H. Stock and Mark W. Watson during the NBER Summer Institute 2008. `http://www.nber.org/minicourse$_$2008.html` Other useful references:

Brockwell., P. and R. Davis. *Time Series: Theory and Methods.* Second edition. New York: Springer-Verlag, 1991. (more advanced)

Stock J. H. and M. W. Watson. Introduction to Econometrics. Second Edition. Pearon, Addison Wesley. (Chapters 14 and 15–Undergraduate level)

Hayashi, F. Econometrics. Princeton University Press, 2000.

5.1 Other interesting readings

The following is a list of references related to the topics that we will cover in the course. They are not mandatory, they are just additional references for those who wish to study specific topics in greater detail. '*' denote more relevant references.

- **Stationary time series**

*Hamilton, Chs. 1-5, 7, 8.

Brockwell and Davis, Chs. 1, 3, Sect. 5.7.

Newey, W.K. and West, K.D. (1987). "A simple positive semi-definite, heteroskedasticity and autocorrelation consistent covariance matrix," *Econometrica* 55, 703-708.

*Andrews, D.W.K. (1991). "Heteroskedasticity and autocorrelation consistent covariance matrix estimation," *Econometrica* 59, 817-858.

Beveridge, S. and Nelson, C.R. (1981). "A new approach to decomposition of economic time series into permanent and transitory components with particular attention to measurement of the 'business cycle'," Journal of Monetary Economics 7, 151-174.

Andrews, D.W.K. and Monahan, J.C. (1992). "An improved heteroskedasticity and autocorrelation consistent covariance matrix estimator," *Econometrica* 60, 953-966.

den Haan, W.J. and Levin, A. (1997). "A practitioner's guide to robust covariance matrix estimation," in Maddala, G.S. and Rao, C.R. (Eds), Handbook of Statistics 15, Ch. 12, 291-341.

Kiefer, N. and Vogelsang, T. (2002). "Heteroskedasticity-autocorrelation robust testing using bandwidth equal to sample size," *Econometric Theory* 18, 1350-1366.

- **Inference and model selection in linear time series models**

*Berk, K.N. (1974), Consistent Autoregressive Spectral Density Estimates, Annals of Statistics 2, 489-502.

*Geweke, J. and R. Meese (1981), Estimating Regression Models of Finite but Unknown Order, International Economic Review 22, no. 1, 55-70.

*Hamilton, Ch. 7; Hayashi, Chapter 2

- **Univariate non-stationary processes**

*Hamilton, Ch. 17.

*Stock, J.H. (1994). "Unit roots and trend breaks in econometrics," *Handbook of Econometrics*, Vol. IV, 2740-2841 (sections 1-4).

Dickey, D.A. and Fuller, W.A. (1979). "Distribution of the estimators for autoregressive time series with a unit root," Journal of the American Statistical Association 74, 427-431.

Campbell, J.Y. and Perron, P. (1991). "Pitfalls and opportunities: what macroeconomists should know about unit roots," NBER Macroeconomics Annual, Vol. 6., pp. 141-201.

Andrews, D.W.K. (1993). "Exactly median-unbiased estimation of first order autoregressive/unit root models," *Econometrica* 61(1), 139-165.

Hansen, B.E. (1999). "The grid bootstrap and the autoregressive model," *Review of Economics and Statistics* 81(4), 594-607.

Phillips, P.C.B. (1987). "Toward a unified asymptotic theory for autoregression," *Biometrika* 74(3), 535-547.

Stock, J. (1991). "Confidence intervals for the largest autoregressive root in US macroeconomic time series," *Journal of Monetary Economics* 28, 435-459.

Mikusheva, A. (2007). "Uniform inference in autoregressive models," *Econometrica*, 75(5).

- **Structural breaks and non-linearity**

*Hamilton (1994), Ch. 22.

Perron, P. (2005), "Dealing with Structural Breaks," in Palgrave Handbook of Econometrics, Vol. 1: Econometric Theory, K. Patterson and T.C. Mills (eds.).

Andrews, D.W.K. (1993). "Tests for parameter instability and structural change with unknown change-point," *Econometrica* 61, 821-856.

*Hansen, B.E. (2001). "The new econometrics of structural change: dating breaks in U.S. labor productivity," *Journal of Economic Perspectives* 15, 117-128.

*Perron, P. (1989). "The great crash, the oil price shock, and the unit root hypothesis," *Econometrica* 57, 1361-1401.

Andrews, D.W.K. and Ploberger, W. (1994). "Optimal tests when a nuisance parameter is present only under the alternative," *Econometrica* 62, 1383-1414.

Bai, J. S. (1997). "Estimating multiple breaks one at a time," *Econometric Theory* 13, 315-352.

Bai, J. and Perron, P. (1998). "Estimating and testing linear models with multiple structural changes," *Econometrica* 66, 47-78.

Zivot, E. and Andrews, D.W.K. (1992). "Further evidence on the great crash, the oil price shock, and the unit root hypothesis," *Journal of Business and Economic Statistics* 10, 251-270.

- **Model selection and information criteria**

Geweke, J. and Meese, R. (1981). "Estimating regression models of finite but unknown order," *International Economic Review* 22, 55-70.

Ng, S. and Perron, P. (2005). "A note on the selection of time series models," *Oxford Bulletin of Economics and Statistics* 67:1, 115-134.

*Kuersteiner, G.M. (2005). "Automatic inference for infinite order vector autoregressions," *Econometric Theory* 21, 85-115.

Leeb, H. and Potscher, B.M. (2005). "Model selection and inference: facts and fiction," *Econometric Theory* 21, 21–59.

Leeb, H. and Potscher, B.M. (2003). "The finite-sample distribution of post-model-selection estimators and uniform versus nonuniform approximations," *Econometric Theory* 19, 100–142.

Hansen, B. (2005). "Challenges for econometric model selection," *Econometric Theory* 21, 60-68.

- **GARCH processes and estimation**

Bollerslev, T., Chou, R. Y. and Kroner, K. F. (1992). ARCH Modelling in finance: A review of the theory and empirical evidence. Journal of Econometrics 52, 5-59.

Bollerslev T., Engle R. F. and Nelson D. B. (1994). ARCH model. In Handbook of Econometrics 4, Engle R. F. and McFadden D. L. (eds). Elsevier Science: New York; 29613031.

*Davis, R. A. and Mikosch, T. (1998). The sample autocorrelations of heavy-tailed processes with applications to ARCH. Annals of Statistics 26, 2049-2080.

Engle R. F. (2001). GARCH 101: An introduction to the use of ARCH/GARCH models in applied Econometrics. Journal of Economic Perspectives 15, 157-168.

* Engle, R. F. (2002). New frontiers for ARCH models. Journal of Applied Econometrics 17, 425-446.

Engle, R. F. (2004). Risk and volatility: Econometric models and financial practice. American Economic Review 94, 405-420.

Hamilton (1994), Ch. 21.

*Mikosch, T. and Starica, C. (2000). Limit theory for the sample autocorrelations and extremes of a GARCH(1, 1) process. Annals of Statistics 28, 1427–1451.

*Poon, S.-H. and Granger, C. W. J. (2003). Forecasting volatility in financial markets: A review, Journal of Economic Literature 41, 478-539.

- **Multivariate unit roots and cointegration**

Chan, N.H., and Wei, C.Z. (1988), Limiting Distributions of Least Squares Estimates of Unstable Autoregressive Processes, Annals of Statistics 16, March 1988, 367-401.

Elliott, G. (1998), The Robustness of Efficient Cointegration Estimators when Regressors Almost Have Unit Roots, Econometrica 66, 149-158.

*Engle, Robert F., and C.W.J. Granger (1987), Co-Integration and Error Correction: Representation, Estimation and Testing, Econometrica 55, 251-276.

Haug, A.A. (1996), Tests for Cointegration: A Monte Carlo Comparison, Journal of Econometrics 71.

Johansen, S. (1988a), Statistical Analysis of Cointegration Vectors, Journal of Economic Dynamics and Control, 12, 231-255.

Phillips, P.C.B. and S. Ouliaris (1990), Asymptotic Properties of Residual Based Tests for Cointegration, Econometrica, 58, 165-94.

Saikkonen, P. (1991), Asymptotically Efficient Estimation of Cointegrating Regressions, Econometric Theory, 7, 1-21.

Sims, C.A., J.H. Stock, and M.W. Watson (1990), Inference in Linear Time Series Models with Some Unit Roots, Econometrica 58, 113-144.

Stock, J.H. (1987), Asymptotic Properties of Least Squares Estimators of Cointegrating Vectors, Econometrica 55, 1035-1056.

Stock, J.H. and M.W. Watson (1993), A Simple Estimator of Cointegrating Vectors in Higher-Order Integrated Systems, Econometrica, 61 (1993), no. 4, 783-820.

*Watson, M.W. (1994), Vector Autoregressions and Cointegration, Handbook of Econometrics, v. IV, 2844-2915 (sections 1 and 2).

*Watson, M. W. (2008), Cointegration, The New Palgrave Dictionary of Economics. Second Edition. Eds. Steven N. Durlauf and Lawrence E. Blume. Palgrave Macmillan. The New Palgrave Dictionary of Economics Online. Palgrave

- **Vector Autoregressions.Impulse response functions, variance decompositions, inference**

*Lutkepohl, H., Introduction to Multiple Time Series Analysis, Second Edition. New York: Springer-Verlag, 1993, ch. 3.7

*Sims, C.A. (1980), Macroeconomics and Reality, Econometrica 48, pp 1-48.

Stock, J.H. and M.W. Watson (2001) Vector Autoregressions, Journal of Economic Perspectives 15 (Fall 2001), 101 116.

Watson, M.W. (1994), Vector Autoregressions and Cointegration, Handbook of Econometrics, v. IV, 2844-2915 (section 3 only).

Wright, J.H. (2000), Confidence Intervals for Univariate Impulse Responses with a Near Unit Root, Journal of Business and Economic Statistics 18, 368 373.

- **Inference for impulse responses**

Kilian, L. (2001). Impulse Response Analysis in Vector Autoregressions with Unknown Lag Order, Journal of Forecasting 20, 161-179.

Kilian, L. and P.-L. Chang (2000). How Accurate are Confidence Intervals for Impulse Responses in Large VAR Models?, Economics Letters 69, 299-307.

Sims, C.A. and T. Zha (1999), Error Bands for Impulse Responses, Econometrica 1113-1155