National Research University – Higher School of Economics

Applied Time Series Econometrics
Syllabus

Fall 2014

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Topics to be covered:

- Review of main characteristics of time series
- OLS estimation with lagged dependent variable
- Stationarity and nonstationarity
- Parameter instability and structural changes
- Stationary AR, MA, and ARMA processes
- Exponential smoothing
- Forecasting
- Autoregressive conditional heteroscedasticity
- Nonstationary processes and unit roots
- Spurious regressions
- Cointegration and error correction models
- ARIMA models
- Vector autoregressive models
- Vector error correction models
- Granger causality
- Nonlinear models
- Discrete-valued time series models

Topics may be added and/or dropped as the semester proceeds.

Course description:

Those of you who successfully complete this course will be familiar with a variety of methods for analyzing time series data and understand how they can be used for empirical work. Course focus is not on the technical details behind each method nor on mathematical proofs, but rather on the intuition behind the econometric techniques. You will obtain good working knowledge of EViews and free JMulTi software, which can be downloaded at http://www.jmulti.de/download.html. The principal forms of study are learning-by-doing and computer simulations of time-series phenomena. The course is taught in English.

Course organization:

There will be a lecture and a seminar in the computer class per week. Three homework assignments (mostly applied and computational) will be an essential part of the course. You are encouraged to work together to help each other in understanding the course material and completing the homework problems. However, everybody has to write up his/her own solutions. Late homework will not be accepted. We will discuss the common mistakes made in the homework assignments during the seminars. There will be one midterm 1-hour examination in the computer class and one 3-hour final examination consisting of two parts: paper-and-pencil and computational. The homework and exam solutions can be written in either English (recommended) or Russian (tolerated). Your feedback and suggestions during the course are more than welcome.

Textbooks:

Main (on your choice):

- Marno Verbeek "A Guide to Modern Econometrics." 3rd ed. John Wiley & Sons, 2008 (translated into Russian) - **Ve**
- Jack Johnston and John DiNardo "Econometric Methods." 4th ed. McGraw-Hill Companies, 2007 (more advanced) - **JD**
- Damodar Gujarati "Econometrics by Example." Palgrave Macmillan, 2011 - **Gu**

Additional (and optional):

- Walter Enders "Applied Econometric Time Series." 3rd ed. John Wiley & Sons, 2010 (written mostly for economists) - **En**
- Ruey Tsay "Analysis of Financial Time Series." 3rd ed. John Wiley & Sons, 2010 (written mostly for financial economists) - **Ts**
- Christopher Dougherty "Introduction to Econometrics." 4th ed. Oxford University Press, 2011 (more introductory level) – **Do**
- Peter Kennedy "A Guide to Econometrics." 6th ed. Blackwell Publishing, 2008 (one of the best econometric textbooks ever written– an excellent source of intuition, insights, skepticism and who-what-how-why-when guide) – **Ke**

Prerequisites:

A spark of curiosity and interest in time series econometrics; at least one course in statistics and econometrics, and/or familiarity with basic mathematical statistics, linear regression, OLS and ML estimations, heteroskedasticity and autocorrelation.

Evaluation:

- Homework 15%
- Midterm examination 25%
- Final examination 60%

Course details (material covered in 2013 class):

- Lecture 1. A rationale for time series modeling. Approaches to forecasting. Brief review of basic statistics (expectations, moments, correlations of random variables). Main characteristics of time series. (Partial) autocorrelation functions. Properties of AR and MA processes. Correlograms and Q-statistics.

  Readings: **Do** (R.2, R.4, 11.7), **JD** (7.1, 7.2), **Ve** (8.1), **Ts** (1.2, 2.2, 2.3)

- Lecture 2. Assumptions for regressions with time-series data. OLS estimation with lagged dependent variable. Autocorrelation of errors: consequences, detection (Durbin-Watson *d* test, Durbin *h* test, Wallis test, Breusch-Godfrey test) and remedies.

  Readings: **Do** (11.1, 11.5, 12.1, 12.2), **Ve** (4.6-4.11), **Gu** (6.1-6.3), **JD** (6.6), **Ke** (8.1, 8.2, 8.4, 10.2)

- Lecture 3. Stationarity and nonstationarity. Difference-stationarity and trend-stationarity. The random walk processes. Lag polynomial. Stationary ARMA processes. Spurious regressions.

  Readings: **Ve** (8.2), **Gu** (13), **Do** (13.1, 13.2), **En** (2.1-2.7, 4.1, 4.2), **Ts** (2.1-2.3), **JD** (7.2)

- Lecture 4. Testing for stationarity: graphical techniques and the formal unit root tests. (Augmented) Dickey-Fuller tests. Other tests of nonstationarity.

  Readings: **Ve** (8.3, 8.4), **Gu** (13), **En** (4.3-4.7, 4.9, 4.10), **Do** (13.3, 13.4), **Ts** (2.7), **JD** (7.3), **Ke** (19.5)

- Lecture 5. Identification, estimation and testing of ARIMA models. Forecasting with ARIMA models. Seasonality. Forecasting in general. Characteristics of forecasts. Subjective and objective forecasting methods. Measures of forecast errors.

  Readings: **Ve** (8.6-8.8), **En** (2.8-2.11), **Ts** (2.4-2.6), **JD** (7.4, 7.5), **Ke** (19.2, 20)

- Lecture 6. Time-varying volatility. Autoregressive conditional heteroskedasticity. ARCH model. GARCH model. Further extensions of ARCH and GARCH models.
  Readings: **Ve** (8.10), **Gu** (15), **En** (3.1-3.10), **Ts** (3.1-3.5), **JD** (6.9)

- Lecture 7. Parameter instability and structural changes. Testing for structural change. Structural changes and unit roots. Perron's test for structural change.
  Readings: **En** (2.12, 4.8), **JD** (4.3-4.5), **Do** (5.4), **Ke** (6.4)

- Lecture 8. Exponential smoothing. Additive and multiplicative seasonality. Deseasonalizing and forecasting seasonal series.
  Readings: "Time series forecasting using Holt-Winters exponential smoothing" by Kalekar; "The Holt-Winters approach to exponential smoothing: 50 years old and going strong" by Goodwin; **JD** (7.6), **Ts** (2.8)

- Lecture 9. Cointegration. Error correction models. Fitting models with nonstationary time series.
  Readings: **Ve** (9.1, 9.2, 9.3), **Gu** (14), **En** (6.1, 6.2), **Do** (13.5, 13.6), **Ts** (2.7), **JD** (8.3, 8.4), **Ke** (19.4, 19.6)

- Lecture 10. Vector autoregressive models. Granger causality. Instantaneous causality.
  Readings: **Ve** (9.4), **Gu** (16.4-16.6), **En** (5.5-5.6), **Ts** (8.1-8.2), **JD** (9.1-9.2), **Ke** (19.3)

- Lecture 11. Cointegration: the multivariate case. Tests for cointegration. Vector error correction models.
  Readings: **Ve** (9.5-9.7), **En** (6.1-6.9), **Ts** (8.5-8.6), **JD** (9.3), **Ke** (19.4, 19.6)

Sample list of questions for exams:

- Consider the following MA(2) process $y_t = u_t + u_{t-1} + 2u_{t-2}$, where u_t is white noise. Can it be written as an AR process? Explain.

- Consider a stationary MA(1) process $y_t = \phi_0 + \phi u_{t-1} + u_t$, where u_t is white noise (E(u_t) = 0, E(u_t u_{t-k}) = 0 for k=1,2,3,… and var(u_t) = σ^2). Compute the first-order autocorrelation ρ_1. in this process.

- In the case of linear time-series regression (without lagged dependent variables) with autocorrelated disturbances, OLS estimators of the slope coefficient β and its variance are biased, even asymptotically. True or False? Briefly explain why.

- ARIMA modeling is more accurate for long-term forecasting, whereas econometric structural modeling has more potential for short-term forecasting. True or False? Briefly explain why.

- Use US quarterly data for 1960Q1-2008Q2 period from the file Problem1 in order to estimate the dynamic interrelationships among industrial production, unemployment rate and interest rates. First, create a variable *spread* as the difference between the interest rate on 10-year US government bonds (*r10*) and the rate on three-month treasury bills (*Tbill*). Now create the logarithmic change in the index of industrial production (*ip*) *as* $\Delta lip_t = ln(ip_t) - ln(ip_{t-1})$ and the seasonal difference of the unemployment rate (*ur*) as $\Delta_4 ur_t = ur_t - ur_{t-4}$. Use three variables $spread_t$, Δlip_t and $\Delta_4 ur_t$ to do the following.
  a) Perform unit root tests for each variable. Report ADF test specification, test statistic, critical value or p-value, diagnostics and your conclusion. If necessary transform the variables to make all of them stationary. Report the order of integration for each variable.

  b) Using all available observations, estimate the three-variable VAR using nine lags and a constant. Make sure that your (adjusted) estimation period is [1963 Q2, 2008 Q1] with T = 180. Report the log likelihood. Report the values of AIC and BIC (aka Schwarz information criterion).

  c) Estimate the VAR model using two lags and a constant, using the same estimation period as in b). Report the log likelihood. Report the values of AIC and BIC.

  d) Which model (b or c) is selected by AIC? By BIC?

  e) Construct the likelihood ratio test for the null hypothesis of six lags against the alternative of two lags. How many restrictions are in the system? Report LR test statistics. Report critical value at 0.01 level. Conclude.

  f) Continue using two-lag model with a constant, using the same estimation period as in b). Perform diagnostics of the model. Report the p-values of the residual Portmanteau tests for autocorrelations up to 12 lags and your conclusion. Is your VAR well specified?