APPLIED TIME SERIES ECONOMETRICS

Module 2, 2024–2025

Professor: Stanislav Anatolyev
sanatoly@nes.ru

Course information

Course Website: my.nes.ru

Instructor's Office Hours: by appointment in Zoom

Class Time: TBA

Site: personal Zoom room https://nesuniversity.zoom.us/j/5445851559

TA: Anton Brennerman

Course description

The course is devoted to the modern applied time series analysis. First we will discuss principles of predictive time series modeling and review various model selection procedures. After that we will study popular models of conditional mean dynamics such as linear autoregressions and vector autoregressions as well as nonlinear structures like threshold, smooth transition and regime switching models. We will also explore such issues as stationarity and unit roots, and get acquainted with the notion of Brownian motion, which is useful in other contexts too. Then we will turn to modeling conditional variance and, more generally, volatility. We will also review modeling and forecasting other conditional objects, such as conditional density, conditional quantiles, and conditional directions. Finally, we will study methods of dealing with structural instability.

Course requirements, grading, and attendance policies

The course presumes the use of publications in applied time series and computer work. There will be 3 home assignments (45% of the grade) containing, apart from a limited number of analytical exercises, also readings and empirical work. One can use any software that seems most suitable for a problem at hand. The exam (70% of the grade) will contain analytical and conceptual questions. These components (including all the home assignments) are mandatory for getting a passing grade.

Course contents

I. Modeling methodology and model selection

- Structural and predictive time series modeling.
- Objects of dynamic modeling: conditional mean/variance/quantile/direction/density.
- Model selection: diagnostic testing, information criteria and prediction criteria. General-to-specific and specific-to-general methodologies. Testing for predictive ability.
- Predictability and testing for predictability.

II. Modeling conditional mean

- Stationary AR models: properties, estimation, inference, forecasting.
- Stochastic and deterministic trends, unit root testing. Brownian motion, FCLT.
- Nonlinear autoregressions: threshold autoregressions, smooth transition autoregressions, Markov switching models, state-space models.
- Stationary VAR models: properties, estimation, analysis and forecasting.
- VAR models with elements of nonlinearity.

III. Modeling conditional variance

- The class of ARCH models: properties, estimation, inference and forecasting.
- Extensions: GARCH, ARCH-in-mean, GARCH-t, IGARCH. Multivariate GARCH.

IV. Other topics on modeling and forecasting

- Analysis and testing of structural stability. Structural breaks. Monitoring.
- Realized measures: notions, modeling and prediction. HAR and MEM.
- Modeling and forecasting conditional density. ARCD modeling. Copulas.
- Modeling and forecasting direction-of-change. Autologit.
- Modeling and forecasting conditional quantiles. Value-at-risk and CAViaR.
- (If time allows) High frequency data models: ACD, UHF–GARCH.

Sample tasks for course evaluation

1. Test the unemployment rate for a unit root using the Augmented Dickey-Fuller test. Take a first difference of the unemployment rate. Perform the tests for mean and sign predictability. Fit the linear autoregression and threshold autoregression repeating Bruce Hansen's strategy. For the linear autoregression, compute and graph impulse responses and predictions with corresponding error bands. Fit the logistic smooth transition autoregression, including a test for linearity. Compute and graph impulse responses.
2. Analyze the Russian monthly unemployment series for structural breaks. Interpret. Split the unemployment sample into a 'retrospection portion' and 'monitoring portion'. Using a model with an intercept only and the OLS-based CUSUM and fluctuation tests, perform retrospection of structural stability with horizontal boundaries, and monitoring of structural stability with 'parabolic' and 'linear' boundaries.
3. Now make bivariate analysis of the Russian unemployment rate and inflation. Construct a suitable linear triangular SVAR. Compute and graph impulse responses. Extend the SVAR analysis to nonlinear triangular SVAR. Economically motivate your model.
4. Take a series of daily prices for an arbitrary but liquid individual stock for a long period of time and turn it to a series of log-returns. Graph the series, present and discuss its summary statistics. Run a test for ARCH effects. Then construct a good model of your choice from the ARCH family that would account for leverage effect and asymmetric and heavy-tailed conditional distribution.
5. Take long series of daily exchange rates (relative to the US$) of two frequently traded currencies. Estimate and interpret a DCC-GARCH(1,1) model. Show how the conditional correlation evolves over time.
6. Name a model mentioned in class that is ideologically (not necessarily technically!) close to the proposed model. What is that critical feature of the two models that makes them ideologically close?
7. Describe a possible application where non-financial time-series data are analyzed, and where it would be appropriate to apply a simplified version of the model presented in the article. Write out your model in full, and explain why each part of it is important for the series under analysis.

Course materials

Textbooks and materials

- Анатольев, Станислав (2013). Объекты неструктурного моделирования временных рядов, *Квантиль*, №11, стр. 1–11
- Hamilton, James (1994). Time Series Analysis, Princeton University Press, selected chapters
- Franses, Philip and Dick van Dijk (2000). Nonlinear Time Series Models in Empirical Finance, Cambridge University Press, selected chapters
- Tsay, Ruey (2005). Analysis of Financial Time Series, John Wiley & Sons, selected chapters

Additional materials on selected topics

- «Эконометрический ликбез: прогнозирование временных рядов», *Квантиль*, №1, сентябрь 2006 г., стр. 3–62, доступно на http://quantile.ru/01/N1.htm
- «Эконометрический ликбез: волатильность», *Квантиль*, №8, июль 2010 г., стр. 1–122, доступно на http://quantile.ru/08/N8.htm; *Квантиль*, №13, май 2015 г., стр. 3–14, доступно на http://quantile.ru/13/N13.htm
- «Эконометрический ликбез: временные ряды», *Квантиль*, №9, июль 2011 г., стр. 1–34, доступно на http://quantile.ru/09/N9.htm

Academic integrity policy

Cheating, plagiarism, and any other violations of academic ethics at NES are not tolerated.