Пермский филиал федерального государственного автономного образовательного учреждение высшего образования "Национальный исследовательский университет "Высшая школа экономики"

Программа учебной дисциплины
«Анализ временных рядов»
(Time series analysis)

Утверждена
Академическим советом основных образовательных программ по направлениям подготовки 38.03.01 Экономика, 38.04.08 Финансы и кредит

Протокол № 8.2.2.1-32-09/04 от 30.08.2019
Академический руководитель ОП
_____ Белых С.А.
Подпись ФИО

Разработчик	Шенкман Евгения Андреевна, старший преподаватель департамента экономики и финансов, НИУ ВШЭ – Пермь epopova@hse.ru
Число кредитов	4
Контактная работа (час.)	26
Самостоятельная работа (час.)	126
Образовательная программа, курс	ОП Экономика, 4 курс
Формат изучения дисциплины	На английском языке, с использованием онлайн курса

Syllabus

Time series analysis

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1. Course Description

A. Pre-requisites:

- Theory of Probability
- Mathematical Statistics
- Econometrics

B. Abstract

The course aims to provide students with a theoretical understanding of the basics of time series modeling and demonstrate their application on real data. This course is blended. Students learn theory from the online course "Macroeconometric forecasting" on the EDX platform, developed by the International monetary fund. On practical session, they will apply models to macroeconomic and financial data. The course begins with essentials of working with time series data. The next part of the course covers all basic time series models, such as: ARIMA, SARIMA, ARCH and GARCH, VAR and VECM. As a result of the course, student will make a project on real data: prepare data for analysis, choose appropriate model, apply it and interpret results. The practical session R language is applied, some basics of it are trained through DataCamp cources.

2. Learning objectives

The objective of the course is, that students should be able to:

- analyze economic data in accordance with the task, make preliminary data analysis;
- build appropriate econometric time series models for the research question, analyze and interpret results;
- understand limitation and relevance of the models.

3. Learning Outcomes

By the end of the course, a student develops the following competencies, where
GK – general competence
GPK – general professional competence

Code	Competencies
GK-2	Is able to identify the scientific nature of problems in the professional field
GK-3	Is able to solve problems in professional activities based on analysis and synthesis
GK-5	Is able to work with information: find, evaluate and use information from various sources, necessary to solve scientific and professional problems (including on the basis of a systematic approach)
GK-6	Capable of conducting research, including analyzing problems, setting goals and objectives, identifying the object and subject of research, choosing the type of research and methods of research, as well as assessing its quality
GPK-3	Is able to analyze socially significant problems and processes and predict their possible development in the future
GPK-11	Is able to collect, analyze and process statistical data, information, scientific and analytical materials needed to solve economic problems
GPK-12	Is able to choose tools for processing economic data in accordance with the task, analyze the results of calculations and substantiate the findings
GPK-13	Based on the description of economic processes and phenomena, is able to build theoretical and econometric models, analyze and meaningfully interpret the results obtained.
GPK-15	Is able to analyze and interpret data of domestic and foreign statistics on socio-economic processes and phenomena, to identify trends in socio-economic indicators
GPK-17	Is able to use modern hardware/software and information technologies for solving analytical and research problems.
GPK-22	Is able to organize the activities of a small group established to implement a specific economic project

4. Course plan

№	Topics	All hours	Lecture hours	Seminar hours	Self-study hours
Topic 1. Univariate time series analysis					
1	Stationary Time Series	24	-	4	20
2	Nonstationary Time Series	48	-	8	30
Topic 2. Mutivariate time series analysis					
3	Vector Autoregression (VAR)	34	-	4	20
4	Structural Vector Autoregression (SVAR)	36	-	4	30
5	Vector Error Correction Model (VECM)	48	-	6	26
Sum		**152**	**0**	**26**	**126**

Course plan in details

Topic 1. Univariate time series analysis

1. Stationary Time Series

Dealing with time series data. Concept of stationary and covariate-stationary series, autocorrelation and partial-autocorrelation functions, white Noise, autoregression models (AR), moving average (MA) models, ARMA models: properties, specification, estimation and forecasting. the Box–Jenkins methodology, diagnostic testing for model adequacy.

Topic 2. Nonstationary Time Series

Problems arise due to nonstationary, unit roots and characteristic relations, testing nonstationary: the Dickey–Fuller and augmented Dickey–Fuller tests, KPSS test and Philip-Pearson test; series transformation: differencing, selecting order of difference and ARIMA model. Dealing with seasonal data: series decomposition into stationary and trend and(or) seasonal component, Fourier decomposition and periodogram, SARIMA models. ARCH-GARCH model to deal with nonstationarity due to non-constant dispersion. Forecasting and forecasting errors.

Topic 2. Mutivariate time series analysis.

3. Vector Autoregression (VAR).

Reduced and structural VAR Forms, model estimation, model conditions, vector AR(p) models, vector moving average models, lag specific criteria: LM test, Granger causality test, exogeneity in a VAR, the impulse-response function, forecasting with VAR: dynamic, static, stochastic and deterministic solutions.

4. Structural Vector Autoregression (SVAR).

SVAR specification, comparison with reduced form VAR, structural impulse responses, Choleski decomposition, Blanchard-Quah decomposition, variance decomposition, identification strategies: recursive and non-recursive.

5. Vector Error Correction Model (VECM).

The concept of cointegration and LR relations, the Engle–Granger cointegration test, the Johansen full-information maximum likelihood cointegration test, VECM specifications and estimation, lag length and causality tests, forecasting with VECM.

5. Reading list

5.1. Required

1. Neusser, K. (2016). Time Series Econometrics. Springer, Cham (access by https://www.springer.com/us/book/9783319328614).
2. Palma W. (2016) Time Series Analysis. John Wiley & Sons, Incorporated (access by https://ebookcentral.proquest.com/lib/hselibrary-ebooks/detail.action?docID=4517503).

5.2. Optional

1. Shumway, R. H., & Stoffer, D. S. (2017). Time series analysis and its applications. Springer, Cham. (access by https://www.springer.com/gp/book/9783319524511).
2. Bleikh, H. Y., & Young, W. L. (2016). Time Series Analysis and Adjustment: Measuring, Modelling and Forecasting for Business and Economics. Routledge (access by https://www.taylorfrancis.com/books/9781315550954)

3. Montgomery, D. C., Jennings, C. L., & Kulahci, M. (2015). Introduction to time series analysis and forecasting. (access by https://ebookcentral.proquest.com/lib/hselibrary-ebooks/detail.action?docID=1895570#)

6. Grading system

There are several assessed activities within course. Theoretical knowledge of the main concepts and models are evaluated through 2 tests. Each test is assessed on a 10 point scale.

The teacher assesses a self-study students' work (details in Appendix 1):

- written report of performed tasks in class; 10 point scale grade ($O_{reports}$) is calculated as an average grade of all reports;
- fulfilment of tasks in datacamp. Each fulfillment task before deadline gives 2 point, Each fulfillment task after deadline gives 1 point. The whole grade (O_{DC}) is calculated as a sum and then converted to 10 point scale.

And **the resulting course grade** is calculated as follows:

$$O_{result} = 0{,}1 * O_{test1} + 0{,}1 * O_{test2} + 0{,}1 * O_{DC} + 0{,}4 * O_{reports} + 0{,}3 * O_{exam}$$

with O_{exam} – a grade for the exam on a 10 point scale, O_{test1}- a grade for test 1, O_{test2}- a grade for test 2, O_{DC}- a grade for fulfilment of tasks in datacamp, $O_{reports}$- a grade for written reports.

7. Examination type

Final student assessment (exam) is a project of team of no more than 2 people. The project should be based on a dataset with variables that are time series. Within the project should be applied one of the following model's type: ARIMA dealing with seasonality, the autoregressive conditional heteroskedasticity (ARCH or GARCH) model, the vector autoregressive model (VAR), the structural vector autoregressive model (SVAR) or the vector error correction model (VECM). The dataset can be related to students' course works.

As a result of the project each team write down the report which contains R script, which is replicating the results. The final presentation of result is up to the lecturer. The grade for the exam includes the grade for the report and for lecturer or audience questions. If report is not rendered or R script is not rendered, then the exam grade will be 0.

The project report should include:

1. Research question (its description and actuality), for example, forecasting with explanation for whom it can be important;
2. All necessary pretesting with interpretation (stationarity, ACF or PACF, the choice of lags etc);
3. Apply chosen model:
    a. Write down equation;
    b. Interpret coefficients
    c. Estimate model coefficients and conclude about quality of the model;
    d. Interpret the results;

4. Conduct all necessary posttesting (usually about residuals) and conclude about quality model
5. Conclusion (answering the research question).

Possible project topics:

- Index arbitrage and nonlinear dynamics between the S&P 500 futures and cash;
- The relationships between trade and labor productivity in different countries;
- Energy consumption, economic growth and prices for developed and developing countries;
- Forecasting cryptocurrency returns;
- etc.

8. Methods of Instruction

Students prepare to each seminar by learning video lectures. Each seminar starts with oral questioning about basic concepts and models, that student learned from video lectures. At the rest part of seminar students apply models to real data. The lecturer should make emphasis on interpretation of models.

9. Special Equipment and Software Support

Software that is essential for the course is:

- Statistical package R (http://r-project.org/) and its libraries;
- RStudio (http://rstudio.com/).

The course is conducted with the use of projector for seminar classes and group project presentations. Course materials, requirements for the final exam are posted on lms.hse.ru.

Appendix 1.

Self-study work

Task 1
Students learn material through online lectures in the course Macroeconometric forecasting" on Edx platform (https://www.edx.org/course/macroeconometric-forecasting-0)

Task 2
After each seminar session student prepare report of performed tasks in a written from

Task 3
During the course students perform tasks on DataCamp platform to master programming skills in R. The tasks can be found by the following links:

- Chapter 1 in DataCamp course "Working with Dates and Time" (https://www.datacamp.com/courses/working-with-dates-and-times-in-r)
- Chapter 1 in DataCamp course "Manipulating Time Series Data in R with xts & zoo" (https://www.datacamp.com/courses/manipulating-time-series-data-in-r-with-xts-zoo)
- Chapter 1-2 in DataCamp course "Visualizing Time Series Data in R" (https://www.datacamp.com/courses/visualizing-time-series-data-in-r)