200610 - ST - Time Series

Coordinating unit: 200 - FME - School of Mathematics and Statistics
Teaching unit: 715 - EIO - Department of Statistics and Operations Research
Academic year: 2017
Degree: MASTER'S DEGREE IN STATISTICS AND OPERATIONS RESEARCH (Syllabus 2013). (Teaching unit Optional)
ECTS credits: 5
Teaching languages: Spanish

Teaching staff
Coordinator: JOSEP ANTON SÁNCHEZ ESPIGARES
Others: Segon quadrimestre:
LESLEY MARIA ACOSTA ARGUETA - B
JOSEP ANTON SÁNCHEZ ESPIGARES - A, B

Opening hours
Timetable: Office hour by appointment

Prior skills
The course assumes basic levels of statistics similar to those that can be achieved in the first semester of the Master. Students should be familiar with the concepts related with statistical models, like linear models, and hypothesis testing and statistical significance.
Some basic concepts related to the Box-Jenkins methodology for fitting ARIMA models would help to follow the course (see the three first chapters of ‘Time Series Analysis and Its Applications. With R examples’ 3rd Edition Shumway and Stoffer http://www.stat.pitt.edu/stoffer/tsa3/).
Although many examples come from the econometric field, methodology from the course might be applied in different areas (ecology, epidemiology, engineering,...)
Methods of prediction based on Machine Learning techniques, in particular artificial neural networks (ANNs) will be treated.
The course will introduce techniques related with state-space models and the Kalman filter. Prior basic knowledge of this framework will also help to follow the course, but it is not essential.
A good knowledge of the R programming language can help to get the most out of the course.

Requirements
Knowledge about the linear model will be useful

Degree competences to which the subject contributes

Specific:
3. CE-2. Ability to master the proper terminology in a field that is necessary to apply statistical or operations research models and methods to solve real problems.
4. CE-3. Ability to formulate, analyze and validate models applicable to practical problems. Ability to select the method and / or statistical or operations research technique more appropriate to apply this model to the situation or problem.
5. CE-5. Ability to formulate and solve real problems of decision-making in different application areas being able to choose the statistical method and the optimization algorithm more suitable in every occasion.
Translate to english
200610 - ST - Time Series

6. CE-6. Ability to use appropriate software to perform the necessary calculations in solving a problem.

Transversal:

1. ENTREPRENEURSHIP AND INNOVATION: Being aware of and understanding how companies are organised and the principles that govern their activity, and being able to understand employment regulations and the relationships between planning, industrial and commercial strategies, quality and profit.
2. EFFECTIVE USE OF INFORMATION RESOURCES: Managing the acquisition, structuring, analysis and display of data and information in the chosen area of specialisation and critically assessing the results obtained.

Teaching methodology

* Theory:

Sessions (1,5h) with presentation and discussion of the theoretical aspects and case studies from the time series methodology. All material will be accessible on the website.

* Laboratory:

Sessions (1,5h) on computer labs with problem solving and case studies and discussion of the results with the teacher.

* Practicals:

Off-site study work, completion of exercises and practical case studies. Group work outside of lecture hours, the students must complete practical case studies, two of which are presented in laboratory sessions.

At the end of the course, each group of students must prepare a written report on actual data.

Learning objectives of the subject

To acquire experience in the methodology for constructing models and obtaining forecasts from true (o millor actual) cases of time series within different fields, especially in econometric and financial applications.

Identification, estimation and validation of a model for making forecasts from available data in a time series. ARIMA and VAR models.

Consolidation of theoretical knowledge and practice in modeling univariate and multivariate time series, as well as evaluation of the impacts of intervention and outliers and calendar effects.

Apply and evaluate the predictions obtained through artificial neural networks.

Understanding the formulation of state space models and the Kalman filter for explaining the evolution of non-observable variables from others, in relation to them, that indeed we can observe.

Use of structural models in state space formulation in order to identify components that are not directly observable in time series.

Introduction to volatility models for econometric series and of the financial markets.

Skills to be learned
200610 - ST - Time Series

Understanding of the particularities that are present in time series, in which one singular observation is made each instant of time and it is related to the past, that is to say they are not independent.

Use of R and other statistical packages for analysis and time series forecasts.

Learning to work in a group and the ability to publicly present the results of a study.

### Study load

<table>
<thead>
<tr>
<th>Total learning time: 125h</th>
<th>Hours large group:</th>
<th>22h 30m</th>
<th>18.00%</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>Hours medium group:</td>
<td>0h</td>
<td>0.00%</td>
</tr>
<tr>
<td></td>
<td>Hours small group:</td>
<td>22h 30m</td>
<td>18.00%</td>
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<td></td>
<td>Guided activities:</td>
<td>0h</td>
<td>0.00%</td>
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<tr>
<td></td>
<td>Self study:</td>
<td>80h</td>
<td>64.00%</td>
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## Content

### Analysis and modeling of univariate time series. ARIMA models. ARIMA forecasting models

**Learning time:** 36h  
Theory classes: 6h  
Laboratory classes: 6h  
Self study: 24h

**Description:**  
- Exploratory study of a time series: trend, seasonality and cycles. Data Transformation  
- Dynamic Dependency: autocorrelation and partial autocorrelation  
- Stationary stochastic processes. ARMA models. Invertivilitat and stationary model  
- Non-stationary stochastic processes. ARIMA and Seasonal ARIMA models.  
- Identification, estimation and model validation. Criteria for selecting the best model  
- Forecasting with ARIMA models

### Outlier, Calendar Effects and Intervention Analysis

**Learning time:** 16h  
Theory classes: 3h  
Laboratory classes: 3h  
Self study: 10h

**Description:**  
- Techniques and Algorithms for the Automatic outlier detection, Calendar effects analysis (Easter and Trading days) and Intervention analysis

### Machine Learning-based Forecasting methods

**Learning time:** 7h  
Theory classes: 1h 30m  
Laboratory classes: 1h 30m  
Self study: 4h

**Description:**  
- Forecasting Methods based on Machine Learning: Artificial Neural Networks and Support Vector Regression  
- Validation and sensitivity analysis. Measures to compare with statistical models
## Exercises and problems presented, cases developed for each group of students, plus partial and final exams.

Final grade will be the result of the following formula:

\[ N = 0.2 \times Np + 0.15 \times Nl + 0.15 \times Nmr + 0.5 \times Nf \]

- **Np**: Midterm exam
- **Nl**: Two Homeworks from the labs sessions
- **Nmr**: Model from a real case
- **Nf**: Final Exam

## Qualification system

Exercises and problems presented, cases developed for each group of students, plus partial and final exams.

### Applications of the Kalman Filter

<table>
<thead>
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<tbody>
<tr>
<td>Theory classes: 6h</td>
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<tr>
<td>Laboratory classes: 6h</td>
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<tr>
<td>Self study: 24h</td>
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**Description:**
- Use of the Kalman Filter for filtering and smoothing data and for Estimating Parameters.
- ARMA and ARIMA models representation in State Space and Estimating the Maximum Likelihood of the Parameters in a Univariate and Multivariate Series.
- Missing data treatment by using the Kalman filter

### Structural Models in State Space

<table>
<thead>
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<th>Learning time: 7h 30m</th>
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<tr>
<td>Theory classes: 3h</td>
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<tr>
<td>Laboratory classes: 3h</td>
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<tr>
<td>Self study: 1h 30m</td>
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**Description:**
Structural Time Series models: estimation and validation.

### Introduction to Volatility Models

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<tr>
<td>Theory classes: 3h</td>
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<tr>
<td>Laboratory classes: 3h</td>
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<tr>
<td>Self study: 1h 30m</td>
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**Description:**
Bibliography

Basic:


Complementary:


