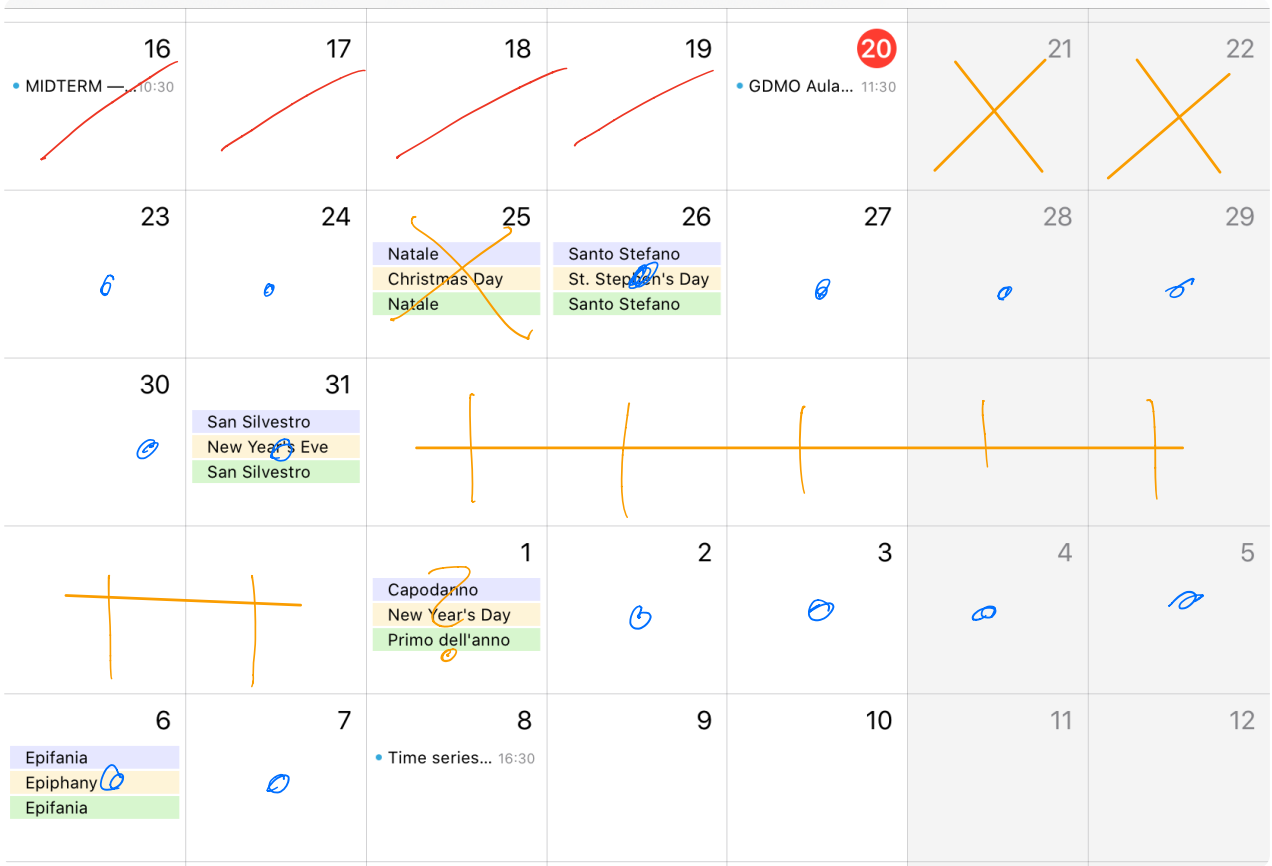

14 GIORNI TOTALI

11 ARGOMENTI → 2 X GIORNO

PRIMA DEL 30 FINIRE TEORIA!!

DOPO IL 30 ESERCIZI

5 GG ESERCIZI

6/7 GG TEORIA

1/2 GG RIPASSO

B-74-3-B Time Series Econometrics

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Syllabus and General information
Autumn term 2019
Update 28 October 2019

Warning: the information in this sheet is provisional and will be updated as the module progresses. Please make sure you always check to see if you have the most up-to-date file.

Module Leader:
Professor Fabrizio Iacone
e-mail: fabrizio.iacone@unimi.it

Intended Audience
This module is part of Module B-74-3.19.1, Micro-econometrics, Causal Inference and Time Series Econometrics. It is designed for students of the Laurea *Magistrale* (Master), *Data Science and Economics*.

Credit Value
6 Credits

Web page:
All relevant information, including the Syllabus, additional teaching material, further communication including the office and feedback hours will be announced on the dedicated page on ARIEL (https://ariel.unimi.it/); please, check it regularly.

Assessment
There is a final compulsory exam. The exam covers all the topics presented during the (including the computer sessions) and it consists of a series of open-ended questions which may include calculations and/or explanation and/or technical analysis. It may also include some Multiple-choice questions. Further information regarding the format of the exam will be communicated as the module progresses.

At this point, I am also considering the possibility of a practical mini-project, to be completed by the end of the 2019 Autumn term.

A Sample exam paper (Specimen paper) will be available on ARIEL at some point during the term.

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Learning Objectives.

A great variety of physical and economic data are in the form of time series. Typical objectives include:

- Identify the effect of past shocks on the current state of the world: were the shocks transitory or permanent? How much of a past shock is still relevant today?
- Forecasting future values

For multivariate time series, we are also interested in

- Modelling the dynamic interaction between different series.

Much empirical literature in macroeconomics uses time series. By the end of the module you should have a working knowledge to understand the techniques used in this literature.

Learning outcomes.

By the end of the module you will be able to:
Understand the difference between a time series and an independent random sample.
Apply non-parametric and parametric techniques to model time series.
Choose and estimate parametric models for time series.
Compute the impulse response function.
Forecast future values.

Topics overview (this is not a Syllabus)**:**

Topics will include.

- Definition of univariate time series.
- Non-parametric characterisation.
- Ergodicity and stationarity as generalisation of the iid framework.
- Inference for stationary and ergodic processes.
- Forecasting for stationary processes and forecast evaluation.
- Parametric modelling of weakly dependent univariate time series (ARMA modelling). Impulse response functions for ARMA.
- Inference in ARMA modelling.
- Forecasting with ARMA models.
- Model selection: parsimonious modelling.
- Parametric modelling of strongly dependent univariate time series: unit root modelling. Forecasting with unit roots.
- Unit root testing.
- Multivariate modelling: VARMA and VAR modelling for weakly autocorrelated time series. Impulse response function for VARs.
- Identification and estimation in VAR models.
- Regression models for weakly dependent and unit root multivariate time series
- Cointegration.
- Error Correction Models VECM
- Forecasting for multivariate time series.
- Large dimensional weakly dependent time series: estimation and forecasting of factor models.

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References

The main reference textbook for the course is:

Time Series Analysis, by J. D. Hamilton, 1994, Princeton University Press.

Other main references may be mentioned as the course progresses.

Other references

Brockwell, Peter J; Davis, Richard A. (2002). Introduction to time series and forecasting. New York: Springer

Pdf presentations will also be available on the ARIEL website. Pdf presentations represent a guide to the different subjects. They are neither complete nor exhaustive; they integrate but not replace the reference book and class attendance.

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Syllabus

This is a preliminary list of the topics discussed in the module. **NOTE: THE LIST IS NOT COMPLETE** Appropriate references to the relevant item(s) in the reading list are given at the beginning of each lecture and are written in the slides.
Please be aware that the time devoted to each topic and the list of subjects may change according to the requirements of the course. Please notice that there is no coincidence between the points of this plan and the lectures; some topics may take more than one session and *vice versa*.

1. Introduction

Moments (H, Appendix 5 and Chapter 3);
Lag & Difference operators (H, Chapter 2);
Stationarity (definition) (H, Chapter 3);
Ergodicity (definition) (H, Chapter 3);
Autocovariance (definition) (H Chapter 3);
Wold decomposition (H, Chapter 4);
Impulse Response Function (H Chapter 1 and 11);
Autocorrelation (definition) (H Chapter 3);
Partial autocorrelation (definition) (H, Chapter 4);
Forecasting and linear projection (H, Chapter 4);
Forecast evaluation (DM)

.

2. ARMA Models

White noise (H, Chapter 3; BD, Chapter 1);
MA(1) model (H, Chapter 3; BD Chapter 1&2);
MA(q) model (H, Chapter 3; BD Chapter 2&3);
MA(∞) model (H, Chapter 3);
AR(1) model (H, Chapter 3; BD, Chapter 1&2);
AR(2) model (H, Chapter 3; BD, Chapter 1&3);
AR(p) model (H, Chapter 3; BD, Chapter 3);
ARMA(1,1) model (H, Chapter 3; BD, Chapter 2&3); ARMA(p,q) model (H, Chapter 3; BD, Chapter 3);

3. Transformations of ARMA Models,

linear filters (H, Chapter 3; BD, Chapter 2&3) sum of ARMA processes (H, Chapter 4);

4. Estimation - 1

Sample Moments (H Chapter 7)
Estimation from the correlogram (BD Chapter 5)

5. Estimation - 2

Exact Maximum Likelihood estimation (H, Chapter 5)
Conditional Maximum Likelihood estimation (H, Chapter 5)
Optimisation of the (Pseudo) Maximum Likelihood (H, Chapter 5)[1]

6. Asymptotic properties of the estimates

Asymptotic properties of the sample mean (H, Chapter 7; BD Chapter 2)
Asymptotic properties of the sample autocorrelations (BD Chapter 2)
Asymptotic properties of the estimates based on the autocorrelation function (BD, Chapter 5)
Asymptotic distribution of the OLS/CML estimates in an AR(p) (H, Chapter 8)

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Asymptotic distribution of (Pseudo) Maximum Likelihood estimates (H, Chapter 5; BD, Chapter 5)[2]

7. Model selection
Test of randomness on the sample autocorrelation (H, Chapter 4; BD Chapter 1)
Portmanteau test (BD Chapter 1)
Model validation, Portmanteau statistic (BD, Chapter 1)
Order selection (BD, Chapter 5)
Parsimonious modelling (H, Chapter 4; BD, Chapter 5)
Models of non-stationary time series (H, Chapter 4 &15; BD, Chapters 1&6)
Deterministic trends and other deterministic components (H, Chapter 16; BD, Chapters 1&6)
Unit roots / Integrated processes (H, Chapters 15&17; BD, Chapters 1&6)

8. Unit root tests
Brownian motion (H, Chapter 17)
Functional central limit theorem (H, Chapter 17)
Limit properties of the sample mean of a random walk (H, Chapter 17)
Limit properties of the OLS estimate of the autoregressive parameter in a random walk (H, Chapter 17)
Limit properties of the t statistic associated to the OLS estimate of the autoregressive parameter in a random walk (H, Chapter 17)
The Dickey Fuller test for a unit root in a random walk, Case 1 (H, Chapter 17; BD, Chapter 6)
The Dickey Fuller test for a unit root in a random walk, Case 2 (H, Chapter 17; BD, Chapter 6)
The Dickey Fuller test for a unit root in a random walk with drift, Case 3 (H, Chapter 17)
The Dickey Fuller test for a unit root in a random walk with drift, Case 4 (H, Chapter 17)
Choice of the unit root test (H, Chapter 17)
Augmented Dickey Fuller test for a unit root when the disturbances have a stationary AR(p) structure: Case 1, Case 2, Case 3, Case 4 (H, Chapter 17; BD, Chapter 6) Choice of the order p in the ADF test (H, Chapter 17)
Phillips-Perron tests for a unit root in a generic $I(1)$ process (H, Chapter 17)

9. Regressions with I(0) and I(1) processes
Inference on the mean for $I(0)$ processes
Regression with stationary and invertible ARMA processes (H, Chapter 8; BD, Chapter 6)
Spurious regression for $I(1)$ processes (H, Chapter 18)
Cointegration for $I(1)$ processes (H, Chapter 19)
Testing for cointegration with the ADF test (H, Chapter 19)

10. Vector Autoregressions
Vector White Noise, Vector ARMA, (H, Chapter 10)
Inference for VARs, (H, Chapter 11)
Granger- causality, (H, Chapter 11)
Impulse Response Function, (H, Chapter 11)
Structuralised IRF, (H, Chapter 11)
Forecast error variance decomposition (H, Chapter 11)

11. Vector Error Correction (topics to be included later)
Unit root VARs (H, Chapter 18)
Triangular representation (H, Chapter 19)
Vector Error Correction (H, Chapter 19)
Testing hypotheses in the cointegration vector (H, Chapter 19 and Chapter 20)
Estimation of the cointegration rank (H, Chapter 20).

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12. Factor Analysis (topics to be included later)

Notes

1) The Newton-Raphson procedure is part of the Syllabus, but it is not examinable. However, you must still know that the optimization of the loss function requires a numerical procedure, and for this is important to select a starting value appropriately. A discussion of why the correlogram based estimate could be that appropriate starting value is also part of the syllabus.

2) The derivation (proof) of the asymptotic distribution of the generic CML estimate is part of the Syllabus but it is not examinable (Exception: the proof for the AR(p) is examinable). However, you must still be familiar with the limit properties of the estimates, and apply them appropriately.

3) H is "Hamilton, James D (1994). Time series analysis. Princeton University Press"; BD is "Brockwell, Peter J; Davis, Richard A. (2002). Introduction to time series and forecasting. New York : Springer".

Other References: DM is Diebold, F.X., and R.S. Mariano, 1995. Comparing predictive accuracy, *Journal of Business and Economic Statistics*, 20, 134-144.

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