University of Gdańsk

Subject card

Subject name and code	Time Series Analysis, PG_00102830						
Field of study	Mathematical Modeling and Data Analysis						
Date of commencement of studies	October 2023		Academic year of realisation of subject	2025/2026			
Education level	Bachelor's studies		Subject group				
Mode of study	full-time studies		Mode of delivery	at the university			
Year of study	3		Language of instruction	Polish			
Semester of study	5		ECTS credits	5.0			
Learning profile	academic		Assessment form	exam			
Conducting unit							
Name and surname of lecturer (lecturers)	Subject supervisor		dr Marta Frankowska				
	Teachers						
Lesson types	Lesson type	Lecture	Tutorial	Laboratory	Project	Seminar	SUM
	Number of study hours	30.0	0.0	30.0	0.0	0.0	60
	E-learning hours included: 0.0						
Learning activity and number of study hours	Learning activity	Participation in didactic classes included in study plan		Participation in consultation hours		Self-study	SUM
	Number of study hours	60		0.0		0.0	60
Subject objectives	To familiarise students with the basics of theory relating to time series, to provide a working knowledge of the methods of estimating the parameters of selected models, the predictions in these models and their use in the analysis of real data.						

Learning outcomes	Course outcome	Subject outcome	Method of verification
	[MMiADL3_U09] is able to use the learned software package or the learned programming language to solve selected problems from the known fields, in particular from mathematical analysis, linear algebra and statistics	Students will be able to (using one of the available statistical packages): - decompose a time series, perform stationarity tests on a time series and interpret the results, - interpret the autorelation function (ACF) and partial autorelation function (PACF), - estimate parameters of ARIMA models and obtain forecasts in this model, -using, inter alia, information criteria, select the optimum among ARMA, SARIMA, GARCH, ARMA-GARCH models, generate forecasts from these models and interpret them	[SU2] presentation/project/paper/ report
	[MMiADL3_U04] correctly uses the concepts of probability theory and statistics, is able - at a simple and medium level of difficulty - to apply the theorems and methods of these fields, and is able to interpret the results obtained	Students will be able to (using one of the available statistical packages): - decompose a time series, perform stationarity tests on a time series and interpret the results, - interpret the autorelation function (ACF) and partial autorelation function (PACF), - estimate parameters of ARIMA models and obtain forecasts in this model, -using, inter alia, information criteria, select the optimum among ARMA, SARIMA, GARCH, ARMA-GARCH models, generate forecasts from these models and interpret them	[SU2] presentation/project/paper/ report [SU4] test/exam - oral or written
	[MMiADL3_K10] is ready to analyse data and communicate the conclusions of such analysis in an accessible form	The student is ready to recognise the importance of knowledge in solving cognitive and practical problems and to communicate conclusions in an accessible form.	[SK8] observation of student's independent or team work
	[MMiADL3_K03] is ready to work in a team; understands the need for systematic work on all projects that have a long-term character	The student is ready to: work in a team, understands the necessity to work systematically on any projects that are long-term in nature.	[SK2] presentation/project/paper/ report [SK8] observation of student's independent or team work
	[MMiADL3_U13] knows how to use computer programmes in the field of data analysis	Students will be able to (using one of the available statistical packages): - decompose a time series, perform stationarity tests on a time series and interpret the results, - interpret the autorelation function (ACF) and partial autorelation function (PACF), - estimate parameters of ARIMA models and obtain forecasts in this model, -using, inter alia, information criteria, select the optimum among ARMA, SARIMA, GARCH, ARMA-GARCH models, generate forecasts from these models and interpret them	[SU2] presentation/project/paper/ report
	[MMiADL3_W07] knows and understands the construction of mathematical theories, can use mathematical formalism to build and analyse simple mathematical models in other fields of science	The student knows and understands: - the concept of stationarity of a time series, - time series decomposition methods, - autoregressive (AR) processes, moving average (MA), ARIMA models and their properties, - ARCH/GARCH processes and their properties.	[SW4] test/exam - oral or written

Course outcome	Subject outcome	Method of verification
[MMiADL3_W09] knows and understands the basics of computational and programming techniques supporting mathematician's work and understands their limitations	The student knows and understands: - the concept of stationarity of a time series, - time series decomposition methods, - autoregressive (AR) processes, moving average (MA), ARIMA models and their properties, - ARCH/GARCH processes and their properties.	[SW4] test/exam - oral or written [SW2] presentation/project/paper/ report

Subject contents

- Components and decomposition of a time series - trend, seasonality, random component.
- Autoregressive processes AR(p) and their properties.
- Moving average processes MA(q) and their properties.
- Autocorrelation and partial autocorrelation function (ACF, PACF), Ljung-Box test.
- Autoregressive and moving average ARMA(p,q) processes - estimation of model parameters.
- Forecasting in ARMA and ARIMA models.
- Modelling conditional variance - GARCH(p,q) models.
- Prediction in ARMA(p,q) models.
- Model selection using model diagnostics and information criteria.

Prerequisites and co-requisites

Knowledge of probability calculus.

Assessment methods and criteria

Subject passing criteria	Passing threshold	Percentage of the final grade
observation of the student's attitude	100.0%	0.0%
written exam	51.0%	60.0%
project	51.0%	40.0%

Recommended reading

Basic literature	1. Time Series Analysis and Its Applications, With R Examples, Robert H. Shumway, David S. Stoffer, Springer 2. Analysis of financial time series, R. Tsay, John Wiley & Sons, Inc., New York 3. Introduction to time series and forecasting, P.J. Brockwell, R.A. Davis, Springer-Verlag, New York
Supplementary literature	Quantitative Risk Management, Alexander J. McNeil, Rudiger Frey,Paul Embrechts, Princeton University Press
eResources addresses	

Example issues/ example questions/ tasks being completed	1. Concept of time series. Examples of time series: white noise, iid, random walk, random walk with drift, model with trend, etc. 2. Definition of weakly and strictly stationary process and examples of series that are/are not weakly/ strictly stationary. Justify that a process is/is not stationary. 3. Definition and properties of theoretical autocovariance,autocorrelation and partial autocorrelation functions and their estimators. Properties of the estimators. 4. Process MA(1) - definition, proof of stationarity, calculation of autocovariance and autocorrelation functions. 5. AR(1) process - definition, stationarity condition (with proof), calculation of autocovariance and autocorrelation functions, properties, Wold's form. 6. Decomposition of a time series into trend, seasonality and random component. Methods of elimination/ estimation of trend and seasonality. 7. Definition of process: q-dependent, q-correlated and linear. 8. MA(q) processes - definition, properties, autocovariance and autocorrelation and partial autocorrelation. Proofs of formulas for q=1. 9. AR(p) processes - definition, properties, autocovariance and autocorrelation, and partial autocorrelation. Proofs of formulas for p=1. 10. Definition of MA(infinity) process. 11. ARMA(p,q) processes - definition, stationarity condition, causality (casuality) and invertibility (innvertibility), autocorrelation and partial autocorrelation. Proofs for p=1 and q=1. 12. Forecasting: best linear predictors, Durbin-Levinson algorithm (relation to PACF), Innovation Algorithm. 13. Wold's decomposition. 14. Yule-Walker equations. 15. Parameter estimation of ARMA(p,q) models. Preliminary estimation: the Yule-Walker method (proof), Burg's Algorithm, Innovation Algorithm (proof), Hannan-Rissanen Algorithm - which method for which model? Proper estimation: the Method of Greatest Reliability with details and the Method of Least Squares. 16. Seasonal ARMA models (definitions) and non-stationary ARIMA and SARIMA models (definitions). 17. Diagnostics. Diagnostics of model residuals: graphs (what kind and how to interpret them), how the ACF function should behave, what formal tests of randomness of residuals we perform (test description, null hypothesis and test statistic), verification of normality of residuals (graphs and test - what kind?). Information criteria, significance analysis of coefficients and criteria for assessing the accuracy of predictions. 18. ARCH(p) and GARCH(p,q) models - definition, application.
Work placement	Not applicable

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