

Syllabus

Generalized Linear Models

2 credits/4 ECTS

Prof. Dr. Thomas Gautschi

Video lecture by
Prof. Dr. Thomas Gautschi

February 10 – April 7, 2025

Short Course Description

The main focus of this course lies on the introduction to statistical models and estimators beyond linear regression useful to social and economic scientists. It provides an overview of generalized linear models (GLM) that encompass non-normal response distributions to model functions of the mean. GLMs thus relate the expected mean $E(Y)$ of the dependent variable to the predictor variables via a specific link function. This link function permits the expected mean to be non-linearly related to the predictor variables. Examples for GLMs are the logistic regression, regressions for ordinal data, or regression models for count data. GLMs are generally estimated by use of maximum likelihood estimation. The course thus not only introduces GLMs but starts with an introduction to the principle of maximum likelihood estimation. A good understanding of the classical linear regression model is a prerequisite and required for the course.

Course Objectives

By the end of the course, students will...

- Understand how to appropriately translate research question into statistical models
- Be able to apply statistical models appropriate for non-linear problems
- Estimate regression parameters using the maximum likelihood principle
- Perform hypothesis tests for regression models using the maximum likelihood principle
- Be able to identify limitations of non-linear regression models
- Be able to identify violations of the respective regression assumptions of the discussed GLMs

Prerequisites

A sound understanding of linear regression models (OLS) is required. Knowledge in linear algebra and calculus is useful.

Class Structure and Course Concept

This is an online course, using a flipped classroom design. It covers the same material and content as an on-site course but runs differently. In this course, you are responsible for watching video-recorded lectures and reading the required literature for each unit prior to participating in mandatory weekly one-hour online meetings where students have the chance to discuss the materials from a unit with the instructor. Just like in an on-site course, homework will be assigned and graded and there will be a final exam at the end of the course.

Although this is an online course where students have more freedom in when they engage with the course materials, students are expected to spend the same amount of time overall on all activities in the course – including preparatory activities (readings, studying), in-class-activities (watching videos, participating in online meetings), and follow-up activities (working on assignments and exams) – as in an on-site course. As a rule of thumb, you can expect to spend approximately 3h/week on in-class-activities and 9 hours per week on out-of-class activities (preparing for class, readings, assignments, projects, studying for quizzes and exams). Therefore, the workload in all courses will be approximately 12h/week. This is a 2-credit/4ECTS course that runs for 8 weeks. Please note that the actual workload will depend on your personal knowledge.

Mandatory Weekly Online Meetings

Sec. 1: Mondays, February 10 – April 7 2025, 12 pm ET/6 pm CET - 1 pm ET/7 pm CET

Meetings will be held online through Zoom. Follow the link to the meeting sessions on the course website on <https://umd.instructure.com/> video participation via Internet is not possible, arrangements can be made for students to dial in and join the meetings via telephone.

In preparation for the weekly online meetings, students are expected to watch the lecture videos and read the assigned literature before the start of the meeting. In addition, students are encouraged to post questions about the materials covered in the videos and readings of the week in the forum before the meetings (deadline for posting questions is Sunday, 5:00 PM ET/11:00 PM CET).

Students have the opportunity to use the BigBlueButton feature in Canvas to connect with peers outside the scheduled weekly online meetings (e.g., for study groups). Students are not required to use BigBlueButton and can of course use other online meeting platforms such as Google Hangouts, Skype or Microsoft Teams.

Grading

Grading will be based on:

- 7 homework assignments (49% of grade total, 7% each)
- Participation in online meetings and submission of questions
- Demonstrating understanding of readings (10% of grade)
- Final Exam (41% of grade)

Students must get a 70% or higher in order to pass the class.

A+ 100 - 97
A 96 - 93
A- 92 - 90

B+ 89 - 87
B 86 - 83
B- 82 - 80
Etc.

Variations for grading on a scale are at the discretion of the instructor.

The final grade will be communicated under the assignment "Final Grade" in the Canvas course. Please note that the letter grade written in parentheses in Canvas is the correct final grade. The point-grade displayed alongside the letter grade is irrelevant and can be ignored.

Dates of when assignment will be due are indicated in the syllabus. Extensions will be granted sparingly and are at the instructor's discretion.

Technical Equipment Needs

The learning experience in this course will mainly rely on the online interaction between the students and the instructors during the weekly online meetings. Therefore, we encourage all students in this course to use a web camera and a headset. Decent quality headsets and web cams are available for less than \$20 each. We ask students to refrain from using built-in web cams and speakers on their desktops or laptops. We know from our experience in previous online courses that this will reduce the quality of video and audio transmission and therefore will decrease the overall learning experience for all students in the course. In addition, we suggest that students use a wire connection (LAN), if available, when connecting to the online meetings. Wireless connections (WLAN) are usually less stable and might be dropped.

Long Course Description

The main focus of this course lies on the introduction to statistical models and estimators beyond linear regression useful to social and economic scientists.

Although very useful, the general linear model (ordinary linear regression, OLS) is not appropriate if the range of the dependent variable Y is restricted (e.g., binary, ordinal, count) and/or the variance of Y depends on the mean of Y . Generalized linear models extend the general linear model to address both of these shortcomings.

The course provides an overview of generalized linear models (GLM) that encompass non-normal response distributions to model functions of the mean of Y . GLMs thus relate the expected mean $E(Y)$ of the dependent variable to the predictor variables via a specific link function. This link function is chosen such that it matches the data generating process of the dependent variable Y , therefore permitting the expected mean $E(Y)$ to be non-linearly related to the predictor variables. Examples for GLMs are the logistic regression, regressions for ordinal data, or regression models for count data. GLMs are generally estimated by use of maximum likelihood estimation. The course thus not only introduces GLMs but starts with an introduction to the principle of maximum likelihood estimation. A good understanding of the classical linear regression model is a prerequisite and required for the course.

The first two units are dedicated to an introduction to maximum likelihood estimation while the rest of the units will then discuss generalized linear models (GLM) for binary choice decisions (Logit, Probit), ordinal dependent variables, and count data (Poisson, Negative Binomial).

All units will be accompanied by homework assignments to repeat and practice the topics from the units. Any statistic program can be used to solve the homework assignments. Solutions provided by the instructor will use the statistical packages R and Stata.

Readings

Mandatory Readings

Verbeek, M. 2017. *A Guide to Modern Econometrics*. 5th ed. Chichester: Wiley.

Cameron, C.A. and P.K. Trivedi. 1998. *Regression Analysis of Count Data*. Cambridge: Cambridge University Press.

Greene, W.H. (2008). *Econometric Analysis*. 6th ed. Upper Saddle River: Prentice Hall.

Long, J.S. (1997). *Regression Models for Categorical and Limited Dependent Variables*. Thousand Oaks: Sage.

Wooldridge, J.M. 2002. *Econometric Analysis of Cross Section and Panel Data*. Cambridge, MA: MIT Press.

Wooldridge, J.M. 2008. *Introductory Econometrics. A Modern Approach*. 4th ed. Mason, OH: Thompson

Complementary Readings

Eliason, S.C. 1993. Maximum Likelihood Estimation. Logic and Practice. Newbury Park, CA: Sage.

Gujarati, D.N. (2003). Basic Econometrics. 4th ed. Boston: McGraw-Hill.

Maddala, G.S. 2001. Introduction to Econometrics. 3rd ed. Chichester: Wiley.

Academic Conduct

Clear definitions of the forms of academic misconduct, including cheating and plagiarism, as well as information about disciplinary sanctions for academic misconduct may be found at

<https://www.president.umd.edu/sites/president.umd.edu/files/documents/policies/III-100A.pdf> (University of Maryland)

Knowledge of these rules is the responsibility of the student and ignorance of them does not excuse misconduct. The student is expected to be familiar with these guidelines before submitting any written work or taking any exams in this course. Lack of familiarity with these rules in no way constitutes an excuse for acts of misconduct. Charges of plagiarism and other forms of academic misconduct will be dealt with very seriously and may result in oral or written reprimands, a lower or failing grade on the assignment, a lower or failing grade for the course, suspension, and/or, in some cases, expulsion from the university.

Accommodations for Students with Disabilities

In order to receive services, students at the University of Maryland must contact the Accessibility & Disability Service (ADS) office to register in person for services. Please call the office to set up an appointment to register with an ADS counselor. Contact the ADS office at 301.314.7682; <https://www.counseling.umd.edu/ads/>.

Course Evaluation

In an effort to improve the learning experience for students in our online courses, students will be invited to participate in an online course evaluation at the end of the course. Participation is entirely voluntary and highly appreciated.

Sessions

Week 1: Maximum Likelihood Estimation

Estimator and Variance

Video lecture: available Monday, February 03, 2025

Online meeting: Monday, February 10, 2025, 12 PM ET/6 PM CET

Homework assignment 1: due Thursday, February 13, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch. 6.1

Week 2: Maximum Likelihood Estimation

Specification Tests, Model Fit, and Numerical Optimization

Video lecture: available Monday, February 10, 2025

Online meeting: Monday, February 17, 2025, 12 PM ET/6 PM CET

Homework assignment 2: due Thursday, February 20, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch. 6.2

Greene (2008) Ch. 16.6.1-16.6.3

Week 3: Binary Choice Models

LPM, Binary Choices, Logit and Probit Models

Video lecture: available Monday, February 17, 2025

Online meeting: Monday, February 24, 2025, 12 PM ET/6 PM CET

Homework assignment 3: due Thursday, February 27, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch 7.1

Wooldridge (2008) Ch. 17.1

Week 4: Binary Choice Models

Coefficient Interpretation, Statistical Inference, and Goodness-of-Fit

Video lecture: available Monday, February 24, 2025

Online meeting: Monday, March 3, 2025, 12 PM ET/6 PM CET

Homework assignment 4: due Thursday, March 6, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch. 7.1

Long (1997) Ch. 3.7-3.8

Week 5: Models for Ordinal Data

Ordered Outcomes, Modelling Strategy, Identification, and Estimation

Video lecture: available Monday, March 3, 2025

Online meeting: Monday, March 10, 2025, 12 PM ET/6 PM CET

Homework assignment 5: due Thursday, March 13, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch. 7.2.1-7.2.3

Wooldridge (2002) Ch. 15.10

Long (1997) Ch. 5.1-5.2

WEEK BREAK – UMD SPRING BREAK – NO MEETING ON MARCH 17, 2025

Week 6: Models for Ordinal Data

Inference, Threshold and Coefficient Interpretation, Outcome Probabilities

Video lecture: available Monday, March 10, 2025

Online meeting: Monday, March 24, 2025, 12 PM ET/6 PM CET

Homework assignment 6: due Thursday, March 27, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch. 7.2.1-7.2.3

Long (1997) Ch. 5.5

Week 7: Models for Count Data

Poisson Distribution, Generalization, and Estimator

Video lecture: available Monday, March 24, 2025

Online meeting: Monday, March 31, 2025, 12 PM ET/6 PM CET

Homework assignment 7: due Thursday, April 3, 2025, 5:00 PM ET/11:00 PM CET

Required Readings:

Verbeek (2017) Ch. 7.3

Wooldridge (2008) Ch. 17.3

Cameron and Trivedi (1998) Ch. 3.1, 3.2.1, 3.5.1

Week 8: Models for Count Data

Variance, Overdispersion, and Negative Binomial

Video lecture: available Monday, March 31, 2025

Online meeting: Monday, April 7, 2025, 12 PM ET/6 PM CET

Required Readings:

Verbeek (2017) Ch. 7.3

Recommended Readings:

Cameron and Trivedi (1998) Ch. 3.2.2, 3.3.1, 3.3.3, 3.4, 4.7

Final exam

Available: April 2, 2025

Due: April 21, 2025, 6:00 PM ET/11:00 PM CET