

## Syllabus

### Generalized Linear Models 2 credits/4 ECTS

Prof. Thomas Gautschi  
Video lecture by Prof. Thomas Gautschi

February 4 – April 1, 2021

#### 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 questions 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/4-ECTS course that runs for 8 weeks. Please note that the actual workload will depend on your personal knowledge.

## Mandatory Weekly Online Meetings

*Thursday, 2:00 PM EST/8:00 PM CET, starting February 4*

Meetings will be held online through Zoom. Follow the link to the meeting sessions on the course website on [mannheim.instructure.com](http://mannheim.instructure.com). If 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 Thursday, 4:00 AM EST/10:00 AM CET).

Students have the opportunity to use a different Zoom meeting room to connect with peers outside the scheduled weekly online meetings (e.g., for study groups). Detailed information is posted on the course page in Canvas. Students are encouraged to post the times that they will be using the room to the course website forum to avoid scheduling conflicts. Students are not required to use Zoom and can use other online meeting platforms, such as Microsoft Teams, Google Hangout or Skype.

## 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.	

The grading scale is a base scale recommended by the IPSDS. 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 assignments will be due are indicated in the syllabus. Extensions will be granted sparingly and are at the instructors' 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 (linear regression) 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 Stata and R.

## Readings

### Mandatory Readings

Verbeek, M. 2008. *A Guide to Modern Econometrics*. 3rd 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)

and in the MBS Honor Code, signed at the beginning of the program.

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/>.

Students at the University of Mannheim should contact the Commissioner and Counsellor for Disabled Students and Students with Chronic Illnesses at [http://www.uni-mannheim.de/studienbueros/english/counselling/disabled\\_persons\\_and\\_persons\\_with\\_chronic\\_illnesses/](http://www.uni-mannheim.de/studienbueros/english/counselling/disabled_persons_and_persons_with_chronic_illnesses/)

### 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 (in addition to the standard university evaluation survey). Participation is entirely voluntary and highly appreciated.

## Sessions

**Daylight saving time begins in the US on March 14, 2021 and clocks are turned forward 1 hour. Daylight saving time begins in Europe on March 28, 2021. Therefore, look carefully at the times of meetings and deadlines!**

### Week 1: Maximum Likelihood Estimation

#### *Estimator and Variance*

Video lecture: available Thursday, January 28, 2021

Online meeting: Thursday, February 4, 2021, 2:00 PM EST/8:00PM CET

Homework assignment 1: due Monday, March 8, 2021, 2:00 PM EST/8:00 PM CET

#### **Required Readings:**

Verbeek (2008) Ch. 6.1

### Week 2: Maximum Likelihood Estimation

#### *Specification Tests, Model Fit, and Numerical Optimization*

Video lecture: available Thursday, February 4, 2021

Online meeting: Thursday, February 11, 2021, 2:00 PM EST/8:00 PM CET

Homework assignment 2: due Monday, February 15, 2021, 2:00 PM EDT/8:00 PM CET

#### **Required Readings:**

Verbeek (2008) 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 Thursday, February 11, 2021

Online meeting: Thursday, February 18, 2021, 2:00 PM EDT/8:00 PM CET

Homework assignment 3: due Monday, February 22, 2021, 3:00 PM EDT/8:00 PM CET

#### **Required Readings:**

Verbeek (2008) Ch 7.1

Wooldridge (2008) Ch. 17.1

### Week 4: Binary Choice Models

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

Video lecture: available Thursday, February 18, 2021

Online meeting: Thursday, February 25, 2021, 2:00 PM /8:00 PM CET

Homework assignment 4: due Monday, March 1, 2021, 2:00 PM EDT/8:00 PM CET

**Required Readings:**

Verbeek (2008) 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 Thursday, February 25, 2021

Online meeting: Thursday, March 4, 2021, 2:00 PM EDT/8:00 PM CET

Homework assignment 5: due Monday, March 8, 2021, 2:00 PM EDT/8:00 PM CEST

**Required Readings:**

Verbeek (2008) Ch. 7.2.1-7.2.3  
Wooldridge (2002) Ch. 15.10  
Long (1997) Ch. 5.1-5.2

**Week 6: Models for Ordinal Data**

*Inference, Threshold and Coefficient Interpretation, Outcome Probabilities*

Video lecture: available Thursday, March 4, 2021

Online meeting: Thursday, March 11, 2021, 2:00 PM EDT/8:00 PM CEST

Homework assignment 6: due Monday, March 15, 2021, 3:00 PM EDT/8:00 PM CEST

**Required Readings:**

Verbeek (2008) 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 Thursday, March 11, 2021

Online meeting: Thursday, March 18, 2021, 3:00 PM EDT/8:00 PM CEST

Homework assignment 7: due Monday, March 22, 2021, 3:00 PM EDT/8:00 PM CEST

**Required Readings:**

Verbeek (2008) 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 Thursday, March 18, 2021

Online meeting: Thursday, March 25, 2021, 3:00 PM EDT/8:00 PM CEST

**Required Readings:**

Verbeek (2008) 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: March 20, 2021

Due: April 8, 2021, 2:00 PM EDT/8:00 PM CEST