Ph.D. programme in Civil Systems Engineering

Discrete choice modelling

eng. Fiore Tinessa

Credits: 4 CFU
Number of hours: 24 frontal hours
Date: 22, 25, 29 June, 2, 6, 9 July 2027

Objectives: The course aims to provide a basic understanding of discrete choice analysis, from a theoretical and applied perspective. The course is suitable both for all students who want to gain basic knowledge - mainly practitioners and students interested in facing case studies for research purposes - and for those who want to have a more comprehensive understanding of topics already covered in other academic courses or discover new topics.
First and foremost, the course aims to provide the basic tools to tackle a case study of any discipline (e.g., engineering, marketing, health, social sciences etc.), whether for research or professional purposes, through the basic methods of discrete choice analysis. In particular, the student who will have completed the course will be able to estimate basic random utility models, apply them to a real-world context, design a data collection using Revealed Preference (RP) or stated Preference (SP) surveys, and interpret the outputs for various decision-making purposes (e.g., planning, design, product / service customization, marketing campaigns). Above all, the student will also be aware of the advantages and limitations of each tool discussed in the course.
Secondly, some hints at more advanced theoretical issues and possible research developments (including "trendy research issues" and geography of the research groups / journals treating the topics) will be addressed, to provide a more comprehensive overview for all those who would, later on, like to go deeper into the topics.

Course programme: The course covers both basic topics related to discrete choice analysis, such as fundamental models of random utility theory (including Generalized Extreme Value models, continuous and discrete mixtures of models) and basic principles of survey design, and some notes on more advanced topics, such as integrated choice and latent variable models, alternative discrete choice theories and further examples of extensions / cross-fertilizations with other scientific fields. To this end, for each lecture, the topics that need to be learned to acquire a basic level of knowledge and those related to more advanced theoretical topics will be appropriately marked as "basic", "intermediate" and "advanced". Each student will therefore be able to best choose the level of detail with which to explore each topic.
NOTE: To best follow the course, it would be advisable to have already established some basic tools on probability theory (e.g. monovariate-multivariate distributions of discrete and continuous random variables, moments of random variables, statistical estimators, hypothesis tests). In any case, the course includes short recaps of the basic tools needed to understand the topics covered.

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Teaching materials: Lecture notes and slides, practical exercises with MS Excel and Apollo (RStudio), and further material projected during the lectures.

Assessment methods: Practical exercises in class with MS Excel and Apollo on synthetic data, exercises at home, brief proposal (half to one page document) of a survey design example to address problems pertaining to the student's research work.

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Lectures Program

N	Date	Schedule	Duration	Topic / Teacher
1	24/06/25	9:30 - 13:30	4 hours	• Introduction to choice problems and their importance for decision-making issues, examples of problems from different scientific fields from the scientific literature; • Probability theory and statistics fundamentals recalls.
2	26/06/25	9:30 - 13:30	4 hours	• Introduction to the discrete choice model paradigm, basic assumptions of the course, introduction to random utility theory; • Introduction to simple models for binary outcomes (binary logit, binary probit); • Estimation of discrete choice models: specification, estimation; • Estimation of simple binary models with Microsoft Excel; • Introduction to Multinomial Logit (MNL) model – theory, limitations and drawbacks; • Estimation of simple MNL models in Microsoft Excel.
3	01/07/25	9:30 - 13:30	4 hours	• Multinomial Logit (MNL). The theory, advantages, drawbacks and limitations, analogies with other models • Estimation of discrete choice models: validation; • Introduction to the open access library Apollo (RStudio); • Estimation of simple MNL models in Apollo; • Extensions: models for ordered data, models for ranked data, multiplicative random utility models, alternative discrete choice paradigms, discrete choice and machine learning.

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4	03/07/25	9:30 - 13:30	4 hours	• Application of discrete choice models at an aggregate level, aggregation techniques, aggregate economic measures, examples of real-world problems; • Introduction to Generalized Extreme Value (GEV) models: - The Nested Logit (NL) or Hierarchical Logit model: basic theory, intermediate and advanced theory, exercises in Microsoft Excel and Apollo, limitations and drawbacks; - The Cross Nested Logit model: basic theory in intuitions, hints on intermediate and advanced-level theory aspects, exercises in Apollo, limitations and drawbacks; - The GEV theoretical framework and further extensions: hints on the fundamental theory and further extensions.
5	08/07/25	9:30 - 13:30	4 hours	The problem of taste heterogeneity and models for panel data: • The mixed Multinomial Logit: basic theory, intermediate-advanced topics, exercises with Apollo; • The latent class and discrete mixtures of Logit models: basic theory, intermediate-advanced topics, exercises with Apollo; • Further extensions: mixed GEV, latent class GEV, latent class mixed multinomial GEV, latent class with different kernels, latent class models for different purposes, advanced approaches for modelling taste heterogeneity, individual level parameter.
6	10/07/25	9:30 - 13:30	4 hours	• Design of surveys: theory and examples ○ Sampling theory ○ Revealed Preferences ○ Stated Preferences (SP): preliminary steps of the design, basics of full, orthogonal,

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efficient and Bayesian efficient designs, examples of SP designs;

- Joint RP-SP surveys;
- Design of questionnaires;
- Examples of surveys;

- Brief introduction to Integrated choice and latent variable models: Explanatory Factor Analysis, structural equation models, measurement equations models, hybrid choice models.

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