

Probability

Introduction

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Objectives of the course

- ▶ The goal of this course is to lay the foundations of probability theory.
- ▶ We will introduce the fundamental concepts and tools needed to understand randomness, quantify uncertainty, and model real-world phenomena.
- ▶ You will learn how probabilistic reasoning can be applied in economic and social contexts.

Outline of the course

- 1 Combinatorics
- 2 Probabilistic model
- 3 Random variables
- 4 Pairs of random variables
- 5 Asymptotic convergence

Skills

Upon completion of the course, you will be able to:

- ▶ work with basic probabilistic models,
- ▶ analyse random variables,
- ▶ understand key notions of convergence upon which statistical and econometric methods are based.

Instructor

- ▶ Ewen GALLIC
- ▶ Aix-Marseille School of Economics
- ▶ *Maître de Conférences* (Assistant Prof.) in Economics
- ▶ Research interests: data science, algorithmic fairness, environmental economics
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Course organization

- ▶ Duration: 10 classes, each lasting 3 hours.
- ▶ The course will be based on lectures.

References

- ▶ Stand-alone course materials will be provided (on AMeTICE).
- ▶ No single textbook is required.
- ▶ Complementary readings:
 - Blitzstein, J. K., & Hwang, J. (2019). *Introduction to probability*. Chapman and Hall/CRC.
 - McClave, J. T., Benson, P. G., & Sincich, T. (2022). *Statistics for business and economics*. Pearson. [3rd Chapter]
 - Miller, S. J. (2017). *The probability lifesaver: all the tools you need to understand chance*. Princeton University Press. [Chapters 1–4, 6—9, 12—17]
 - Newbold, P., Carlson, W. L., & Thorne, B. M. (2013). *Statistics for business and economics* (10th Global Edition). Pearson. [Chapters 3–6].
- ▶ Special thanks to Mathieu Faure who kindly shared his teaching material.

Why should an economist study probabilities?

- ▶ Economics studies **decisions-making under uncertainty**:
 - Consumers choose without knowing future prices or income.
 - Firms invest without knowing future demand or costs.
 - Governments design policies without knowing future shocks.
 - Financial markets price assets whose payoffs are uncertain.
- ▶ Deterministic reasoning is insufficient for economic analysis.
- ▶ Probability provides the language and tools to reason systematically about uncertainty.
- ▶ Probability also allows economists to **compare decisions** in terms of expected outcomes and risks.

The future is not deterministic

- ▶ Even with complete information today, **future outcomes remain uncertain.**
- ▶ Uncertainty comes from:
 - individual behaviour,
 - aggregate shocks,
 - institutional changes,
 - technological innovations,
 - natural and geopolitical events, ...
- ▶ For example:
 - Tomorrow's stock price cannot be predicted exactly.
 - Future unemployment rates depend on multiple interacting shocks.
 - A firm's profits depend on uncertain demand and competition.
- ▶ The idea is **not to predict exact outcomes**, but to **understand distributions of possible outcomes.**

Probabilistic Models

- ▶ The economic reality is complex, noisy and partially unobservable.
- ▶ To formalize assumptions, make predictions and test them, and to communicate about uncertainty, economists build **models**:
 - modelling consumer demand, default risk, asset prices, ...
- ▶ Building a model means deciding what is **random** and what is taken as given.

Definition 1. Probabilistic Model

A probabilistic model is a simplified representation of an uncertain economic reality.

- ▶ *We identify: (i) a set of possible outcomes, (ii) rules assigning probabilities to these outcomes.*
- ▶ *The model does not claim to be true, only useful. It describes our representation of uncertainty about reality.*
- ▶ *Probabilities are always **conditional on the model and the information set**.*

From uncertainty to risk

- ▶ Probability allows economists to:
 - quantify uncertainty,
 - compare risky alternatives,
 - reason about expectations and variability.
- ▶ It allows to transform vague uncertainty into **measurable risk**.
- ▶ For example:
 - Insurance pricing based on loss probabilities.
 - Portfolio diversification to reduce risk.
 - Cost-benefit analysis under uncertainty.
- ▶ Not all uncertainty can be fully quantified: some risks remain partially or poorly measured (e.g., financial crises, technological innovations, political events).

Where this course fits?

- ▶ This course provides :
 - The mathematical language of probabilistic models.
 - Tools to:
 - define random variables,
 - work with joint distributions,
 - understand convergence and long-run behaviour.
- ▶ Later courses will focus on:
 - Choosing/designing models,
 - Estimating them,
 - Testing them against data.