# Markov Chains: Applications to Economic Modelling

**Level:** L3
**Track:** Minor in Modelling and Data Science
**Semester :** S2
**Teaching hours:** 18 hours of lectures
**Teaching language:** English
**Teacher:** Sylvain Ferrières
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**Course's objectives:**
This course builds on the Markov chain course taught in Semester 5, extending its mathematical foundations toward economic applications. Markov chains are essential tools for modelling random dynamic processes, with a focus on both theoretical understanding and computational practice. Students will learn how to formalize, analyze, and simulate both discrete-time and continuous-time memoryless stochastic systems using Python, including the use of the SimPy library.
The course explores a range of classic economic and data-science applications (credit rating transitions, unemployment dynamics, queueing systems, PageRank) before turning to major extensions such as hidden Markov models, Markov decision processes and stochastic games. These frameworks play a central role in modern economic modelling, decision theory, and dynamic strategic analysis.
By the end of the course, students will possess a practical quantitative toolbox for understanding and implementing many dynamic models used in economics and finance.

**Lesson plan:**

1. Introduction and review of theoretical results
2. Basic applications
   Credit rating and default transitions; natural unemployment rate models; the PageRank algorithm.
3. Information diffusion models
   Discretized Bayesian learning. Applications to stochastic information diffusion among consumers.
4. Queueing models
   Simulation of M/M/1 queues using SimPy.
5. Extensions: Hidden Markov models, Markov decision processes, Introduction to stochastic games.

**Skills developed:**

- Ability to model and analyze discrete-time, memoryless stochastic processes in various economic contexts.
- Ability to simulate Markovian dynamics using the Python programming language.
- Understanding of key extensions of Markov chains in decision theory (Markov decision processes) and game theory (stochastic games).

**Grading system:** One written exam (in-class test) and one group assignment involving the Python simulation of a model based on a research article.

**Prerequisites:** Markov chains and advanced probability theory (S5 level).

**Bibliography / references:** Lecture notes and materials provided during the course.