

Francesco Mascari

he/him — PhD Student

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in francesco-mascari

I am currently working as a PhD student in Statistics and Computer Science at Bocconi University in Milan.
My main research interests are Bayesian Nonparametrics, Reproducing Kernel Hilbert Spaces, Wasserstein Distance, and Random Measures.

Education

PhD in Statistics and Computer Science <i>Bocconi University, Milan, Italy</i>	2021 – ongoing
MSc in Mathematics for Life and Data Sciences, cum laude <i>University of Trento, Trento, Italy</i>	2018 – 2021
BSc in Mathematics, cum laude <i>University of Bologna, Bologna, Italy</i>	2015 – 2018
High School Diploma in Scientific Studies, cum laude <i>Liceo Scientifico Copernico, Bologna, Italy</i>	2010 – 2015

PhD Research Project

Title: *Hilbert-based Indices of Dependence between Random Probability Measures for Distributional Data and Bayesian Nonparametrics*

Advisor: Prof. Hugo Lavenant, *Bocconi University*

Co-advisor: Prof. Marta Catalano, *Luiss University*

First paper (submitted): : **Measuring Partial Exchangeability with Reproducing Kernel Hilbert Spaces.**

In Bayesian multilevel models, the data are structured in interconnected groups, and their posteriors borrow information from one another due to prior dependence between latent parameters. However, little is known about the behaviour of the dependence a posteriori. In this work, we develop a general framework for measuring partial exchangeability for parametric and nonparametric models, both a priori and a posteriori. We define an index that detects exchangeability for common models, is invariant by reparametrization, can be estimated through samples, and, crucially, is well-suited for posteriors. We achieve these properties through the use of Reproducing Kernel Hilbert Spaces, which map any random probability to a random object on a Hilbert space. This leads to many convenient properties and tractable expressions, especially a priori and under mixing. We apply our general framework to i) investigate the dependence a posteriori for the hierarchical Dirichlet process, retrieving a parametric convergence rate under very mild assumptions on the data; ii) eliciting the dependence structure of a parametric model for a principled comparison with a nonparametric alternative.

Second paper (pre-print): **Hilbert-Based Correlation Indices for Distributional Data.**

We present a unified mathematical framework for defining correlation indices when data are probability measures using Hilbert space embeddings. This approach allows us to reinterpret existing Wasserstein and kernel-based correlation indices, and suggests new strategies by extending the notions of Kernelized Canonical Correlation and Centered Kernel Alignment to the space of probability measures. We analyze these indices at the extreme values and demonstrate their practical utility by examining their behavior on synthetic data and in hierarchical clustering in cortical regions for functional brain imaging data.

MSc Thesis

Title: *A Micro-macro Connection: The Valuable Relation between Large Deviations for Diffusion Processes and Wasserstein Gradient Flows*

Supervisors: Prof. Carlo Orrieri, *University of Pavia*; Dr. Giovanni Conforti, *École Polytechnique*

Abstract: This work aims to present the passage from the microscopic stochastic description of a system of particles to its macroscopic description as a Fokker-Planck equation. After a brief introduction to some basics in Convex Analysis and Measure Theory, a complete review of optimal transport and Wasserstein metric, on the one hand, and of large deviations for path measures of diffusion processes, on the other, is displayed. A thorough description of the gradient flow formulation for the Fokker-Planck equation is then analyzed with a particular interest in the JKO functional, which is shown to be equivalent in Γ -convergence to the rate functional arising in the large deviation principle for a system of independent Brownian particles.

Ongoing Research Projects

Measuring Partial Exchangeability with Reproducing Kernel Hilbert Spaces

with M. Catalano and H. Lavenant

Hilbert-Based Similarity Indices When Data Are Probability Measures

with M. Catalano and H. Lavenant

Research Experience

Contract Researcher

Bocconi University, Milan, Italy

Sep 2025 – ongoing

Visiting PhD Student

Luiss University, Rome, Italy

Oct 2024 – Jan 2025

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Other Exchange or Visiting Programs.....

Erasmus+ Traineeship <i>École Polytechnique, Palaiseau, France</i>	Oct 2020 – Feb 2021
Erasmus+ Study <i>Cardiff University, Cardiff, Wales, UK</i>	Jan – Jun 2018

Talks, Posters, and Conferences

Invited Talks.....

4th Italian Meeting on Probability and Mathematical Statistics <i>Sapienza University of Rome, Rome, Italy</i> <i>Measuring Dependence under Partial Exchangeability with Reproducing Kernel Hilbert Spaces</i>	Jun 2024
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Contributed Talks.....

BAYSM 2025 <i>Online</i> <i>Measuring Partial Exchangeability with Reproducing Kernel Hilbert Spaces</i>	Apr 2025
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Posters.....

BNP 14 World Meeting <i>University of California, Los Angeles, Los Angeles, USA</i> <i>Measuring Partial Exchangeability with Reproducing Kernel Hilbert Spaces</i>	Jun 2025 <i>Travel Award, Best Poster Award</i>
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Early Career Workshop on Nonparametric Statistics <i>Luiss University, Rome, Italy</i> <i>Measuring Partial Exchangeability with Reproducing Kernel Hilbert Spaces</i>	May 2025
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2024 ISBA World Meeting <i>Ca' Foscari University of Venice, Venice, Italy</i> <i>Measuring Dependence under Partial Exchangeability with Reproducing Kernel Hilbert Spaces</i>	Jul 2024 <i>Best Poster Award</i>
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BAYSM 2024 <i>Ca' Foscari University of Venice, Venice, Italy</i> <i>Measuring Dependence under Partial Exchangeability with Reproducing Kernel Hilbert Spaces</i>	Jun 2024
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Other Conferences, Workshops and Schools.....

Summer School on Optimal Transport, Stochastic Analysis and Applications to Machine Learning <i>KAIST, Daejeon, South Korea</i>	Jun 2024
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2023 LMS Invited Lecture Series <i>Durham University, Durham, England, UK</i>	Jul 2023
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Turin-Bath PhD Workshop in Applied Probability and Statistics <i>Collegio Carlo Alberto, Turin, Italy</i>	Jun 2023
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Workshop Mathematical Statistics <i>Bocconi University, Milan, Italy</i>	Apr 2023
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Optimal Transport and Applications <i>University of Pisa, Pisa, Italy</i>	Oct 2022
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Summer School in Mathematics of Machine Learning <i>Scuola Matematica Interuniversitaria, Cortona, Italy</i>	Jul 2022
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Summer School in Advanced Statistics and Probability: Random Structures and Combinatorial Statistics <i>Lake Como School of Advanced Studies, Como, Italy</i>	Jul 2022
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Stochastic Games and Martingale Optimal Transport <i>University of Milan, Milan, Italy</i>	May 2022
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Summer School in Geometric Statistics <i>University of Toulouse III, Toulouse, France</i>	Sep 2019
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Teaching

Machine Learning – Module I – Introduction (30677) <i>BSc International Politics and Government, Bocconi University</i>	Spring 2025
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Quantitative Methods For Social Sciences – Module II – Data Analytics (30673) <i>BSc International Politics and Government, Bocconi University</i>	Spring 2025
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Teaching Assistantships.....

Statistics (30001) <i>BSc International Economics and Management, Bocconi University</i>	Fall 2025
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Bayesian Statistical Methods (20231) <i>MSc Data Science and Business Analytics, Bocconi University</i>	Fall 2025
Mathematics – Module 1 – Theory and Methods (30448) <i>BSc Economic and Social Sciences, Bocconi University</i>	Fall 2025
Applied Stochastic Processes (30515) <i>BSc Economics, Management and Computer Science, Bocconi University</i>	Spring 2024
Foundations of Data Science (30607) <i>BSc Economics, Management and Computer Science, Bocconi University</i>	Spring 2024
Optimization (20603) <i>MSc Data Science and Business Analytics, Bocconi University</i>	Spring 2024
Mathematics – Module 2 – Applied (30063) <i>BSc Economia Aziendale e Management, Bocconi University</i>	Spring 2024
Statistics (30001) <i>BSc International Economics and Finance, Bocconi University</i>	Fall 2023
Bayesian Statistical Methods (20231) <i>MSc Data Science and Business Analytics, Bocconi University</i>	Fall 2023
Mastering Data for Insurance <i>SDA Bocconi</i>	Spring 2023
Optimization (20603) <i>MSc Data Science and Business Analytics, Bocconi University</i>	Spring 2023
Mathematics – Module 2 – Applied (30063) <i>BSc International Economics and Finance, Bocconi University</i>	Spring 2023
Advanced Analysis and Optimization – Module 1 (30551) <i>BSc Mathematical and Computing Sciences for Artificial Intelligence, Bocconi University</i>	Fall 2022
Mathematics and Statistics II (145105) <i>BSc Biomolecular Sciences and Technologies, University of Trento</i>	Spring 2020
Calculus A (145503) <i>BSc Mathematics, University of Trento</i>	Fall 2019
Calculus I (145432) <i>BSc Physics, University of Trento</i>	Fall 2019
Other teaching activities	
Workshop Instructor <i>Data Science Lab, Bocconi University</i>	Summer 2023
Workshop Instructor <i>Data Science Lab, Bocconi University</i>	Summer 2023
Math Help Desk for Applicant Refugee Students and Asylum Seekers <i>University of Trento</i>	Spring 2020

Other activities

Volunteering	
PhD Representative in the PhD Board <i>Department of Decision Sciences, Bocconi University, Milan, Italy</i>	2022 – 2025
Student Representative in the Department Council <i>Department of Mathematics, University of Bologna, Bologna, Italy</i>	2016 – 2018
Student Representative in the BSc Board <i>BSc Mathematics, University of Bologna, Bologna, Italy</i>	2016 – 2018
Student Representative in the School Board <i>Liceo Scientifico Copernico, Bologna, Italy</i>	2013 – 2014