TSE Master of Science in
Finance and Data Science

Program Structure and Description of the Courses

Program Structure

The Master is a 60-credit program organized as follows:

Foundations

The program begins with a foundation period designed to harmonize students' backgrounds and ensure that they have a solid understanding of the basic concepts in microeconomics, statistics, and programming. This one-month period (September) consists of three optional courses that are strongly recommended for students without a background in economics or finance. Each course consists of 21 hours of lectures and has no credit. The courses are

- Refresher in Statistics
- Programming with AI
- Microeconomics for Finance

Term 1

The first term (October to December) consists of four core courses, two focusing on finance and two on data science and quantitative methods. Each course consists of 27 hours of lectures and 12 hours of tutorials and is worth 4 credits. The courses are

- Asset Pricing
- Mathematics for Finance
- Quantitative Methods
- Financial Data Analysis

Term 2

The second term (January to March) consists of five core courses: two focusing on finance, one on macro-finance, and two on data science and quantitative methods. Each course consists of 27 hours of lectures and 12 hours of tutorials and is worth 4 credits.

Students are required to take four of these five courses. They may also take the fifth course as an elective, in which case it will count for 3 credits. The courses are

- Corporate Finance
- Fixed-Income Securities and Derivatives

- Macro-Finance
- Empirical Asset Pricing
- Machine Learning in Finance and Risk Management

Term 3

The third term (March to April) consists of elective courses organized into three blocks: Finance, Macro-Finance, and Data Science. Each course consists of 15 hours of lectures and is worth 3 credits.

Students are required to take five elective courses and may choose courses from different blocks.

Finance Elective Courses

- AI in Finance
- Behavioral Finance
- Sustainable Finance
- Corporate Reorganization
- Trades and Exchange Economics
- Financial Technologies

Macro-Finance Elective Courses

- Advanced Macro-Finance
- Economic Outlook Analysis
- Financial Intermediation and Banking
- International Finance
- Monetary Policy and Prudential Regulation

Data Science Elective Courses

- Advanced Machine Learning
- Causal Inference
- Extreme Risks
- Forecasting
- LLM and Text Analysis
- Portfolio and Risk Management
- High-Frequency Data Statistics

Group Project

Throughout the academic year (September to April), students will work in groups on a project. The Group project is worth 3 credits

Internship or Applied Project

After completing their coursework, students will either undertake an internship (lasting 2 to 6 months) or work on an applied project.

Description of the Courses

FOUNDATIONS: 3 optional courses

Refresher in Statistics (21 hours, no credit)

This course aims to provide the main concepts and tools in probability and statistics, serving as a refresher for students, with a focus on data analysis in finance. The material includes linear algebra, introduction to probability theory, popular discrete and continuous random variables, estimation, hypothesis testing, asymptotic theory. These concepts and tools are applied to financial and economic data.

Programming with AI (21 hours, no credit)

This course provides the main concepts and practical tools for programming in R and Python, with the help of Artificial Intelligence like Claude Code. The focus of the course is on data analysis and applications in finance. It introduces fundamental programming structures, data manipulation, and visualization techniques to support analytical thinking. Students learn how to handle and process datasets, implement basic algorithms, and write clear and efficient code. The course also emphasizes reproducible workflows and good programming practices. These tools are applied to financial and economic data, including data cleaning, exploration analysis, and simple modeling tasks.

Microeconomics for Finance (21 hours, no credit)

This course goes through the core concepts and reasoning used by economists to understand how markets and institutions allocate resources efficiently, highlighting the role of price signals at equilibrium in guiding individual and corporate decisions. Game theory is introduced to analyze strategic interactions, market failures, and regulation. In the second part, these concepts and tools are applied to financial markets, with a focus on efficient capital allocation, asset valuation, discounting, and risk premia.

TERM 1: 4 core courses

Asset Pricing (27 hours, 12 hours of tutorials, 4 credits)

This course provides the main concepts and tools of asset pricing theory, with a focus on understanding how risk is measured and priced in financial markets. It introduces expected utility, risk aversion, and the notion of risk premium, and highlights their role in investment decisions. Core concepts such as diversification and measures of risk are presented, along with the mean-variance framework, leading to portfolio theory and the Capital Asset Pricing Model (CAPM). The course also introduces the Arbitrage Pricing Theory (APT) and discusses extensions such as the Consumption CAPM. Finally, key empirical challenges, including the equity premium puzzle, are explored, and the stochastic discount factor is presented as a unifying framework.

Mathematics for Finance (27 hours, 12 hours of tutorials, 4 credits)

This course introduces the core concepts and tools of financial mathematics, with a focus on modeling uncertainty and pricing financial derivatives. It introduces discrete-time models, starting with the one-period and multi-period binomial frameworks, and highlights the role of arbitrage and replication in pricing. Core probabilistic tools, including conditional expectation and martingales, are developed to formalize pricing methods. The course then presents contingent pricing through the Arrow–Debreu framework. In the second part, these concepts are extended to continuous-time models using stochastic calculus, leading to the Black–Scholes–Merton formula. Applications to interest rate modeling and portfolio selection, including the Merton model, are also covered.

Quantitative Methods (27 hours, 12 hours of tutorials, 4 credits)

The goal of the course is to cover the main econometric and statistical methods for the analysis of cross-section financial variables. The material will include the analysis of the linear regression model by using the ordinary least square (OLS) method or the instrumental variable (IV) method under endogeneity, the maximum likelihood estimation (MLE) and the related method of Quasi-MLE (QMLE) under misspecification, the logit and probit models, kerned based non-parametric methods, and the difference in difference method. Each lecture will include empirical financial applications on R and Python.

Financial Data Analysis (27 hours, 12 hours of tutorials, 4 credits)

The goal of the course is to master the main time series concepts and methods to study and predict time series financial variables like stock prices, interest rates, exchange rates, as well as macroeconomic variables like inflation and GDP. The course will contain an introduction to

linear time series, in particular ARMA processes, OLS regression with time series, unit-root regressions, multivariate autoregressive regression models (VAR) and co-integration, volatility models (GARCH and stochastic volatility models), popular non-linear models in finance like Markov switching and affine models, the estimation of continuous time models, and a brief introduction to panel models. Each lecture will include empirical financial applications on R and Python.

TERM 2: A student selects 4 courses out of 5

Corporate Finance (27 hours, 12 hours of tutorials, 4 credits)

This course introduces the core principles and tools of corporate finance. It examines how firms make investment, financing, and payout decisions with the objective of maximizing shareholder value. Students develop an understanding of financial statements and learn how financial information supports corporate decision-making. The course introduces the time value of money and its applications to valuation and investment analysis. It covers capital budgeting techniques used to evaluate investment opportunities, including NPV and IRR. Students also learn how firms determine their cost of capital and incorporate risk into financial decisions. The course explores capital structure choices through the Modigliani–Miller framework and discusses the effects of taxes, financial distress, and agency conflicts. Dividend policy and share repurchases are examined as mechanisms for distributing cash to shareholders. The final part of the course focuses on firm valuation using discounted cash flow and relative valuation methods. Throughout the course, students apply concepts using Excel-based financial models and real-world corporate finance examples.

Fixed-Income Securities and Derivatives (27 hours, 12 hours of tutorials, 4 credits)

This course provides a rigorous introduction to fixed-income securities and derivatives, equipping students with both the theoretical foundations and the quantitative tools necessary to analyze, price, and manage risk in these markets. The central objective is to develop a thorough understanding of the instruments that constitute the fixed-income universe — government and corporate bonds, interest rate swaps, credit derivatives, and structured products — and of the mathematical frameworks used to value them and hedge against their risks. The course begins with the fundamentals of bond pricing, yield curve construction, and duration and convexity measures, before introducing the term structure models that underpin modern fixed-income analysis. Students then turn to derivatives markets, covering the pricing and hedging of interest rate options, caps, floors, and swaptions, as well as credit default swaps and collateralized debt obligations.

Macro-finance (27 hours, 12 hours of tutorials, 4 credits)

This course introduces students to macro-finance, the study of interactions between the real economy and financial markets. The central objective is to develop a rigorous understanding of how macroeconomic conditions shape asset prices and risk premia, and conversely how financial frictions and intermediation feed back into economic fluctuations, growth, and stability. The course begins with the foundational questions and empirical puzzles of macro-finance before developing the canonical consumption-based asset pricing framework, drawing on the contributions of Lucas and Bansal–Yaron to understand the equity premium and the role of long-run risks and uncertainty in return determination. Students then examine how financial markets influence savings, investment, and firm financing decisions at the aggregate level, before turning to models of credit cycles, financial accelerators, and pecuniary externalities, with particular attention to the frameworks of Kiyotaki–Moore and Carlstrom–Fuerst. The course further explores the interaction between monetary and fiscal policy and asset pricing, and concludes with a synthesis of macro-finance feedback loops and their implications for policy design. Throughout, theory and empirical evidence are developed in parallel, equipping students to engage critically with academic research at the intersection of macroeconomics and finance and to contribute to ongoing debates on the role of financial markets in the aggregate economy.

Empirical Asset Pricing (27 hours, 12 hours of tutorials, 4 credits)

This course provides a rigorous introduction to empirical asset pricing, combining economic theory with the econometric tools needed to work with financial data. The central objective is to equip students with the skills to test and evaluate theories of asset pricing, understanding both the statistical assumptions that underpin these tests and the economic models they are designed to assess. The course begins with the building blocks of empirical finance — returns, firm characteristics, and factor models — before developing the econometric methods required for their analysis, covering both linear and nonlinear asset pricing frameworks. Students will study the predictability of returns and examine how intertemporal equilibrium models are estimated and assessed in practice. The course will also offer an introduction to machine learning and the use of large models in asset pricing and return predictability. The course also reviews term structure models of interest rates, broadening the empirical toolkit beyond equity markets.

Machine Learning in Finance and Risk Management (27 hours, 12 hours of tutorials, 4 credits)

Big data and the availability of a huge amount of data make the use of some traditional statistical methods like OLS tricky, in particular when the number of explanatory variables exceeds the number of individuals. Likewise, traditional kernel based non-parametric methods

have some shortcomings like the curse of dimensionality, which lead to the introduction of new methods. The course will cover dimension reduction methods to respond to the first issue like factor and principal component analysis (PCA) methods as well as penalized methods like the Ridge, LASSO and Elastic Net. The second issue will be tackled by supervised learning methods like trees regression, bagging, random forest, and support vector machine methos. Non-supervised methos will be also studied. The course will also contain neural networks and methods to build quantitative measures from text data like sentiments or economic policy uncertainty. These methods will be used in the context of asset pricing, forecasting, and risk management with the use of the Value-at-Risk and the expected short fall. Each lecture will include empirical financial applications on R and Python.

TERM 3: A student selects 5 courses

Finance Elective Courses

AI in Finance (15 hours, 3 credits)

This course examines the role of artificial intelligence in transforming financial decision-making and services. We discuss AI within the broader context of technological change, analysing how it is distinct from automation and from other general-purpose technologies. We consider applications in credit, lending, and asset management to illustrate how AI reshapes financial services. We then consider investor behaviours through the lens of AI, including the detection of systematic biases, sentiment analysis, human–AI interactions. Ethical and regulatory issues, including bias, fairness, explainability, and investor protection, are emphasized throughout. The course combines theoretical insights with empirical applications using financial data.

Behavioral Finance (15 hours, 3 credits)

Traditional finance often finds hard time explaining the behavior of investors and of financial markets. Behavioral finance proposes to enrich the toolbox of traditional finance models to accommodate non-standard preferences, beliefs, or decision making. The aim is to make the models more realistic and their predictions more accurate. This course explores some of the most active lines of research in behavioral finance, with applications to household finance and financial markets. It also explores how new technologies shed new light on these issues, and how behavioral finance can be used to design new technologies that help investors make better decisions.

Sustainable Finance (15 hours, 3 credits)

What is the role of financial markets and their stakeholders in the tentative ecological transition necessary to face our individual and collective responsibilities towards future generations? In this course, I will explore two facets of the same coin. First, I will show how environmental externalities trigger the most dramatic market failure of our liberal democracy. Financial markets can contribute to fix it only in the presence of strong environmental policies. Second, I will show how to adapt asset valuation techniques to the presence of ecological impacts with ultra-long maturities and deep uncertainties.

Corporate Reorganization (15 hours, 3 credits)

Some of the biggest events in the life of a corporation are reorganizations: mergers and acquisitions, spin-offs and divestitures, taking a listed company private or vice-versa, as well as distressed reorganizations. In each case, the financial ramifications are significant. This course aims to highlight the economic effects driving the reorganization and the accompanying financial (re)structuring. The course will make use of economics, such as game theory to study the nature of strategic interactions, as well as finance to assess the valuation and financial structuring of reorganizations. It will also draw on case studies and discuss on-going transactions using information from the financial press.

Trades and Exchange Economies (15 hours, 3 credits)

This course is about how securities are traded: the design, operation and regulation of trading processes, mechanisms and protocols. Today's markets for stocks, bonds, derivatives and cryptocurrencies vary in sophistication and complexity. For some securities, markets have evolved to anonymous networks that are fast, widely accessible, and transparent. We also have markets where a few traders act as "dealers". Our markets are infused with tensions between efficiency and fairness, competition and regulation, consolidation and fragmentation, speed and stability, and so on. The course is based on a realistic picture of the trading process, so we go into a fair amount of institutional detail, as well as some law and market regulation.

Financial Technologies (15 hours, 3 credits)

Information technologies (IT) have a profound impact on the design and delivery of financial services. This course explores how innovation in IT has led to the creation of new financial products and the entry of new players. We begin by discussing the structure and governance of decentralized ledger technologies (blockchains) and their applications to digital money (cryptocurrencies, stablecoins) and decentralized finance (DeFi). Next, we examine the entry of commercial platforms (e-commerce, social networks) into the markets for payment and

credit. Finally, we discuss how financial technologies can promote financial inclusion in developing countries.

Macro-Finance Elective Courses

Advanced Macro-Finance (15 hours, 3 credits)

This advanced course in macro-finance examines the two-way feedback loop between the real economy and financial markets. We study how credit cycles, leverage, and financial frictions amplify fluctuations and generate systemic crises. Core frameworks include credit cycles, financial frictions, and the financial accelerator. We also examine models of crises and the role of bubbles. Beyond rational models, we incorporate behavioral and heterogeneous-agent approaches, offering alternative explanations for persistent mispricing and instability. Combining theory, empirics, and policy perspectives, the course equips students to analyze and critically evaluate the dynamics of macro-financial instability.

Economic Outlook Analysis (15 hours, 3 credits)

This course trains students in the tools and methods used to analyze the economic outlook, linking macroeconomic theory with applied forecasting. We begin with national accounts and basic statistics, building a solid understanding of the data underlying growth, inflation, and financial indicators. Students learn to distinguish trend from cycle in real and nominal variables, and to interpret turning points—peaks, troughs, amplitudes, and seasonality. The course emphasizes leading indicators and contrasts real and financial cycles and their sources. Advanced topics include factor models, the “anatomy” of business cycles, and modern nowcasting techniques combining real-time data and econometric models.

Financial Intermediation and Banking (15 hours, 3 credits)

This course examines the banking industry and its ongoing transformation in the context of digitalization and financial innovation. It draws on insights from microeconomic theory, particularly mechanism design and industrial organization, to analyze how banks operate and compete in modern financial systems. The course explores the traditional and emerging roles of banks, emphasizing their function in mitigating informational frictions between borrowers and lenders. Students study the structure and organization of banking markets, as well as the design of financial contracts under conditions of asymmetric information. Key topics include risk sharing, repayment enforcement, moral hazard, and adverse selection in lending relationships. The course also investigates the macroeconomic consequences of financial imperfections and the mechanisms that can generate banking instability. Particular attention is given to the provision of liquidity services by banks and shadow banking institutions. Finally, the course introduces the foundations of banking regulation, covering both micro-prudential

and macro-prudential approaches, systemic risk, and the policy challenges posed by an increasingly digital financial environment.

International Finance (15 hours, 3 credits)

This course introduces students to the analytical tools and policy debates in international finance, focusing on the interaction between capital flows, exchange rates, and macroeconomic policies. We begin with uncovered interest rate parity (UIP), its empirical deviations, and implications for exchange rate determination. Students study spot and forward market dynamics, expectations, and speculative behavior, including crises and attacks. The course addresses sovereign debt sustainability, risk premia, and default. Policy discussions cover monetary and fiscal unions, constraints of fixed versus flexible regimes, and challenges of international coordination. Combining theory, evidence, and case studies, students critically analyze real-world financial globalization.

Monetary Policy and Prudential Regulation (15 hours, 3 credits)

This course examines the design and impact of monetary and macroprudential policies in modern economies, focusing on their influence on asset prices and the feedback loop between finance and the real economy. We study conventional tools (interest rate setting) and non-conventional instruments (quantitative easing, credit interventions), alongside research on monetary and prudential frameworks. Special attention is given to central bank communication in shaping expectations and stabilizing markets. Beyond traditional concerns, we explore debates on climate change, biodiversity, and whether central banks should address redistribution. The course integrates theory, empirical evidence, and policy case studies.

Data Science Elective Courses

Advanced Machine Learning (15 hours, 3 credits)

This course delves into state-of-the-art machine learning techniques tailored to finance, with a particular focus on asset pricing, credit scoring, and financial market forecasting. Building on prior foundational knowledge (classification, PCA, regularization, tree-based methods, neural networks, SVMs), the course emphasizes practical implementation using Python. Core themes include recurrent and deep neural network modeling, model optimization, hyperparameter fine-tuning, data privacy, and algorithmic interpretability. An emphasis is placed on fairness and regulatory compliance in AI models. While some theoretical insights are introduced, mathematical proofs are kept minimal to prioritize applied learning through real-world financial case studies.

Causal Inference (15 hours, 3 credits)

In economics and finance, variables often interact contemporaneously, in both static and dynamic settings. This gives rise to endogeneity and, more generally, to questions of causality—economic rather than purely statistical—between variables. Such issues arise frequently in empirical work in corporate finance.

This course will introduce the potential outcomes framework and the main concepts used to measure treatment effects, including ATE, ATT, and LATE. It will cover randomized experiments and randomization inference, propensity scores and selection on observables, matching methods, regression discontinuity designs (RDD), and synthetic control methods. Empirical applications in finance will be studied throughout the course to illustrate how these methods can be used in practice.

Extreme Risks (15 hours, 3 credits)

This course introduces the statistical modeling of extreme risks in financial markets. Building on extreme value theory, students will study the probabilistic foundations of rare events, including the Generalized Extreme Value and Generalized Pareto distributions, and learn how to quantify tail behavior in asset returns. Core topics include the estimation of tail indices, high quantiles, and extreme risk measures such as Expected Shortfall. The course also covers the use of machine learning for extreme risk prediction and time series models for dynamic risk forecasting. Beyond financial risk, case studies examine actuarial, disaster, and cyber risks.

Forecasting (15 hours, 3 credits)

This course addresses methodological and empirical aspects of forecasting in data science. It examines both classical statistical models and modern machine learning approaches, with a focus on rigorous model evaluation and comparative analysis. Core topics include traditional models (e.g., ARMA processes), non-linear and data-driven forecasting methods (AI/ML methods), and advanced procedures for assessing predictive accuracy, such as the Diebold-Mariano test and the Model Confidence Set. The course also considers forecast combination strategies, dimensionality reduction via Principal Component Analysis, and rolling window implementations. Students will critically engage with methods and apply them to complex forecasting tasks.

LLM and Text Analysis (15 hours, 3 credits)

This course introduces a range of models and methods for transforming textual information into quantitative data. Particular attention will be paid to the construction of sentiment and economic uncertainty indices and to their use in empirical financial analysis.

Because such indices are typically proxies rather than perfect measures of the underlying variables of interest, their use in econometric models raises important measurement-error issues. The course will examine how measurement error affects econometric analysis and will provide solutions, when text-based indices are used either as explanatory variables or as dependent variables, in both linear and nonlinear models. We will also discuss the implications of measurement error for causal inference.

Throughout the course, the methods will be illustrated and applied to concrete empirical problems, with an emphasis on their practical implementation and interpretation.

Portfolio and Risk Management (15 hours, 3 credits)

The purpose of this course is to provide participants with a comprehensive understanding and practical training in the quantitative management of portfolio risks within the context of banking and asset management. By the end of the course, participants will be able to apply advanced quantitative techniques to measure both credit and market risks and to manage them effectively, while accounting for regulatory constraints. Furthermore, participants will strengthen their ability to analyze and manage risk data through the use of programming applications in Python or R.

High-Frequency Data Statistics (15 hours, 3 credits)

This course provides students with modern tools for the analysis of high-frequency financial data. It covers key measures of risk relevant to high-frequency settings, as well as methods for detecting jumps, accounting for market microstructure noise, and modeling intraday seasonality. The course also introduces high-frequency factor models and examines the impact of economic announcements, particularly central bank announcements, on financial markets. Theoretical concepts and methods will first be developed and then applied to real-world empirical examples.

Group Project (7 months, 3 credits)

The Year-Long Group Project provides students with the opportunity to apply the concepts, theories, and analytical tools acquired throughout the program to a complex real-world problem in finance. Working in teams, students are expected to identify, analyze, and address a relevant financial or economic challenge by integrating knowledge from multiple courses. The project encourages the development of critical thinking, problem-solving, and data analysis skills, while fostering teamwork, project management, and professional communication abilities. Students are required to conduct independent research, collect and analyze relevant data, and formulate evidence-based recommendations. Regular progress

reports and presentations ensure continuous feedback and allow students to refine their approach over the course of the year. The project culminates in a comprehensive written report and an oral presentation before a faculty panel. Through this experience, students gain practical experience in managing long-term projects and develop the analytical and professional skills expected in the finance industry and related fields.

Internship or Applied Project (10 credits)

Internship

The Internship provides students with the opportunity to gain substantial professional experience in a financial institution, corporation, consulting firm, regulatory body, fintech company, or other organization operating in the financial sector. It enables students to apply the knowledge and skills acquired throughout the program in a professional environment and to develop a deeper understanding of industry practices and challenges. During the internship, students are expected to contribute to ongoing projects and business activities while gaining exposure to areas such as corporate finance, financial markets, asset management, risk management, financial analysis, data analytics, or financial technology. The internship fosters the development of technical expertise, professional judgment, teamwork, communication, and problem-solving skills. It also allows students to build professional networks and gain insights into potential career paths. The experience culminates in a written internship report and an oral presentation, enabling students to reflect on their contributions, assess the practical application of academic concepts, and demonstrate the competencies acquired during their placement.

Applied Project

The Applied Project provides students with the opportunity to address a real-world challenge faced by a financial institution, corporation, regulatory body, or other organization operating in the financial sector. Conducted individually, the project enables students to apply the theoretical knowledge and analytical tools acquired throughout the program to a practical problem of direct relevance to industry. Depending on the needs of the partner organization, projects may focus on areas such as investment analysis, risk management, corporate finance, financial markets, data analytics, financial innovation, or strategic decision-making. Students are expected to define the problem, conduct rigorous analysis using appropriate quantitative and qualitative methods, and develop actionable recommendations tailored to the organization's objectives and constraints. The project encourages close interaction with industry professionals and fosters the development of professional, analytical, and communication skills. It culminates in a written report and an oral presentation, demonstrating the student’s ability to deliver value-added insights in response to the specific needs of a financial institution or company.