MSc in Quantitative Finance at Universidad del Rosario
# Overview

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<th>Overview</th>
<th>Details</th>
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<tbody>
<tr>
<td>Total number of credits</td>
<td>45</td>
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<tr>
<td>Program length</td>
<td>3 semesters (full-time)</td>
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<tr>
<td>Campus</td>
<td>Bogotá / Colombia</td>
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<tr>
<td>Frequency of admission</td>
<td>Annual</td>
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<tr>
<td>Hours</td>
<td>Tuesday to Friday from 6:00 pm to 8:00 pm and Saturdays from 8:00 a.m. to 12:00*</td>
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<tr>
<td>Program director</td>
<td>Rafael Serrano</td>
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*The faculty reserves the right to modify the schedules when there is an eventuality.

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# About the Program

The constant development of the regional capital market, its integration with other markets globally, the expansion of the financial derivatives market and the constant changes in financial regulation and tax and pension systems, oblige the financial industry to seek more professionals with quantitative and computational skills who can address the complex challenges of financial markets.

The Master’s Degree in Quantitative Finance is a pioneering and innovative postgraduate program at Universidad del Rosario, created and developed in collaboration with leaders of the financial industry and aimed at professionals who wish to acquire a highly technical and analytical understanding of quantitative finance problems.

The program seeks to train professionals with an excellent command of practical computational methods and tools that allow them to perform professionally in areas such as risk management, portfolio management, valuation and structuring of financial products and analysis of data and financial information, both at financial institutions as well as in manufacturing sector firms.
The Faculty of Economics at the Universidad del Rosario is one of the best schools of economics in Colombia. Its educational project is characterized by promoting an analytical and critical environment, promoting state of the art research in order to strengthen academic training and the capacity to understand national and international economic facts. The research group of the Faculty of Economics is uniquely positioned as it occupies the third place by its level of scientific production in the RePEc ranking for Colombia and as A1 group in the classification of COLCIENCIAS. The members of the group partake significantly in international networks and projects with international research groups. The work of the faculty has earned them the Merit Award to the Research Group of Excellence by the Colombian Association for the Advancement of Science.

Four full-time professors exclusively associated to the program are specialists in areas such as financial engineering, derivatives, structuring of financial instruments and products, modeling stochastic, econometrics, financial risk management, portfolio management and computational finance.

In addition, the program has the participation of a select group of outstanding professionals from the main financial companies of the country who contribute with their work experience and research as lecturers of mainly of elective subjects. The program also has a group of international teachers who support the courses from time to time.
Candidate and Graduate Profiles

Candidate Profile:
The MSc in Quantitative Finance is offered to professionals with a background in finance, economics, engineering, statistics, mathematics and physics. Applicants must have performed satisfactorily in subjects with quantitative content such as calculus, probability, and statistics.

The director of the program will determine if the subjects previously attended by the applicant comply with the minimum content required to be admitted to the program. The most important thing is that the student has a predisposition and interest in formalizing mathematical and computational modeling, as this is the central axis of the program.

Graduate Profile:
The graduate of the MSc in Quantitative Finance is a professional with rigorous theoretical training in the areas of mathematics, probability, statistics and econometrics applied to finance and to risk management. The graduate will have the computational tools with which he or she can apply his/her theoretical knowledge in making financial decisions. They will be able to analyze and interpret data and financial information correctly, work in teams and participate actively in solving problems related to the challenges imposed by national and international financial markets.

Graduates of the master’s program will be able to perform in the areas of financial analysis risk management, asset management and money tables, structured product development, financial technology development and research, in financial and regulatory institutions (commercial banks, investment funds, stock brokers, pension funds, insurance companies, etc.) as well as consulting firms.
Curriculum

The program curriculum seeks to reconcile theoretical training with practical tools needed to successfully meet current challenges and requirements in the area of quantitative finance. It also seeks to foster the spirit of innovation and research in this area at the regional level.

Applicants are strongly advised to take the pre-master course Introduction to stochastic modeling, especially those who have not taken any intermediate probability and stochastic processes in their previous studies. This course aims to formally review some concepts of probability and present an introduction to the theory of stochastic processes. It has a duration of 32 hours (2 credits) and is offered as an intensive course months before the beginning of the first semester. The course will be graded as approved or not approved.

During the first semester the student acquires fundamental knowledge common to different problems of quantitative finance. Special emphasis is placed on general aspects of financial markets, financial economics and derivatives and on mathematical tools and statistics such as stochastic calculation and advanced econometrics.

The second semester courses are designed to allow students to acquire numerical and programming skills in the R and Python languages and combine them with the tools acquired in the first semester to efficiently solve general problems of quantitative finance: construction of performance curves, optimization of portfolios, simulation, valuation of financial derivatives, modeling of time series, empirical finance, among others.

In the third semester, students are required to take a compulsory course of Quantitative Risk Management (2 credits - 24 hours) and must elect 4 electives (each of 2 credits) which allows them to deepen and specialize in more specific subjects, depending on their interests.

The curriculum is consistent with the Academic content of the major examinations of the GARP (Global Association of Risk Professionals) as well as the actuarial societies (SOA, Society of Actuaries).

This program can be done with a full or part time dedication. The program is designed for the student to complete in a year and a half or two and a half years, according to their flexibility to attend classes and the evolution of their study work.
Elective Courses

Students must choose 4 elective courses in order to complete 8 elective credits. These are some of the elective courses that have been offered in previous years.

- Interest rate derivatives
- Quantitative Portfolio Management
- Credit and counterparty risk
- Introduction to Actuarial Mathematics
- Term structure models of interest rates
- Behavioral Finance
- Credit derivatives
- Stochastic optimal control
- Advanced models of financial markets
- Advanced numerical methods: finite differences
- Data Analytics

<table>
<thead>
<tr>
<th>FIRST SEMESTER</th>
<th>Credits</th>
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<tr>
<td>Stochastic Calculus</td>
<td>5</td>
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<tr>
<td>Financial Theory 1</td>
<td>5</td>
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<tr>
<td>Advanced Econometrics</td>
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<tr>
<td>Cátedra Rosarista</td>
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<th>SECOND SEMESTER</th>
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<tr>
<td>Financial Theory 2</td>
<td>5</td>
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<tr>
<td>Financial Econometrics</td>
<td>5</td>
</tr>
<tr>
<td>Numerical Methods in Finance</td>
<td>5</td>
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<tr>
<th>INTERSEMMESTRAL SEMESTER</th>
<th>Credits</th>
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<tr>
<td>Empirical studies in finance</td>
<td>1</td>
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* The faculty reserves the right to make changes to the curriculum
Quantitative Finance Research Group

NIKITA RATANOV
Full professor
nikita.ratanov@urosario.edu.co

Ph.D in Physics and Mathematics. Moscow State University Lomonosov

Research interests: Stochastic processes and their applications, including financial modeling.

Teaching experience: Stochastic calculus, Mathematical Finance, Quantitative Methods for Finance, Mathematical Economics.

PUBLICATIONS

Monograph

Textbooks
RATANOV N. Modelos Estocásticos de Mercados Financieros. Textbook for students in economics and applied mathematics, 2009 - University of Rosario, Colombia, in Spanish.

Recent journal articles
• Ratanov N. Piecewise linear process with renewal starting points. Statistics and Probability Letters. 131 (2017) 78-86
• Ratanov N. On piecewise linear processes.
• López O. and Ratanov N. Option pricing driven by a telegraph process with random jumps. J. Appl. Prob. 49(3) (2012) 838-849

CURRENT RESEARCH PROJECTS

1. Markov modulated Lévy processes
The topic continues previous research on telegraph-like processes. This is a deep generalization of telegraph processes. Some aspects and examples of exponential functionals will be studied as well. Lévy processes under markovian modulation are widely used for applications in finance.

2. Piecewise deterministic process with viscous boundary conditions
The project generalizes recent works on telegraph-like processes with boundary conditions of various types. Some explicit formulae have been obtained before, but the project presumes a generalization and this will give new ideas and approaches to the problem. Boundary conditions make the processes much more attractive from the viewpoint of applications.

3. Stochastic financial models with supporting levels
The problem of mathematical description of the idea of a supporting level of the price evolution is important for financial modeling. In the case of piecewise deterministic processes this problem is not studied before. The project will give new approaches to application in finance, assuming the supporting levels to be dynamic and random.

4. Asymptotics of piecewise deterministic processes under mixing conditions
The project presumes the study of the asymptotical behavior of piecewise deterministic processes when switching times are not independent, but satisfy mixing condition of various types (Ibragimov, Rosenblatt etc.) New limit theorems will be obtained. This project has applications to biology, in particular to so-called DNA sequences.
**Ph.D. in Economics**, Université Libre de Bruxelles

**Research interests:** Financial Econometrics, Quantitative Risk Management, Empirical Finance.


**PUBLICATIONS**

**Journal articles**
- Confidence sets for asset correlations in portfolio credit risk, Revista de Economía del Rosario, Vol. 15, No.1, 2012
- Portfolio choice under local industry and country factors, Financial Markets and Portfolio Management, 24(4), December 2010 https://doi.org/10.1007/s11408-010-0143-9
- Measuring the systemic importance of financial institutions using market information, in Financial stability review, National Bank of Belgium, June 2010, pp. 127-141 (with S. Ferrari)

**Working papers and other publications**
- Racial and spatial interaction for neighborhood dynamics in Chicago, Facultad de Economía, Documento de trabajo. 189, June 2016, pp. 30 (with A. Badel and C. Rodriguez).
- Network externalities across financial institutions, Facultad de Economía, Documento de trabajo. 184, February 2016, pp. 23 (with J.S. Ordoñez and S. Preciado).
- Stock return co-movements and integration within the Latin American integrated market, April, 2014, (with N.J. Marin), Universidad del Rosario, Faculty of Economics, working paper, no. 154.
- Default risk in agricultural lending: the effects of commodity price volatility and climate, IDB working paper series no. No. IDB-DP 362
- A Network model of systemic risk: identifying the sources of dependence across institutions, October, 2012, (with J.S. Ordoñez), Universidad del Rosario, Faculty of Economics, working paper, no. 121.
CURRENT RESEARCH PROJECTS

1. Causal inference for event studies: Synthetic matching/portfolio. (Joint work with Cristian Pinto, School of Business University of Connecticut).
   We provide a detailed analysis of the synthetic matching technique, which we denote as synthetic portfolio method. The method has important potential in financial event studies. We provide four methodologies based on synthetic portfolio that are causal based methodological alternatives to traditional approaches in event studies, in particular the use of the market model. These alternative methods are able to handle the high-dimensional challenge brought by the large asset space in the US stock market. We provide simulation results for the estimators proposed and re-examine event studies on the effects of merger announcements and seasoned equity offerings on stock performance. We also have an application of the method applied to a low dimensional asset space for intraday data from the Colombian Stock Exchange. The application evaluated the effectiveness of a type of trading halt denoted as volatility auctions or volatility interruptions.

2. Term structure modelling: forecasting the short rate with higher order autoregressive moving average models (joint work with Carmelo Giaccotto, School of Business University of Connecticut).
   We derive a model for the short rate that is able to capture a more general time series structure than standard affine models which are base mainly in the AR(1) process. We propose an estimation approach that is able to include higher order autoregressive moving average process. We evaluate the forecasting performance of the model with respect to the usual benchmarks: Nelson and Siegel Models and the random walk.

3. Term structure modelling: asymmetric effects. (joint work with Daniel Guzman, at Universidad de los Andes)
   We analyze the feedback effects between the conditional mean and the conditional variance for the term structure of interest rates for the US yield curve and the EURO swap rates. Our main interest is to identify asymmetric effect of innovations to the different yield rates and propose a term structure model that is able to account jointly for such innovations.

4. Term structure modelling: forecasting evaluation with asymmetric loss functions. (joint work with Cristhian Rodriguez, at Universidad Carlos III-Madrid-)
   We derive loss functions for forecast evaluation of term structure models that are motivated by investment strategies in fixed income. We show that taking into account such strategies results in asymmetric loss functions for forecast evaluation. We test different term structure model using these loss functions.

5. Characterizing the Colombian intraday stock market (joint work with Catalina Cadena at Universidad del Rosario)
   We build a set of modules in R (and Python) to monitor the Colombian intraday stock market. The modules look at different elements of trading quality over the intraday market using historical data (inter-arrival times, trading volume, spreads, and volatility, among others). We also estimate price impact for some of the most representative stocks in the market.
Ph.D in Mathematics, University of York United Kingdom

Research interests: Stochastic analysis, optimal control and applications to mathematical finance.


PUBLICATIONS

Journal articles

Working papers and other publications
• R. Serrano. Dynamic programming for stochastic target problems, viscosity solutions and hedging in markets with portfolio constraints and large investors. Universidad del Rosario, Facultad de Economía - Documento de trabajo 170

CURRENT RESEARCH PROJECTS

1. Optimal portfolio allocation for an investor with insurance risk, portfolio constraints and differential rates (with Camilo Castillo – MSc Quantitative Finance student)
We study the optimal investment-consumption problem for a firm that invests in the financial market but also undertakes an insurance business. The firm backs up the
liabilities raised by the insurance contracts with the underwriting profits and the income resulting from investing in the financial assets. Our model assumes policy limits for the insurance contracts but claim-severity distributions as well as intensity can be time-dependent. We also assume the firm can decide at each time on the number of policies held in the portfolio of insurance contracts. Using the martingale approach and convex duality techniques we find explicit portfolio proportions, instantaneous consumption rate and liability ratio that maximize expected utility from consumption and final wealth under CRRA preferences in presence of portfolio constraints, differential interest rates for borrowing and lending, and negative rebate rates for short positions.

2. Portfolio optimization with differential rates and other frictions: taxes on capital gains, expected loss constraint and rank-dependent preferences.

Using martingale and convex duality methods we study portfolio optimization in a continuous-time model for 3 different scenarios: taxes on capital gains, expected loss constraints and rank-dependent risk-averse preferences. We generalize existing results to the case in which borrowing interest rate is higher than investment/lending rate and characterize explicitly the value function and optimal strategies in the case the asset dynamics follow a Markov process.

3. LP formulation in measure spaces of combined optimal stopping and control of jump-diffusions

We formulate an infinite-horizon combined optimal stopping and control problem for jump-diffusions of Ito–Levy type as a LP problem in a measure space, and prove that the optimal value functions of both problems coincide. The main tools are the dual formulation of the LP primal problem, which is strongly connected to the notion of sub-solution of the partial integro-differential equation of Hamilton–Jacobi–Bellman type associated with the optimal control problem, and the Krylov regularization method for viscosity solutions.

4. Utility maximization in a stochastic multi-dimensional time-continuous neo-classical production economy model with Cobb-Douglas technology, CRRA preferences and discontinuous shocks (with Mauricio Junca – Universidad de los Andes)

We find the optimal allocation of wealth and capital for a representative agent in a multi-dimensional time-continuous neo-classical production economy model with Cobb-Douglas technology. The wealth equation (budget constraint) is subject to stochastic shocks that follow a semi-martingale process with jumps. Using the martingale approach and convex duality techniques, we find sufficient conditions for existence of optimal wealth allocation proportions. We characterize this conditions explicitly in the case of CRRA preferences.

5. Dynamic stochastic general equilibrium models with jumps (with Juan Carlos Zambrano – PhD student)

In this project we study non-linearities arising in a neoclassical production model with time-varying, asymmetric risk premia and predictability over the business cycle. We employ analytical solutions of dynamic stochastic general equilibrium models in order to obtain closed-form expressions for the risk premium in a production economy subject to shocks with discontinuities (jumps). We also use numerical methods to solve the Hamilton-Jacobi-Bellman equation and find optimal policies associated with this problem.
Ph.D in Financial Mathematics, The University of Manchester

Research interests: Computational Finance, Portfolio optimization, stochastic optimal control, Limit Order Books, Algorithmic trading.


PUBLICATIONS

- Optimización de portafolios con Capital en Riesgo acotado, Revista Mexicana de Economía y Finanzas Nueva Época REMEF 2012
- Hedge Funds Management with Liquidity Constraint, submitted.

CURRENT RESEARCH PROJECTS

1. The Optimal Interaction Between a Hedge Fund Manager and Investor
Over a hedge fund comprising one risky asset and a risk-less bond, we model a manager’s wealth and the corresponding investor's wealth, subject to the special reward scheme of hedge funds. Then we maximise the expected utility of wealth of the manager, by controlling the percentage invested in the risky asset, and obtain the utility of wealth of the investor under the decisions made by the manager. We use stochastic control techniques to derive partial differential equations (PDEs) and numerically obtain their corresponding viscosity solutions. We then we propose a new hedge fund contract where the investor has the option to reinvest in the fund, to do so we model a strategic game where the manager's movement is allocate the money between the two investments and the investor's movement is to add money to the fund when he perceives benefit. The results show that the investor is inflowing money to keep the fund open because it is more beneficial, and we found that in some extreme cases this strategy does not make both agents benefit.

2. Optimal Trend Following Trading (with Diego Amaya. Wilfrid University)
Following Dai, Zhang and Zhu's paper (2010) we explore mathematical models for trading rules over bear and Bull markets, and we aim create a regime switching algorithm based on optimal stopping times. Additionally, starting with the optimal liquidation problem, we aim to add order imbalance as in Cartea and Jaimungal (2016), which is also solved via dynamic programing.
JACQUES BURRUS
Part-time Professor
jacques.burrus@urosario.edu.co

Master in Financial Engineering, University of California, Berkeley, CA - Haas School of Business

Master in Supply Chain Management, University of California, Berkeley, CA - College of Engineering

Research interests: Pricing of Latam derivatives/fixed income and XVA.

Teaching experience: Derivatives, Options and Continuous-time finance, Credit risk and XVA, Introductory finance, Latam and international market conventions, Bloomberg, numerical methods.

PUBLICATIONS


CURRENT RESEARCH PROJECTS

1. Pricing of local derivatives contracts and fixed income securities.
   We develop and implement a generic pricing framework for the consistent pricing across assets classes (derivatives/fixed income) and the concurrent incorporation of all risk factors (parity, discount, credit, volatility). This methodology allows the accurate calculation of XVA while reconciling the apparent divergence between the international OIS discount and the local funding cost discount. Also, the framework elegantly accounts for the publication lags typical of Latam financial indicators.

2. Documentation of local conventions.
   We are documenting the main market conventions of Latam derivatives contracts and sovereign fixed income securities. Having completed the documentation of Chilean, Colombian, US, and European markets, we are now focusing on Peru, Mexico, Japan, as well as G10 forwards markets.
Visit our web site:
http://www.urosario.edu.co/
Maestria-en-Finanzas-Cuantitativas

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