**Università degli Studi di L'Aquila - Dipartimento di Ingegneria e Scienze dell'Informazione e Matematica**

# Course catalogue

*Page compiled on 19/10/2019*

## Programme of Integrated course "Financial Data Analytics and Investment Data Driven Decisions"

This course is composed of 2 Modules: 1) Financial Data Analytics and Investment Data Driven Decisions I, 2) Financial Data Analytics and Investment Data Driven Decisions II

### Programme of Module "Financial Data Analytics and Investment Data Driven Decisions I"

- Code: DT0321
- Type of course unit: Elective (Bachelor Degree in Computer Science curriculum General), Elective (Master Degree in Computer Science curriculum NEDAS), Elective (Master Degree in Computer Science curriculum SEAS)
- Level of course unit: Undergraduate Degrees, Postgraduate Degrees
- Semester:

Number of ects credits: (Bachelor Degree in Computer Science) 3 (workload 75 hours), (Master Degree in Computer Science) 3 (workload 75 hours)

Teachers: Giuseppe Alesii (galesii@univaq.it)

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| **1** | **Course objectives** | The students quantitative and programming capabilities are applied to asset pricing and positive (economics) portfolio selection corporate finance modelling. |
| **2** | **Course content and learning outcomes (dublin descriptors)** | Topics of the module include:<br>• assets returns and risk; (a) how to compute an asset return, pages 9-13 (Lo and MacKinlay, 1999): i. discrete vs continuously compounded asset returns: ii. overlapping and non overlapping returns; iii. capital gains, dividend yields and return indexes; (b) expected returns and risk gauges, e.g. standard deviation, interquartile diff erences; (c) which distribution represents best stock returns, pages 13-20 (Lo and MacKinlay, 1999); (d) Market efficiency and returns predictability, chapter 2 (Lo and MacKinlay, 1999): i. testing the Random Walk Hypothesis: ii. returns prediction and trading rules; A. technical analysis; B. statistical learning and pattern recognition; (e) variability of pairs of stocks, covariance and Bravais Pearson correlation index; (f) linear relation between two stock returns and its estimation through ordinary least squares: regression line;<br>• diversi cation eff ects when only risky assets are available, (Markowitz, 1959) Portfolio Selection: (a) n = 2 risky stocks portfolio: i. minimum variance opportunity set; ii. effi cient portfolios frontier; iii. global minimum risk portfolio; (b) n > 2 risky stocks portfolio: i. effi cient portfolio for a given expected return; ii. how to choose among portfolios represented on the minimum variance opportunity set: A. (Markowitz, 1959) mean variance criteria; B. stochastic dominance criteria; fi rst order stochastic dominance; second order stochastic dominance; C. indiff erence curves in the risk return space, marginal rate of transformation (supply), marginal rate of substitution (demand); for a quadratic utility function; logarithmic utility function; iii. Two Fund Separation Theorem, (Tobin, 1958) with risky assets only;<br>• some empirical guesses about Data Generating Processes of joint stock returns; (a) equally weighted portfolio experiment; (b) systematic vs idiosyncratic risk: single index model; market model; (c) properties i. additivity principle; ii. covariance and total risk, variance, of a portfolio; iii. covariance of two stocks expressed as a function of their j ; iv. partitioning of total risk, standard deviation of a stock in systematic and idiosyncratic risk, R2 and regression line;<br>• CAPM of Sharpe-Lintner-Mossin, (Sharpe, 1963), (Lintner, 1956), (Mossin, 1966); (a) assumptions; (b) a simple derivation of the Security Market Line; (c) about CAPM and market e ciency: Jensen's ; (d) how to discount risky cash ows: i. risk adjusted rate of return; ii. certainty equivalent; (e) ex post CAPM; i. derivation; ii. the characteristic line of a stock;<br>• CAPM without riskless asset, two factor model of (Black, 1972); (a) orthogonal portfolio derivation; (b) a simple derivation of the Security Market line without riskless asset; (c) (Roll, 1977) critique about the effi ciency of the market portfolio, numerical example;<br>• Ross (1976) APT. a) a new Data Generating Process: multi index model vs multi |

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| | | factor model, orthogonalizing factors; b) a proof of how arbitrage portfolios which endure no risk, neither idiosyncratic nor systematic, must have nil returns on average; c) risk premia and risk sensitivities; d) APT parameters estimation approaches overview; e) Using APT in Asset management e.1) Passive investment strategies; e.2) Active investment strategies;<br><br>On successful completion of this module, the student should :<br><br>-- have a thorough and deep knowledge of some asset pricing and some positive (economics) portfolio selection models. In particular, he/she must be able to provide OLS estimates for both CAPM and APT equations parameters. He/she must be able to construct optimized portfolios according to the closed forms taught at lesson derived from multivariate functions calculus applications. Finally, the student should be able to perform data scraping, getting data needed for the models, and to organize them in a database.<br><br>-- be able to use her/his programming skills in simple Excel spreadsheets and/or in high programming languages such as Gauss or MatLab, not only for financial models and algorithms dealt with at lesson but also for other similar problems.<br><br>-- have acquired general skills in the field of algorithms and applied programming for asset pricing and portfolio selection which enable him/her to make educated choices in a problem solving practice framework. To be specific, the student should be able set up Excel spreadsheets and/or high level language, GAUSS or MatLab, codes implementing CAPM and APT and related portfolio selection solutions derived applying multivariate calculus optimization techniques in both original and new kind of problems.<br><br>-- be capable to give a presentation both in front of a general practitioners' audience and a more academic one about the models dealt within the course.<br><br>-- have acquired a method of study both thanks to a wide knowledge of the main streams in which financial modelling is evolving, theoretical continued learning, and a confident practice with respect to the main high level programming languages, GAUSS and MatLab, which are continually evolving, best practice continued learning. |
| **3** | **Course prerequisites** | The students quantitative and programming capabilities are applied to corporate finance modelling. To be specific, the course will focus on capital budgeting models, i.e. the choice of industrial investment projects, in both a deterministic and a stochastic framework. |
| **4** | **Teaching methodsand language** | lectures and practice drills in the computer lab.<br>**Language**: Italian<br>**Reference textbooks**<br>• Thomas E. Copeland, J. Fred Weston, and Kuldeep Shastri,, ***Financial Theory and Corporate Policy***. Addison-Wesley. 2005.<br>• Luenberger, D, ***Investment Science***. Oxford University Press. 1998.<br>• Edwin J. Elton, Martin J. Gruber, Stephen J. Brown, William N. Goetzmann, ***Modern Portfolio Theory and Investment Analysis*** . Wiley. 2014. |
| **5** | **Assessment methods** | **Pre Assessment** A preliminary assessment of prerequisite skills is not performed in this course. **Formative Assessment** The formative assessment of this course teaching and learning process is performed through class participation during lessons: A) students may be asked to answer questions about topics dealt with at lesson; students may ask instructor questions during lessons both about the very topic dealt with at lesson and about correlated topics they are particularly interested in. B) summary of previous week lessons: a student is randomly selected to sum up topics dealt with in the previous sessions, actually introducing extant session; C) short seminars: students are required to apply their skills in Calculus, Stochastic Calculus, Numerical Analysis and Mathematical Statistics to specific problems in finance, proposing their own solutions previously prepared as homeworks. **Summative Assessment** The summative assessment of this course is performed through A) Written tests: i) during the semester module a mid term and a final test at the end of the |

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| | | semester are given for students attending lessons; ii) a comprehensive test is given in ordinary exam sessions for students not attending lessons and for attending students that do not pass mid term and final semester tests; B) Homeworks and take home projects: some compulsory homeworks are given on specific topics to let students delve into the subject at her/his own pace; some optional take home projects are suggested to students particularly interested in applying quantitative methods of their choice to finance problems. C) Oral exams: after achieving at least an average pass grade in written tests during the semester or, as an alternative, an equivalent valuation on a comprehensive written test in an ordinary exam session, students are required to take an oral exam made up of: 1) questions about mistakes in written tests; 2) one's choice topic question. **aims and formative purposes** students are evaluated with respect to three different dimensions of learning: A) Baseline theoretical knowledge provided through lessons and suggested reading list: tested through open questions to be answered through short essays; B) Problem solving involving symbolic calculus and stochastic calculus capabilities: tested through questions about model building and algorithms tuning for specific formal problems; C) Programming capabilities: tested through small (large) problems in class (at home) assignments to be programmed in a high level language, e.g. MatLab, Gauss, Ox, Scilab. **Evaluation criteria** 1) final numerical results achievement; 2) style: 2.1) in modelling – possibly new – solutions in a symbolic layout; 2.2) in writing codes for extant models; 2.3) in prose for short essays questions. **Assessment breakdown** Formative and Summative Assessment towards the definition of a final grade weights on the final grade: In class participation 5%; Summary of previous week lessons 10%; Short seminars (if given, else the weight is given to class participation) 5%; In Class written tests 50%; Home assignments (homeworks and take home projects) 25%; Oral Exam 5%. |

## Programme of Module "Financial Data Analytics and Investment Data Driven Decisions II"

- Code: DT0322
- Type of course unit: Elective (Bachelor Degree in Computer Science curriculum General), Elective (Master Degree in Computer Science curriculum NEDAS), Elective (Master Degree in Computer Science curriculum SEAS)
- Level of course unit: Undergraduate Degrees, Postgraduate Degrees
- Semester: 2

Number of ects credits: (Bachelor Degree in Computer Science) 3 (workload 75 hours), (Master Degree in Computer Science) 3 (workload 75 hours)

Teachers: Giuseppe Alesii (galesii@univaq.it)

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| 1 | **Course objectives** | The students quantitative and programming capabilities are applied to normative asset pricing and positive portfolio selection modelling. |
| 2 | **Course content and learning outcomes (dublin descriptors)** | Topics of the module include:<br>• Asset pricing, portfolio selection and data analytics: from positive economics modelling to normative approaches. asset management issues and algorithmic solutions.<br>• portfolio selection in practice. case studies to recast optimized portfolios dealt with in the first part of the course: a) constraints used in practice: a.1) no short selling positions; a.2) holding positions; a.2) turnover; a.3) factor sensitivity; a.4) cardinality; a.5) minimum holding and transaction size; a.5) round lot; a.6) tracking error; a.7) other soft constraints; b) tail risk measure constraints: b.1) VaR optimized portfolios; b.2) CVaR optimized portfolios. c) incorporating transation costs in portfolio optimization: c.1) linear; c.2) piecewise linear; c.4) quadratic; c.5) fixed; d) incorporating taxes in portfolio optimization.<br>• robust equity portfolio construction: a) box uncertainty b) ellipsoidal uncertainty<br>• shrinkage methods and the Black Litterman model for equity portfolio construction<br>• VaR and CVaR constrained equity portfolio construction.<br>• Performance testing. main performance ratios: 1) Sharpe Ratio; 2) Jensen's alpha; 3) Tracking Error; 4) Information Ratio; 5) Sortino Ratio; 6) Maximum Draw-down; 7) VaR; 8) CVaR; Stress testing of portfolio strategies.<br><br>On successful completion of this module, the student should : |

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| | | -- have a thorough and deep knowledge of some asset pricing and some normative portfolio selection models. In particular, he/she must be able to estimate using also Bayesian statistical methods the main inputs for portfolio modelling. He/she must be able to construct optimized portfolios using Monte Carlo and bootstrapping methods and numerical optimization approaches as well, having laid out the mathematical setting to be simulated and/or optimized. Finally, the student should be able to perform data scraping, getting data needed for the models, and to organize them in a database.<br><br>-- be able to use her/his programming skills in simple Excel spreadsheets and/or in high programming languages such as Gauss or MatLab, not only for financial models and algorithms dealt with at lesson but also for other similar problems.<br><br>-- have acquired general skills in the field of algorithms and applied programming for asset pricing and portfolio selection which enable him/her to make educated choices in a problem solving practice framework. To be specific, the student should be able set up Excel spreadsheets and/or high level language, GAUSS or MatLab, codes implementing numerical optimization and Monte Carlo or bootstrapping simulation in view of achieving portfolio selection solutions in both original and new kind of problems.<br><br>-- be capable to give a presentation both in front of a general practitioners' audience and a more academic one about the models dealt within the course.<br><br>-- have acquired a method of study both thanks to a wide knowledge of the main streams in which financial modelling is evolving, theoretical continued learning, and a confident practice with respect to the main high level programming languages, GAUSS and MatLab, which are continually evolving, best practice continued learning. |
| **3** | **Course prerequisites** | Programming skills in Excel and in a matrix oriented language such as MatLab, Gauss, Ox, Scilab, Octave. The student should be confident in calculus in both univariate and multivariate functions studies, in the basics of probability calculus, namely main continuos and discrete density functions. In order to attend the course it is highly advisable to have passed the following exams or equivalent: Probability And Mathematical Statistics, Foundations Of Programming And Laboratory, Operation Research And Optimization in addition to Financial Data Analytics and Inverstment Data Driven Decisions I |
| **4** | **Teaching methodsand language** | lectures and practice drills in the computer lab.<br>**Language**: Italian<br>**Reference textbooks**<br>• Benninga, Simon et al, ***Financial modeling***. The MIT Press. 2008.<br>• Fabozzi, Frank J.; Pachamanova, Dessislava A., ***Portfolio construction and analytics***. John Wiley & Sons. 2016.<br>• Kim, Woo Chang; Kim, Jang Ho; Fabozzi, Frank J, ***Robust Equity Portfolio Management,+ Website: Formulations, Implementations, and Properties Using MA***. John Wiley & Sons. 2015.<br>• Fabozzi, Frank J; Kolm, Petter N.; Pachamanova, Dessislava A.; Focardi, Sergio M., ***Robust portfolio optimization and management***. John Wiley & Sons. (vol. 1) 2007.<br>• Pachamanova, Dessislava A.; Fabozzi, Frank J., ***Simulation and Optimization in Finance: Modeling with MATLAB,@ RISK, or VBA***. John Wiley & Sons. (vol. 1) 2010. |
| **5** | **Assessment methods** | **Pre Assessment** A preliminary assessment of prerequisite skills is not performed in this course. **Formative Assessment** The formative assessment of this course teaching and learning process is performed through class participation during lessons: A) students may be asked to answer questions about topics dealt with at lesson; students may ask instructor questions during lessons both about the very topic dealt with at lesson and about correlated topics they are particularly interested in. B) summary of previous week lessons: a student is randomly selected to sum up topics dealt with in the previous sessions, actually introducing extant session; C) short seminars: students are required to apply their skills in Calculus, Stochastic Calculus, Numerical Analysis and Mathematical Statistics to specific problems in finance, proposing their own solutions previously prepared as homeworks. **Summative |

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| | | Assessment** The summative assessment of this course is performed through A) Written tests: i) during the semester module a mid term and a final test at the end of the semester are given for students attending lessons; ii) a comprehensive test is given in ordinary exam sessions for students not attending lessons and for attending students that do not pass mid term and final semester tests; B) Homeworks and take home projects: some compulsory homeworks are given on specific topics to let students delve into the subject at her/his own pace; some optional take home projects are suggested to students particularly interested in applying quantitative methods of their choice to finance problems. C) Oral exams: after achieving at least an average pass grade in written tests during the semester or, as an alternative, an equivalent valuation on a comprehensive written test in an ordinary exam session, students are required to take an oral exam made up of: 1) questions about mistakes in written tests; 2) one's choice topic question. **aims and formative purposes** students are evaluated with respect to three different dimensions of learning: A) Baseline theoretical knowledge provided through lessons and suggested reading list: tested through open questions to be answered through short essays; B) Problem solving involving symbolic calculus and stochastic calculus capabilities: tested through questions about model building and algorithms tuning for specific formal problems; C) Programming capabilities: tested through small (large) problems in class (at home) assignments to be programmed in a high level language, e.g. MatLab, Gauss, Ox, Scilab. **Evaluation criteria** 1) final numerical results achievement; 2) style: 2.1) in modelling – possibly new – solutions in a symbolic layout; 2.2) in writing codes for extant models; 2.3) in prose for short essays questions. **Assessment breakdown** Formative and Summative Assessment towards the definition of a final grade weights on the final grade: In class participation 5%; Summary of previous week lessons 10%; Short seminars (if given, else the weight is given to class participation) 5%; In Class written tests 50%; Home assignments (homeworks and take home projects) 25%; Oral Exam 5%. |