Course syllabus «Modeling of financial transactions»

Educational program – applied mathematics and informatics

Bachelor program

Утверждена

Академическим советом ООП

№ 8.1.2.1-11/03 «29» июня 2018 г.

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Credits	3
Class work (hours)	44
Individual work (hours)	70
Year of study	4
Method of study	No use of distant courses

I. ЦЕЛЬ, РЕЗУЛЬТАТЫ ОСВОЕНИЯ ДИСЦИПЛИНЫ И ПРЕРЕКВИЗИТЫ

The objectives of the course is to get acquainted with the basic mathematical models of financial transactions, the development of skills in working with financial data, the main methods and algorithms of analysis of financial time series.

As a result of the development of the discipline the student must:

- Know the basic theoretical principles of the basic mathematical models of financial transactions;
- Be able to use professional computer packages to analyze financial data, compare their capabilities, advantages and disadvantages;
- Be able to use software products to solve problems;
- Be able to find the necessary information in additional literature;
- Be able to use this knowledge to describe and solve problems using the apparatus of mathematical and computer Sciences;
- Have practical skills in analyzing real financial data;
- To have skills in development and computer implementation of new methods of financial data analysis.

This discipline belongs to the elective part of the professional block of disciplines for bachelor degree. The study of this discipline is based on the fundamental courses "Mathematical analysis", "Linear algebra", "Probability ", "Mathematical Statistics". The main provisions of this course are used in the study of disciplines of the block of decision-making.

II. COURSE CONTENT

1. Stock market. Assets. Return on assets as a random variable. Distributions of returns. The relationship between the returns: correlation, linear regression, contingency table. Risk (standard deviation of return, Value at Risk)

2. Markowitz Model. The return and risk of the portfolio. Mean-variance optimization. Efficient frontier. Theorem on two investments. Risk aversion. Selection of the optimal portfolio in relation to risk. Utility function. Selection of the optimal portfolio by utility function. Value at risk. Construction of the optimal portfolio by the criterion of minimizing the value at risk.

3. Markowitz-Tobin Model. Portfolios in the presence of a risk-free asset. Efficient frontier. Optimal portfolio. Calculation of the optimal portfolio.

4. Model with one index. Index definition. The coefficients alpha and beta of the asset. The coefficients alpha and beta of the portfolio. Determination of the optimal portfolio in the model with one index.

5. Capital Asset Pricing Model (CAPM). Market portfolio. Capital line. The beta of asset. The beta of the portfolio. The ratio between the expected return and the beta ratio of the portfolio. Securities market line. Overvalued and undervalued portfolios. Aggressive and defensive portfolios.

5. Factor model for the market. Arbitrage. The ratio between alpha and beta assets in the absence of arbitrage. Determination of arbitrage opportunities.

6. The structure of the efficient frontier when the short sales are not allowed. The peace-wise linear structure of the portfolio.

7. Options. Binomial model of prices. Black-Scholes Formula. Computational algorithms.

III. EVALUATIONS

At the seminars, students make reports on the topics of the seminar and present the results of practical work. Reports and results are commented by the teacher, who highlights the problems of using different methods of financial data analysis, typical errors and ways to correct them. The current control is carried out in the form of homework. Final control, the exam is held in the test week of the last module. When writing homework (laboratory work), the student must demonstrate an understanding of the basic concepts of financial data analysis. According to the results of the current control, individual consultations are organized either within the framework of the second half of the working day of the teacher, or by e-mail. The results of individual and laboratory work provided by the students are discussed at the seminars and evaluated by the lecturer and teacher conducting practical classes. Final result formula is as follows

FinalResult = 0.4 * Home Work + 0.6 * Exam

The result obtained after rounding this value to an integer value is set as the resulting score on a 10-point scale. The rounding method is arithmetic.

IV. EXAMPLES OF CONTROL TASKS

Homework topics

- Primary analysis of stock market data
- Optimal investment portfolio. The Markowitz Model.
- Single index model. Arbitrage opportunities
- Calculation of prices of options

Example of homework task

Homework 1. Primary analysis of market data.

1. Collect data on asset prices (shares) and sales volumes on the indicated stock market for the period 01.01.2010-31.12.2014 (four years)
2. Convert price data in the return data (use logarithmic returns). Investigate (selectively) distributions of returns and sales volumes for assets from different industrial sectors. Draw conclusions.
3. Investigate the dependence (selectively) between the returns of different assets with the help of the technique of dependency analysis
   - correlation coefficient (estimate the significance of correlation)
   - linear regression (estimate the quality of regression)
   - contingency table (use chi-square independence test).
4. Analyze the dependency between returns of pairs of assets for assets from one industrial sector and for assets from different industrial sectors.
5. Make an analysis of the relationship (selectively, according to the scheme above) between the returns and sales volumes of one asset. Consider assets from different industrial sectors.

Examples of exam tasks.

Efficient frontier. Investment portfolios are formed from two assets with returns R1 and R2. It is known that

- E(R1) =0.3, E(R2) =0.1, σ(R1) = 0.1, σ(R2) =0.1, Cov (R1, R2) = - 0.005.
- Calculate the minimum risk value (standard deviation), that can have a portfolio made up of these two assets? How effective will be this portfolio?
- In the plane (σ2, E,), draw the efficient frontier of the considered investment portfolios for two cases: short sales are allowed, and short sales are forbidden.

V. SOURCES

5.1 Main references

1. 1. Dunis Christian L. Artificial Intelligence in Financial Markets [Электронный ресурс]: Cutting Edge Applications for Risk Management, Portfolio Optimization and Economics / Dunis Christian L., Peter W. Middleton, Andreas Karathanasopolous, Konstantinos Theofilatos. БД Springer. ISSN 2192-4333 ISSN 2192-4341 (electronic) Springer-Verlag Berlin Heidelber, 2016. Режим доступа: https://link.springer.com/book/10.1057/978-1-137-48880-0 - - Загл. с экрана.

5.2 Additional references

2. 1. Zapounidis at al. Handbook in Financial Engineering [Электронный ресурс] / Constantin Zopounidis, Michael Doumpos, Panos M. Pardalos. Springer 2008. ISBN: 978-0-387-76681-2 e-ISBN: 978-0-387-76682-9 Режим доступа: https://link.springer.com/book/10.1007/978-0-387-76682-9 - Загл. с экрана
3. 2.Arratia, Argimiro. Computational Finance [Электронный ресурс]: An Introductory Course with R / Arratia, Argimiro. Atlantis Press, 2014. ISSN 2352-3255, ISSN 2352-3115 (electronic). Режим доступа: https://link.springer.com/book/10.2991/978-94-6239-070-6 - Загл. с экрана.

Additional references for individual work

4. Панджер Х. и др. Финансовая экономика с приложениями к инвестированию, страхованию и пенсионному делу. М. Янус-К, 2005.
5. Шведов А.С. Теория эффективных портфелей ценных бумаг, Изд-во ГУ ВШЭ. 2000
6. Люу Ю.Д. Методы и алгоритмы финансовой математики, Москва, БИНОМ, 2007. Kolm, Petter N. & Tütüncü, Reha & Fabozzi, Frank J., 2014. "60 Years of portfolio optimi-

zation: Practical challenges and current trends," European Journal of Operational Research, Elsevier, vol. 234(2), pages 356-371. DOI: 10.1016/j.ejor.2013.10.060
7. Kuersteiner G. Time Series Analysis, lectures for students of economic department, Massachusetts Institute of Technology, 2002
8. Cochrane J.H. Time Series for Macroeconomics and Finance, Graduate School of Business, University of Chicago, 1999.
9. Best M.J. Portfolio optimization, pp.238, CRC Press, 2010.
10. Tsay R.S. Analysis of Financial Time Series, John Wiley and Sons, 2002.

5.3 Software

№ п/п	Name	Access
1.	MathWorks MATLAB	From interior university network
2.	R (programming language)	Free license agreement

5.4 Professional databases

№ п/п	Наименование	Условия доступа
	Профессиональные базы данных, информационно-справочные системы	
1.	Электронно-библиотечная система Юрайт	URL: https://biblio-online.ru/
	Интернет-ресурсы (электронные образовательные ресурсы)	
1.	Открытое образование	URL: https://openedu.ru/

5.5 Technical support

Multimedia equipment: laptop, screen, projector.