Scientific Report on the implementation of the project "Portfolio Selection Models and Applications" in the period october 2011- october 2016

Name of the project: Portfolio selection models and applications
Project number CNCS UEFISCDI: PN-II-ID-PCE-2011-3-0908.
Project director: dr. Radulescu Marius

The project has several objectives. A list of them is presented in the following.
Project objectives

1. Development of new mathematical models for sustainable development
2. Realization of decision support tools based on these models.
3. Research on sustainable development models
4. Models of decision-making for sustainable development based on portfolio theory and the theory of loss functions.
5. Research on the efficient frontier of portfolio selection theory models
6. Research on absolutely optimal portfolios
7. Analysis efficient frontier of portfolio selection models
8. Single period portfolio selection models with complementarity constraints
9. Multi-period portfolio selection models with complementarity constraints

One of the main goals of the project was to develop new mathematical models and achieve sustainable development decision support tools based on these models. The models in this area are characterized by multiple objectives and restrictions. Several surveys on applications of portfolio theory in sustainable development with emphasis on issues of sustainable agriculture and Operational Research mathematical models were made in the papers [A8], [F1] and [C1].

The research report [G1] contains such a survey.
In the book [E1] were studied several multi-criteria decision models and applications to sustainable development.
In [A8] was made a survey on the models of sustainable development in industry and agriculture. The models fall in the category of the planning models with environmental constraints. The ideas underlying these models are inspired from the theory of financial investments. The role of financial assets is played here by various industrial products manufactured or the crops. The models are in continuous variable and in discrete variable.
In the paper [A1] was presented a general criterion for determining the existence and uniqueness of solutions of nonlinear equations. Solving nonlinear equations appear in optimization problems (in particular of portfolio theory models).
In [A8] they were formulated several models based on portfolio theory for planning crops in the presence of some environmental constraints.
The models aim to solve the tradeoff between economic objectives and those related to reducing the application of fertilizers and pesticides. Several numerical examples have been studied. In the paper [A9] were presented several crop planning models in continuous variable. The models are based on portfolio theory and risk is measured using two

symmetrical measures: mean absolute deviation and variance of the return. The decision variables of the model are represented by land areas allocated to crops. Among the models considered we remind the financial risk minimization and the maximization of the expected return models. Unlike the previously crop planning models considered, which were discrete models, models in [A9] are mathematical programming models in continuous variable. Several numerical examples for symmetric measures of risk were analyzed. Comparisons were made between efficient frontiers.

In the paper [C4] was presented a multi-objective model for crop planning that takes into account environmental issues. The models fall into the category of crop diversification models and provide optimal allocation of land plots to agricultural crops. Since the models avoid monoculture its application contributes to the reduction of the amount of fertilizers and pesticides applied to crops. The planning model is a binary mathematical programming model. The efficient frontier of the model is analyzed.

In the paper [C1] were developed two single period portfolio selection models for production planning in fish farms. The programming models are stochastic models and represent an alternative to mean-variance type models. One of these models is a "safety first" type and the other is a "chance constraints" type. Some of the variables are real numbers and others are binary variables, i.e. take only the values zero and one. Models constraints are related to budgets fish farms and the quantities of fish of each species to be collected.

In the paper [D1] were presented several optimization models for renewable energy based on the portfolio theory. The models refer to the determination of the optimal location and the sizes of units for producing renewable energy (wind farms or solar parks). The constraints of the models are connected to the investment budgets, the average amount of energy captured, the degree of stability of energy obtained. Are considered the costs of connecting to the transmission network energy, land prices on which the units for producing renewable energy are located, historical data on the quantities of renewable energy at various locations. The optimization models are mathematical programming models in integer numbers. A numerical result for the minimum variance model is studied.

The realization of decision support tools based on these models was treated in the paper [A2]. Here it was presented a software tool for risk minimization of investment in agriculture. Several numerical results were analyzed. For details see research report [G2].

In the paper [C3] a crop planning model in the presence of charges related to environmental protection is studied. The model aims to find an allocation of crops to lots in order to reduce the impact of farming practices on the environment. The objective function of the model is linked to environmental taxes paid by the farmer, so it has the significance of environmental risk.

The purpose of the model is to minimize the objective function. Simulations are made on efficient frontier model mentioned above in terms of historical data of different lengths.

In [A3] was proposed a general method that transforms a non-convex optimization problem in an issue which has better properties. In certain cases the local convexity of the Lagrangean function is ensured, consequently the class of optimization models to which dual methods can be applied is extended. An application for a numerical optimization problem which particularly belongs to the class of portfolio selection models is presented.

In [A4] portfolio selection models of mean-variance type in which there are missing data are studied. A formalization of the process of building the vector of means and the NaN-covariance matrix for these models is presented. Based on this idea, starting from a matrix containing historical data on the rate of return from a series of binary matrices that describe the location of missing data in the matrix containing historical data on the rate of return,the efficient frontier of the risk minimization models is studied.

In several talks given at international conferences were defined and studied the properties of functions and sets of the efficient frontier associated to portfolio selection problems. The duality between the risk minimization problems and the expected return maximization problems was studied. Absolutely optimal portfolios were defined and the necessary and sufficient conditions that for a given portfolio there exists a stochastic vector such that this portfolio to be absolutely optimal.
The results related to the goal of "Single period portfolio selection models with complementary constraints" are original, were included in the research reports [G3] and [G4]. In the research report [G3] we define a class of mathematical programming problems with complementarity constraints. Such constraints increase the difficulty of the problems that now fall into the category of combinatorial optimization problems. The set of feasible solutions to the problems from the above class is the union of a family of convex sets but it is not convex.
In this paper we present an algorithm for solving the problems with complementarity constraints which involves resolving a series of mathematical programming problems with the set of feasible solutions being convex. The algorithm requires a large computational effort. Applications of the models considered are made to portfolio selection models that include transaction costs and initial portfolio for the investor. In the case of linear transaction costs we give an equivalent formulation between the models with complementarity constraints and the mixed-binary type models. A numerical example is analyzed. In the research report [G3] an analysis of portfolio selection models with transaction costs is presented. For the case of linear transaction costs two equivalent linear models are presented.
The first model has non-smooth constraints. The second model has complementarity constraints. The second type models are equivalent to mixed- binary type models. Estimations of the optimum value of the objective functions for these models are obtained. Several heuristic algorithms for solving models with complementarity constraints are presented. A numerical analysis of the results and an analysis of the sensitivity of the models were performed.
In the research report [G4] there is a formulation of multi-period portfolio selection models with complementarity constraints in the presence of some simplified assumptions.
In the research report [G5] several multi-period portfolio selection models are studied. Transaction costs are assumed to be proportional to the volume of assets traded. Risk is measured by the variance of retum. The obtained models have complementary constraints. By introducing additional binary variables are obtained some mixed-binary type models which are equivalent to the original models. Some numerical examples for the multi-period portfolio selection models are analyzed.
In the paper [A10] were formulated several models inspired from portfolio theory for the selection of vendors of software products. The models contain complementary constraints. The performances of the software products offered for sale by the software companies are evaluated by several experts. A risk minimization model is formulated that is a binary programming model. A procedure for solving the minimum risk model mentioned above is described. A numerical example for the marketing of an ERP software product is studied.
In papers [A13] and [B1] was presented an approach based on an integrated approach to portfolio selection. The methodology proposed in [A13] focuses on incorporating investor preferences in Mean-Risk type models. The paper proposes a measure of downside risk type that captures in very good conditions the risk averse behavior of the investor. The proposed methodology has two stages. The first phase determines the set of investment opportunities (efficient frontier). In the second stage is selected one portfolio (i.e. the portfolio that has the highest average utility).

Dissemination of results obtained in the work of the grant was made through the presentation of papers in prestigious conferences in the field. All results presented at conferences were published or will be published in prestigious journals.
The appendix to this report contains a selective list of works developed under the grant that had high visibility. The citations from literature are presented.

Positions held by the team members of the research grant in the international conferences:

Name of the team member: Fulga Cristinca
Name of the international conference: Conference EURO XXV, Vilnius, Lithuania, 2012
Positions held in the conference: Stream organizer with 5 sessions
Name of the stream: Decision Making Modeling and Risk Assessment in the Financial Sector

Name of the team member: Radulescu Marius
Name of the international conference: Conference EURO XXV, Vilnius, Lituania, 2012
Positions held in the conference: Chair al session: Portfolio Decision Analysis

Name of the team member: Radulescu Marius
Name of the international conference: 21st International Symposium on Mathematical Programming (ISMP), Berlin, 2012
Positions held in the conference: Chair of the session: Portfolio Selection Problems

Name of the team member: Radulescu Marius
Name of the international conference: 8th EUROSIM Congress on Modelling and Simulation, (EUROSIM2013), Cardiff, Wales, United Kingdom
Positions held in the conference:

- Co-chair of two sessions: september 10 and september 12, 2013
- Representative of ROMSIM (Romanian Society for Simulation) at EUROSIM (Federation of European Simulation Societies) Board Meeting september 11, 2013.

References

The list of the papers published as a result of the research made in the framework of the project

Papers published in international journals (ISI indexed)

[A1] Radulescu M., Radulescu S., Balreira C. E., A generalization of the Fujisawa-Kuh global inversion theorem, J. Math. Anal. Appl., 382, (2011), 559-564. (2014 impact factor 0,12) Relative Influence Score: 1.168.

[A2] Radulescu C.Z., Radulescu M., A decision support tool based on a portfolio selection model for crop planning under risk, Studies in Informatics and Control, Vol. 21, No. 4, (2012), 377-382. (2014 impact factor 0.913).

[A3] Fulga C., Convexification Technique and Portfolio Optimization, Studies in Informatics and Control, Vol. 22, No. 4, (2013), 285-290. (2014 impact factor 0.913).

[A4] Radulescu M., Radulescu C.Z., Mean-variance models with missing data, Studies in Informatics and Control, Vol. 22, No. 4, (2013), 299-306. (2014 impact factor 0.913).

[A5] Vasile S.L., Query optimization on random databases, Studies in Informatics and Control, Vol. 23, No. 3, (2014), 257-265. (2014 impact factor 0.913).

[A6] Vasile S.L., Some estimations in database queries, Bull. Math. de la Soc. Sci. Math. Roumanie, Vol. 57(3), (2014), 319-325. (2014 impact factor 0.512).

[A7] Radulescu M., Radulescu S., On the Maksa-Volkmann functional inequality $|f(x+y)|\geq|f(x)+f(y)|$ when the range of f is a space of functions, Carpathian Journal of Mathematics, Vol. 30, No. 2, (2014), 253-256. (2014 impact factor 0.792).

[A8] Radulescu M., Radulescu C.Z., Zbaganu Gh., A portfolio theory approach to crop planning under environmental constraints, Annals of Operations Research, Vol. 219, (2014), 243-264. DOI: 10.1007/s10479-011-0902-7. (2014 impact factor 1.217) Relative Influence Score: 1.175.

[A9] Radulescu M., Radulescu C.Z., Crop planning models with symmetric risk measures, Studies in Informatics and Control, Vol. 23, No. 4, (2014), 333-340. (2014 impact factor 0.913).

[A10] Radulescu M., Radulescu C.Z., A portfolio theory approach to software vendor selection, Studies in Informatics and Control, Vol. 24, No. 4, (2015), 8p. (2014 impact factor 0.913).

[A11] Raducan A. M., Vernic R., Zbaganu Gh., Recursive calculation of ruin probabilities at or before claim instants for non-identically distributed claims, ASTIN Bull., 45 (2) (2015), pp. 421-443. (2014 impact factor 0.738).

[A12] Raducan A.M., Vernic R., Zbaganu Gh., On the ruin probability for nonhomogeneous claims and arbitrary inter-claim revenues, Journal of Computational and Applied Mathematics, 290 (2015), 319-333. (2014 impact factor 1.266).

[A13] Fulga C., Portfolio optimization under loss aversion, European Journal of Operational Research, Vol. 251, Nr. 1, (2016), pp.310–322, http://dx.doi.org/10.1016/j.ejor.2015.11.038, IF 2016 = 2.679, SRI 2016=1.685.

Papers published in international journals (non-ISI indexed)

[B1] Fulga C., Integrated bi-criteria decision support system for portfolio selection, Journal of Decision Systems, 24, (2), (2015), 159-177. DOI: 10.1080/12460125.2015.1046684.

[B2] Raducan A.M., Vernic R., Zbaganu Gh., "How common sense can be misleading in Ruin Theory", Annals of the University of Craiova, Mathematics and Computer Science Series Volume 43(1), (2016), 72-81.

Papers published in Proceedings of international conferences

[C1] Radulescu M., Radulescu C.Z., Turek Rahoveanu M., Safety-first and chance-constrained production planning models for fish farms, 11th WSEAS Int. Conf. on Systems Theory and Scientific Computation (ISTASC 2011), Florence, Italy, (2011), 199-204. ISBN: 978-1-61804-027-5.

[C2] Fulga C., Dedu S., M ean-risk portfolio optimization with prior PCA-based stock selection, International Workshop "Stochastic Programming for Implementation and Advanced Applications" (STOPROG-2012) July 3-6, 2012, Neringa, Lithuania, Editors: L. Sakalauskas, A. Tomasgard, S. W.Wallace, Proceedings. Vilnius, 2012, pp. 37-42. ISBN 978-609-95241-4-6, doi:10.5200/stoprog.2012.07 http://www.moksloperiodika.lt/STOPROG_2012/contents.html

[C3] Radulescu M., Radulescu C. Z., Simulation and Optimization for Crop Planning Under Risk, Proceedings of the 8th EUROSIM Congress on Modelling and Simulation, EUROSIM 2013, Cardiff, UK, 2013, pg 409-414. IEEE 2013. ISBN 978-0-7695-5073-2. DOI 10.1109/EUROSIM.2013.117. (Indexat ISI)

[C4] Radulescu M., Radulescu C. Z., A multi-objective crop planning model with environmental constraints, Proc. Int. Conf. Ag. Eng., AgEng2014, Zurich. Eur. Soc. Ag. Eng. (EurAgEng), 2014, 7 p. ISBN 978-0-9930236-0-6.

Papers sent for publication in international journals (ISI indexed)

[D1] Radulescu M., Radulescu C. Z., Mean-variance models for the location problem of renewable power plants, Computers and OR., (trimisa spre publicare).

[D2] Raducan A.M., Vernic R., Zbaganu Gh., "Upper and lower bounds for a finite-type ruin probability in a nonhomogeneous risk process", Proc. Romanian Academy, Ser. A.

Books

[E1] Radulescu C.Z., Multicriteria decision-making, methods and applications in sustainable development, Editura Printech, 278 pg, 2013, ISBN: 978-606-23-0025-8. (Romanian).

Chapters în books

[F1] Radulescu M., Radulescu C.Z., Zbaganu Gh., Operations research methods in production management with environmental constraints, chapter 5 in Environmental Planning, Editor: Rebecca D. Newton, pg 135-166, 2011 Nova Science Publishers, Inc. New-York, ISBN: 978-1-61728-654-4.

Research reports

[G1] Radulescu M., Portfolio selection models for production planning under environmental constraints, 2011.

[G2] Radulescu M., Decision making models for sustainable development, 2012.

[G3] Radulescu M., Single period with complementarity constraints. 2014

[G4] Radulescu M., Single period and multi-period portfolio selection models with complementarity constraints. 2015.

[G5] Radulescu M., Multi-period portfolio selection models with complementarity constraints. 2016.

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ANNEX 1 Scientific Report 2016

Selection of papers published as results of the research project PN-II-ID-PCE-2011-3-0908 which were quoted in international journals.

The paper

Rădulescu M., Rădulescu C.Z., Zbaganu Gh., A portfolio theory approach to crop planning under environmental constraints, Annals of Operations Research, vol. 219, (2014), 243–264.

was cited in the following articles:

1. Alfandari, Laurent, Agnès Plateau, and Xavier Schepler. "A branch-and-price-and-cut approach for sustainable crop rotation planning." European Journal of Operational Research 241, 3, (2015), 872-879.
2. Cong, R. G., Hedlund, K., Andersson, H., & Brady, M., Managing soil natural capital: An effective strategy for mitigating future agricultural risks?, Agricultural Systems, 129, (2014), 30-39.
3. Din, Gregory Yom, Do industry and academic experts differ in weighting criteria for agricultural planning and in their loss aversion?, International Journal of the Analytic Hierarchy Process 8.1 (2016).
4. Fotakis, D., Sidiropoulos E., Combined land-use and water allocation planning, Ann. Oper. Res. Vol. 219, Issue 1, (2014), 169-185.
5. Jaehn F., Sustainable Operations, European Journal of Operational Research, 253 (2), (2016), 243-264.
6. Lee, H., Bogner, C., Lee, S., & Koellner, T., Crop selection under price and yield fluctuation: Analysis of agro-economic time series from South Korea, Agricultural Systems, 148, (2016), 1-11.
7. Takacs-Gyoergy, Katalin; Rahoveanu, Turek Maria Magdalena; Takacs, Istvan, Sustainable new agricultural technology - economic aspects of precision crop protection, Edited by: Luminita, C; Constantin, C; Valeriu, IF Conference: 1st International Conference on Economic Scientific Research - Theoretical, Empirical and Practical Approaches (ESPERA) Location: Bucharest, ROMANIA, ESPERA 2013, Book Series: Procedia Economics and Finance Vol. 8, (2014), 729-736.
8. Wang G., Gunasekaran A., Modeling and analysis of sustainable supply chain dynamics, Ann. Oper. Res., 2015

The paper

Fulga, C. (2016) Portfolio optimization under loss aversion, European Journal of Operational Research, ISSN: 0377-2217, Vol. 251, Nr. 1, pp.310–322, http://dx.doi.org/10.1016/j.ejor.2015.11.038, IF 2016 = 2.679, SRI 2016=1.685.

was cited in the following articles:

(1) Sini Guo, Lean Yu, Xiang Li, Samarjit Kar (2016) Fuzzy multi-period portfolio selection with different investment horizons, European Journal of Operational Research, ISSN: 0377-2217, Volume 254, Issue 3, Pages 1026–1035, http://dx.doi.org/10.1016/j.ejor.2016.04.055.

(2) Lazov, Igor (2016) Profit management of car rental companies, European Journal of Operational Research, Available online 31 August 2016, In Press, http://dx.doi.org/10.1016/j.ejor.2016.08.064.

(3) Huo Zaiqiang, Shu Xiaoling (2016) Establishing an Option-Based Portfolio Based on a Comprehensive Method, Management Science and Engineering, Vol. 10, No. 2, pp. 33–39, DOI:10.3968/8347, ISSN 1913-0341 [Print], ISSN 1913-035X [Online], http://cscanada.net/index.php/mse/article/view/8347/9356.

(4) Gorelik, Victor, and Zolotova, Tatiana (2016) On the Equivalence of Optimality Principles in the Two-Criteria Problem of the Investment Portfolio Choice, In: Proceedings of the 9th International Conference on Discrete Optimization and Operations Research and Scientific School (DOOR 2016), Vladivostok, Russia, September 19 - 23, 2016, Edited by: Alexandr Kononov, Igor Bykadorov, Oleg Khamisov, Ivan Davydov, Polina Kononova, ONLINE: http://ceur-ws.org/Vol-1623, ISSN: 1613-0073.