MULTICRITERIA DECISION SUPPORT IN FINANCIAL DECISION MAKING: AN OVERVIEW AND A CASE STUDY ON BANK RATING

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Outline

- Financial decisions
  - Types, problematics, multicriteria character
- Main concepts of multicriteria decision aid (MCDA)
  - The paradigm of MCDA
  - Types of decision models and construction approaches
  - Examples of MCDA applications in financial decision making
- A multicriteria DSS for bank rating
- Conclusions & perspectives
Modern finance mainly focuses on two major issues
- Risk management
- Asset valuation

Examples
- Credit risk assessment and bankruptcy prediction
- Portfolio optimization and asset management
- Valuation of complex financial products (e.g., derivatives)
- Interest rating modeling
- Risk measurement and management systems

Financial decision making requires analytic procedures
- Extensive use of quantitative techniques
  - Statistics, econometrics, operations research (optimization, simulation, optimal control, MCDA, etc.), artificial intelligence, ...
Problematics of financial decisions

- Choice
  - Selection of investment plans
- Ranking
  - Evaluation of bank branches performance
- Classification
  - Credit rating
- Description
  - Analysis of factors that drive the financial markets
Types of financial decision problems

- **Discrete problems**
  - Evaluation of a finite set of alternative solutions and choices
    - Evaluation of firms and organizations
    - Selection of investments

- **Continuous problems**
  - Selection among an infinite set of alternative solutions, described through a set of constraints
    - Portfolio optimization and asset management
    - Financial planning
Multicriteria nature of financial decisions

- **Discrete problems**
  - “Traditional” finance research usually employs multidimensional statistical techniques
    - Multicriteria paradigm: The attributes used in the analysis provide preferential information (criteria)
    - Financial decision makers are not only interested in statistical patterns, but also seek for individualized decision support

- **Continuous problems**
  - The traditional approach of profit/wealth maximization is too restrictive
  - The introduction of risk naturally leads to a bi-objective approach
    - But there are various types of risks, difference risk factors and risk measures
    - Thus, even the bi-objective approach can be restrictive
  - *The financial decision makers’ preferences and policy are crucial*

*From the neo-classical perspective of perfect markets, financial decision problems can be moulded in terms of a single objective. However, imperfections such as information asymmetries, conflicting interests and transactions costs (which restrict choice opportunities) require a much richer description of the decision context.*


*Many normative decision models assume that a firm pursues the single objective of stockholder wealth maximization. However, a modern enterprise is a complex organization in which various stakeholders interact with one another, each with its own possible interpretation of wealth maximization, subject to concerns about risk, liquidity, social responsibility, environmental protection, employee welfare, and so forth. Consequently, it may well be appropriate to pursue a multiple objective approach to many financial decision making problems.*

Further discussion and examples can be found in:

Multicriteria decision aid (MCDA)

Main characteristics
- Multiple conflicting criteria
- No single best solution exists
- Subjective results depending on the preferential system of the decision maker

Objectives
- Analysis of the conflicting nature of the criteria
- Preference modeling
- Identification of satisfactory solutions (e.g., efficient solutions)

Multivariate statistical analysis is completely different from multicriteria decision aid
- Statistical analysis is involved with making inferences about an unknown population
- Multicriteria decision aid is about preference modeling and individualized decision support
The framework of MCDA

- Specification of alternatives
- Problematic
  - α) Choice
  - β) Classification
  - γ) Ranking
  - δ) Description
The framework of MCDA

- Decision context
- Consistent family of criteria
- Global evaluation model
- Decision support

- Monotonicity
- Exhaustiveness
- Non redundancy
The framework of MCDA

- Decision context
- Consistent family of criteria
- Global evaluation model
- Decision support
  - Aggregation of criteria
    - Value functions
    - Outranking relations
    - Decision rules
The framework of MCDA

- Decision context
- Consistent family of criteria
- Global evaluation model
- Decision support

- Validation & justification
- Implementation
Methodological streams

- **Multiattribute utility/value theory**
  - Aggregation of the criteria into a utility/value function
  - Strong axiomatic basis
  - Decisions under certainty and uncertainty

- **Outranking relations**
  - Grounded on social choice theory (e.g., voting systems)
  - Pairwise comparisons of the alternatives
  - Non-compensatory models (modeling of veto conditions)
  - Modeling of incomparabilities

- **Multiobjective optimization**
  - Optimization with multiple objective functions

- **Preference disaggregation analysis**
  - Inference of decision models from decision examples
  - Regression-based procedures for preference learning
Development of multicriteria models

- Direct (interactive) approach
  - The analyst elicits the required model’s parameters through an interactive dialog with the decision-maker

- Examples of methods based on direct approaches
  - Analytic hierarchy process (Saaty, 2000)
  - MACBETH (Bana e Costa and Vansnick, 1994)
  - SMART/SMARTER (Edwards and Barron, 1994)

- Direct procedures are well-suited to situations involving complex decisions of strategic nature
  - But due to time and cognitive limitations they may be difficult to implement in several cases
Development of multicriteria models

- Indirect approach (preference disaggregation analysis)
  - Instead of asking the decision-maker to provide specific preferential information ask for some decision examples
  - Infer the decision model from a given set of decision instances
  - Discuss the obtained model with the decision-maker and calibrate it if needed

The problem

Development of accurate decision models for classifying credit applicants in risk grades depending on their creditworthiness

Multicriteria aspects of the problem

Credit risk grades are ordinal

From a business perspective, it is often assumed that the risk attributes are monotonically related to the probability of default (criteria)

Credit analysts often expect (or would like) the model to have specific characteristics
MCDA in financial decision making

Credit scoring

- Preference disaggregation techniques: UTADIS, MHDIS
  - Additive value function models, compatible with scorecards used by financial institutions
  - Compensatory models
    - Low performance on a criterion can be compensated by good performance on others
  - Models which are easily understood and implemented
  - Model fitting with linear programming techniques


Outranking methods

- Noncompensatory models
- Modeling of incomparability
  - Cases with special characteristics that need careful examination
- Model fitting with evolutionary techniques


MCDA in financial decision making

Credit scoring

- Multicriteria decision support systems
  - FINEVA, FINCLAS
  - Integration of MCDA with other approaches
    - Financial analysis
    - Multivariate statistical techniques
    - Expert systems
- Database management
- Graphical user interface


MCDA in financial decision making
Asset evaluation & portfolio construction

- The problem
  - Evaluate assets and build investment portfolios that meet the needs and risk attitude of specific investors

- Multiple risk measures
  - Variance, semi-variance, expected shortfall, value at risk, ...

- Investor’s preferences with regard to:
  - Diversification policy
  - Investment horizon
  - Additional characteristics of the portfolios (marketability & liquidity, dividends, short selling, etc.)
Stock evaluation stage

Helpful for cutting down the set of available investment options

Selection schemes
- Ranking from the best to the worst stocks
- Classification of the stocks into groups according to their investment opportunities and the needs of an investor


Portfolio construction stage

Multiobjective optimization using measures such as
- Expected return
- Volatility
- Systematic risk
- Dividend yield
- Value at risk, Conditional value at risk, Expected shortfall

Interactive optimization procedures


MCDA in financial decision making

The investment decision

- The choice of investment projects entails an important decision for every firm, public or private, large or small.
- The financial theory proposes either a ranking from the better to worst when there are many investment projects in competition or an acceptance or refusal if there is only one investment project.
  - Payback method
  - Accounting rate of return
  - Discounting techniques (net present value, internal rate of return, index of profitability, discounted payback method, etc.).
MCDA in financial decision making

The investment decision

- The tools of financial theory should be improved so that they could take into account time, inflation and risk (i.e. analytical methods, simulation methods, games theory, CAPM, etc.)
- There are still problems concerning the evaluation and selection of investment projects
  - Reduction of the investment notion in a time series of monetary flows (inflows, outflows)
  - Choice of the discount rate
  - Conflicts between financial criteria (e.g., net present value vs internal rate of return)
- The discount rate provides an acceptance rule for investment projects when the internal rate of return is used.
  - The investment decision of a firm depends on one variable only (discount rate)
- Different profitability criteria often lead to divergent rankings
- In consequence, the financial approach of investment decision seems limited and unrealistic
  - It is limited because it remains in the stages of evaluation and choice, and it is unrealistic because it is based only on financial criteria.
MCDA in financial decision making

The investment decision

- MCDA facilitates the investment decision process, beginning from the stages of perception and formulation to the stages evaluation and choice.
- Identification of investment opportunities and to the definition of a set of potential actions (i.e. possible variants).
  - The set of projects can be global, fragmented, stable or evolutionary
- Decision “problematics”:
  - Choice: choosing the best investment project or in developing a selection procedure for investment projects
  - Classification: classification of investment projects according to norms or in building an assignment procedure for investment projects
  - Ranking: ordering of the investment projects according to a decreasing preference order or in building an ordering procedure for investment projects.
Other applications of MCDA in financial decision making

- Venture capital investments
- Mergers & acquisitions
- Country risk assessment
- Asset-liability management
- Capital budgeting and financial planning
- Auditing & accounting

A case study on bank rating

Problem context

- Lack of adequate historical bank default data
- Empirical rating systems based on quantitative and qualitative criteria
  - Financial analysis
  - CAMELS (Capital, Assets, Management, Earnings, Liquidity, Sensitivity to market risk)
- Early warning systems
  - Bankruptcy prediction
  - Prediction of capital adequacy
  - Estimation of credit rating downgrade probability
A case study on bank rating

Problem context

- Bank rating systems are mostly used by supervisory authorities (central banks) and their scope focuses on:
  - The construction of global measure of the soundness of a bank
  - The classification of the banks in risk groups
  - The identification of strengths and weaknesses
  - The design of policy measures

A multicriteria DSS

- Development of a user-friendly multicriteria decision support system (DSS) currently in use at a central bank
- Senior and junior analysts can use the system simultaneously
  - Senior analysts have full control over the evaluation process and perform permanent modifications
    - Add/remove banks and criteria, specify different weights, etc.
  - Junior analysts have full access to the evaluation process and perform temporary changes
- The evaluation process is fully parameterized and a user can specify multiple options such as:
  - Which banks to evaluate, the time period of the analysis, the evaluation criteria and their relative importance, the evaluation method and its parameters

Outline of the evaluation process

- Relative evaluation
  - Identification of the strengths and weaknesses of a bank relative to the others

- Absolute evaluation
  - Comparison to a predefined reference point (ideal or anti-ideal)

- Rating in 5 risk groups (1=low risk, ..., 5=high risk)

- Overall and partial evaluation

- Impact of model’s parameters
  - Sensitivity and scenario analysis
Evaluation criteria

- 31 criteria grouped in 6 categories
- Financial ratios
  - Capital adequacy ratio
  - TIER I & II capital
  - Profits/Assets
  - Interest income/Assets
  - Loans/Deposits
  - Insecure loans/Total loans
- Qualitative criteria
  - Management (operating expenses, managers experience, management information systems)
  - Risk management systems
  - Control procedures
MCDA methodologies

- A linear value function model (compatible with the CAMELS framework)
- PROMETHEE II
- Criteria weights
  - Direct specification by the analyst
  - Rank-order estimates obtained from ranking the criteria according to their relative importance
  - Multivariate statistical tools (factor analysis)
The PROMETHEE method

- Outranking approach for ranking problems

- Procedure:
  - Step 1: Pair-wise comparison of the $N$ banks on each criterion (partial preference index)
  - Step 2: Aggregate the unicriterion results (global preference index)
  - Step 3: Rank the banks taking into account their strong (leaving flows) and weak points (entering flows)

Example of a Gaussian criterion partial preference function

\[ p_k(x_i, x_j) = 1 - \exp \left[ -\frac{(x_{ik} - x_{jk})^2}{2\sigma^2} \right], \quad x_{ik} > x_{jk} \]

- \[ p_k(x_i, x_j) = 0 \Rightarrow x_i \text{ and } x_j \text{ are indifferent on criterion } k \]
- \[ p_k(x_i, x_j) = 1 \Rightarrow x_i \text{ is strongly preferred over } x_j \text{ on criterion } k \]
The PROMETHEE method

- Global preference index for bank $x_i$ over $x_j$
  \[ P(x_i, x_j) = w_1p_1(x_i, x_j) + ... + w_np_n(x_i, x_j) \]
  - $P(x_i, x_j) \approx 0 \Rightarrow x_i$ and $x_j$ are indifferent
  - $P(x_i, x_j) \approx 1 \Rightarrow x_i$ is strongly preferred over $x_j$

- Leaving flow:
  \[ \varphi^+(x_i) = [P(x_i, x_1) + P(x_i, x_2) + ...] / (N - 1) \]

- Entering flow:
  \[ \varphi^-(x_i) = [P(x_1, x_i) + P(x_2, x_i) + ...] / (N - 1) \]

- Net flow: $\varphi(x_i) = \varphi^+(x_i) - \varphi^-(x_i)$
  - $\varphi(x_i) \approx 1 \Rightarrow x_i$ strongly outranks other banks
  - $\varphi(x_i) \approx -1 \Rightarrow x_i$ is strongly outranked by other banks
Interactive specification of PROMETHEE’s partial preference functions
Evaluation results
## Analysis of a bank’s global score

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Sensitivity analysis

- Interactive sensitivity analysis
  - The user changes the weights of the criteria and the parameters of the preference function and the results are instantly updated

- Analytic sensitivity analysis
  - Intervals of the parameters’ values within which the ratings remain unchanged
    - Minimum changes that alter the ratings
  - Analysis of the impact that the parameters have on the global score of the banks
  - Intervals of the data of the banks within which the ratings don’t change
  - Analysis for each bank and the complete set of banks
Interactive sensitivity analysis

The results are updated to any change in the weight of a criterion (downgrades in red and upgrades in green).

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Scenario analysis

- Scenarios for the criteria weights
  - Random scenarios or scenarios with pre-specified characteristics
  - Analysis of ratings’ stability
- Statistics
  - Net flows (global scores)
  - Ratings
Summary of scenario analysis results

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Bank scenario analysis report

Scenario analysis report: AGR

Cumulative distribution of ratings

Boxplot graph

Ratings' distribution

Criteria's weights

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Evaluation of the DSS

- The system has been customized to take into account the dynamic nature of the banking environment in Greece and the ongoing crisis
  - Modification of the set of criteria and their weights
- The system is used by analysts in the Bank of Greece as part of their peer review analysis of Greek banks
- The results of the system have been found to be in accordance with the deteriorating conditions in Greece
- A research project is under way to integrate the MCDA methodology with stress testing analysis
Conclusions & perspectives

- Financial decision problems have a strong multicriteria character
  - Broad range of problems for applying different MCDA methods

- MCDA methods applied to financial problems provide
  - A realistic approach
  - Helpful insights to the problem and the alternatives
  - Good results

- Limitations and perspectives
  - Cognitive effort required by the decision makers in understanding the methods and their parameters
  - Real-time decision making
  - Support during the implementation at the organization level
  - Integration with other disciplines into hybrid systems
  - Implementation in user friendly DSSs proving advanced database management tools, combining with analytical and distributing decision making capabilities