On risk averse strategies for multistage mixed 0-1 / pure combinatorial optimization under a mixture of Exogenous and Endogenous Uncertainty

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Extended abstract

Stochastic optimization is currently one of the most robust tools for decision making. It is broadly used in real-world applications in a wide range of problems from different areas such as finance, industrial engineering, production planning, capacity allocation, energy generation and transmission, air traffic management and logistics, among others. Particularly, it has been applied to financial portfolio restructuring; hydrothermal electric generation planning; electric power generation capacity expansion planning and sources location; oil, hydrocarbon and chemical supplying; transformation and distribution logistics; strategic and tactical production planning;, sequencing and scheduling; plant location and sizing in strategic Supply Chain Management (SCM); tactical SCM; Revenue Management; production planning dimensioning and location; road construction selection in forestry harvesting planning; designing connected rapid transit networks; tactical portfolio planning in the Natural Gas Supply Chain; prison facility site selection; air traffic flow management planning and flight routes selection; cluster location in multi-period copper extraction planning in mining; multiperiod location-assignment; financial branches restructuring and delocation; and difficult pure combinatorial problems as the Set Packing Problem and the p-Median Problem.

It is well known that a mixed 0-1 optimization problem under uncertainty with a finite number of possible supporting scenarios has a mixed 0-1 / pure combinatorial Deterministic Equivalent Model (for short, DEM), where the risk of providing a wrong solution is included in the model, partially at least, via a set of representative scenarios for the exogenous uncertainty. Traditionally, special attention has been given to optimizing the DEM by optimizing the objective function expected value over the scenarios, subject to the satisfaction of all the problem constraints in the defined scenarios, i.e., the so named risk neutral approach. Currently, we are able to solve huge DEMs by using different types of decomposition approaches. However, the optimization of the risk neutral objective function has the inconvenience of providing a solution that ignores the potential variability of the objective function value over the scenarios and, so, the occurrence of scenarios with an objective value below the expected one.

Alternatively, we present a time consistent multistage risk averse strategy based on first- and second-order Stochastic Dominance Constraints (SDC) for a set of profiles related to given thresholds

on the value of given functions. Our approach is an extension of the two-stage SDC recourse-linear integer by jointly bounding the scenario probability of having shortfall on reaching each threshold and also bounding the expected shortfall at selected stages along the time horizon.

Other contribution consists of treating the uncertainty as a mixture of the exogenous one (where the decision maker cannot not influence it but he must hedge his decisions against future values of the uncertain parameters) and the endogenous uncertainty (where the decision maker actions can influence either the weight of future values of the some uncertain parameters, the same values or both), such that a new stochastic optimization modeling object is presented. The new modeling object requires to use mixed and pure 0-1 quadratic functions in the objective functions as well as in the constraints that are equivalently replaced with linear constraints by using the Fortet inequalities scheme.

Given the dimensions of large-scale instances augmented by the new variables and constraints required by the risk measure to consider as well as the endogenous uncertainty treatment, it is unrealistic to solve the problem up to optimality by plain use of MIP solvers. Instead of it, we present an specialization of our Branch-and-Fix coordination algorithm -the so named BFC risk averse SDC-, to handle the new mixed 0-1 linear model. Computational experience is presented on different mixed 0-1 / pure combinatorial optimization problems.