ADVANCES
in
DECISION TECHNOLOGY
and
INTELLIGENT
INFORMATION SYSTEMS

Volume IX

Edited
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Published by

THE INTERNATIONAL INSTITUTE
FOR ADVANCED STUDIES
IN SYSTEMS RESEARCH AND CYBERNETICS

Risk-Constrained Optimization® and Its Application to the USA-China Trade Problem Under Uncertainty

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ABSTRACT

The two unique concepts described in this paper are critically important.
The first concept is Risk-Constrained Optimization® (RCO), which at long last provides the capability to deal with complete uncertainty. It is the only currently existing methodology for *strategic* risk management. Moreover, RCO does it in a manner especially suitable for conditions of the 21st century, when the uncertainty external to any strategic problem is much more important than the uncertainty internal to the problem, and when the external threats dwarf the potential internal losses.

RCO is, however, much more than just a methodology of dealing with uncertainty. It demonstrates the need, and shows the way, of changing the paradigm of economic decision-making. Instead of abstractly (and probably incorrectly) maximizing the satisfaction of our wants, this strategic risk management approach deals with a simpler, easier to solve, more realistic and pressing problem -- how to avoid a catastrophe.

RCO shows that finding "the best" solution under uncertainty is in principle impossible. The most we can do is to analyze – to identify a small set of reasonably good and reasonably protected from risk candidate strategies. The selection from that set of the final strategy, most acceptable to the decision-maker(s), has to be performed subjectively.

In this paper, RCO is applied, in combination with the second concept, to perhaps the #1 non-military problem of the USA -- how to overcome its huge trade deficit.

The second concept is "compensated free trade". It promises an unexpected multitude of versatile economic and political benefits. But a major, predominantly important benefit is that it will also be a powerful tool of geopolitical containment, a la Kennan, of potential rivals and adversaries.

Keywords: Strategic risk management – Decision-making under uncertainty – Management science -- Scenario planning – International trade

Risk-Constrained Optimization® -- General Description

Risk-Constrained Optimization®, or RCO, is a system of strategic risk management under complete uncertainty that searches for the most acceptable (not "the best"!) compromise between improving results and reducing risk in our decisions (Masch, 2004).

RCO is based on two main ideas. First, the formal methods not reliable enough to find the best alternative strategies are still good enough for an easier task – to screen out the worst. Second, the decision-maker has to be actively involved not only in the final selection of the strategy, but also in the whole process of generation, evaluation, and screening of the alternative candidates.

RCO replicates the "natural" approach to decision-making, used by animal kingdom for millions of years, and later – by mankind, not deviating from it by a single unwarranted assumption.
Maximization decision methods are considered just a special case of the "natural" process. Accordingly, in a more general "natural" framework, these methods are relegated from the top-level conceptual paradigm of the final strategy selection to auxiliary operations, which may, or may not, be used at the earlier stages of constructing and screening the candidates..

Protection from risk dominates in RCO over maximization. But RCO can still include such maximization tools as mathematical programming models, because their output is filtered through four diverse layers of risk protection.

RCO is especially useful when uncertainty comes in two categories, from "internal" and "external" factors, with the "external" uncertainty factors dwarfing the internal one by their possible consequences. Any serious strategic problem of the 21st century USA would almost certainly fit into this category. Under these conditions, the problem corresponds to qualification of complete uncertainty, but still has initial weights (internal probabilities) attached to individual scenarios. In the process of RCO, these probabilities are overridden.

RCO consists of five major parts: (a) construction of a large number of scenarios: (b) generation of multiple candidate strategies that are reasonably good, flexible, robust, and risk-limited; (c) identification of a few most suitable candidates; (d) subjective selection of one of them as the strategy to be implemented; and (e) preparing the contingency plans for the selected strategy.

The main version of RCO includes the following more detailed stages:

(i) Constructing a large number of "internal" scenarios of the future and performing the initial "What if" analysis.
(ii) Formulating a multiscenario (stochastic) MILP model and using the model solution as a starting point for an iterative process of generating a number of alternative candidate strategies.
(iii) Recording the scenario outcomes for any candidate strategy in a three-dimensional "outcome matrix": "scenarios vs. strategies vs. risk types."
(iv) Obtaining a number of alternative candidate strategies by re-running the model, in an iterative process, each time with a different set of "cutting planes", or "risk-limiting constraints", imposed on any unacceptable outcomes ("strong screening").
(v) Converting the multidimensional "outcome matrix" with heterogeneous outcomes into a two-dimensional "payoff matrix" with homogeneous payoffs: "scenarios vs. strategies."
(vi) Screening out the worst alternative candidate strategies by joint use of 6 "synthetic" decision criteria in a framework of "strategic frontier," leaving for final consideration a small subset of the best and safest candidate strategies ("weak screening").
(vii) Making from that subset a final, subjective, but well-informed and reasonably safe, selection of the strategy to be implemented.

(viii) Deriving for the selected strategy a set of contingency plans over the whole range of scenarios.

RCO merges technologies that belong to six fields: (1) Operations Research/Management Science, (2) Scenario Planning, (3) Decision Science, (4) Risk Management, (5) Utility Theory and (6) Portfolio Theory. Most of them are novel.

Stages of RCO – Internal Uncertainty

Internal uncertainty in RCO is introduced as follows. At Stage (i), for each factor of the problem that contributes to uncertainty (an "uncertainty generator") we introduce a number of its values (or states, if it is expressed qualitatively) that represent its important alternatives. Probabilities of these alternatives can be quite approximate.

A scenario is formed by taking one alternative of each "uncertainty generator". Each scenario must be internally consistent, with parameters correlated. The total number of scenarios equals the product of numbers of alternatives for all "uncertainty generators". (The enormous size of the multiscenario models that emerge with a large number of scenarios is not a matter of great concern, because a very efficient algorithm, specially developed in RCO, allows solving multiscenario problems of any size.)

At this stage, we can discover whether the extended RCO process is needed or not. We construct a prototype deterministic (single-scenario) MILP (mixed integer linear programming) model and then diversify it by scenarios, putting in each "what if" model the parameter values that are specific to the scenario. Each "what if" problem is considered here as independent. If the solutions of these problems lead to a similar strategy over the whole range of scenarios, and this strategy is completely satisfactory in all risk types, we may finish the process here.

At Stage (ii), RCO constructs a special multiscenario stochastic MILP model, which, in contrast to stage (i), considers the whole range of scenarios jointly. The RCO model is its first filter. It has two distinctions from the usual stochastic models. The main distinction is that it recognizes that not all decisions are created equal. RCO therefore classifies all decision variables of the model into "strategic" and "operational" variables. "Strategic variables" are a small subset of variables that correspond to the most important decisions. These include, but are not limited to, immediate and irrevocable decisions. The value of any strategic variable remains unchanged, or stays within specified bounds, under each scenario. A "strategy" is defined by the set of solution values of all strategic variables of the model. In the second distinction from the current stochastic programming, RCO calculates the "bookkeeping" scenario components of the objective function, as well as the scenario-specific outcome values of each risk type.

Initially we construct this model without fixing the values of the strategic variables. The model's solution is the end of the stochastic programming, but it just starts the RCO process.

This solution gives rise to the first candidate strategy. In this solution, the values of the operational variables under each scenario define the contingency plan for the analyzed strategy under that scenario, and the objective function summarizes costs and benefits for each of the corresponding contingency plans over the whole range of scenarios.

At Stage (iii), the scenario values of the objective function and the outcomes in all risk types are recorded in a multidimensional "outcome matrix," which is the second filter of RCO. This matrix presents, perhaps in the most condensed format possible, all valuable information that the decision-maker might want to know about the behavior of each candidate strategy under the whole range of scenarios, in regard to all risk types. The matrix is very important, since it allows a "bird's eye view" of everything and immediate reaction. It is the best way to extract meaning from an ocean of information.

The third, most important, "strong" filtering is done by "risk-limiting constraints" (Stage iv). We start with some strategy, formulate the model, and obtain the solution. It is the decision-maker who should view the solution. If he is not satisfied with any outcome for any risk type under any scenario or group of scenarios, he adds to the multiscenario model some "risk-limiting constraints," imposed directly on the poor outcomes (e.g., "profit for scenario 5 should be no less than $1 million"). The constraints should improve these outcomes. The more additional constraints the model has, the more its solution differs from the initial solution of the process, that is, from the solution of the constraint-free multiscenario stochastic model.

Since the constraints are imposed not on the "structural" variables of the model, but rather on the "bookkeeping" variables that reflect only the model results or outcomes, the decision-maker needs no modeling skills to impose these constraints; neither must he understand the internal structure of the model. It is quite sufficient to know the risk types and scenarios. He may be helped, but he probably cannot be replaced.

Each set of constraints leads to a different trade-off, ultimately – to some candidate strategy. The strategy generation process can be repeated many times, branching out at different points, on different risk types, with different types of constraints, or with different bound values, and resulting in one or more "trees" of candidate strategies with different trade-offs.

To complement this process with additional "weak screening", RCO generates "utility" at Stage (v) and transforms the multidimensional "output matrix" into a two-dimensional "payoff matrix". The simplest way is to use two or more conversion coefficients for each risk type.

There are 4 main "single" aggregates of scenario payoff values: the best, the weighted average, the non-weighted average, the worst; similarly, there are 4 regret aggregates. At Stage (vi), RCO creates 3 "synthetic" criteria for payoffs and 3 for regrets, combining pairwise: the best with the worst, the weighted average with the worst, and the non-weighted average with the worst. The crucial advantage of the "synthetic" criteria is that four out of six do not need scenario probabilities at all, while the other two are only weakly connected with them. This frees RCO from almost any reliance on probabilities, which are the weakest part of the input data. Instead, RCO focuses on possibilities.

RCO uses the "synthetic criteria" in such a way that they become much more than just a better technique for comparing strategies: the criteria are used not only jointly, but also in the framework of the "strategic frontier". For each synthetic criterion and for each part of the whole [0, 1] segment, the frontier comprises the straight line of that criterion that belongs to the best strategy on that part of the segment. This is the fourth filter of RCO.

In general, the "synthetic" criteria and strategic frontiers do not select the strategy to be implemented. They just shrink the list of the "finalist candidates" to a few best and safest strategies, leaving the selection to the decision-maker. Similar to the risk-limiting constraints, they do not find the best – they eliminate the worst, which is easier.

At Stage (vii), the decision-maker eventually selects one strategy, based on the most acceptable combination of the outcomes for all risk types under all scenarios, the value of the objective function (after the contingency plans are implemented) being one of these types, and on his subjective preferences. He knows a lot now about the behavior of each candidate strategy under a wide range of scenarios, and his judgment should be reasonably good.

At Stage (viii), the model solution for the selected strategy is then used to derive more detailed and specific information, including contingency plans for each scenario. We already have these plans as the scenario values of the operational variables in the solution for that strategy, so we have only to extract and fully utilize these results. Having good contingency plans ready in advance of any thinkable crisis is the RCO's contribution to executing the selected strategy; the previous parts of RCO created the capability to generate and to evaluate good candidates.

RCO -- External Uncertainty

We can take into account external uncertainty either from the very beginning of the RCO process, or now, when the RCO process for the internal uncertainty has been completed and we can repeat the process only, say, for the short list of the candidate strategies. Either way, we just have to create additional scenarios. Is is important to note though that the impact of external uncertainty changes the process and brings deeper understanding of the whole field of Decision Science.

The consequences of the external turmoil, such as terrorism, may dwarf any outcomes of the internal scenarios. Moreover, these consequences are close to minus infinity for every candidate strategy. All our criteria become meaningless. We have to move the worst outcome upward. How much? How to do that for different strategies?

It becomes clear that, first, that our principles of aggregate representation of scenario outcomes are arbitrary: if the worst outcome is movable, why not the best outcome, too; second, that the process is completely subjective. Subjective decision-making was required even without external uncertainty. Adding external factors aggravates the situation drastically.

The USA-China Trade Problem

The described above RCO process has been applied to perhaps the #1 non-military problem of the USA, the problem of international trade of the USA, specifically – on the USA-China trade. The country's policy of unbridled free trade and uncontrolled globalization is suicidal.

Free trade does not have theoretical justification. Its main foundation, the "law of comparative advantage", never was valid. Contrary to the economic doctrine, to the standard cost/benefit analysis, and to the commandments of the real world, it takes into account only the benefits, neglecting the negative "externalities", or adjustment costs. As a result, a specialization of countries becomes possible only if we, say, sacrifice the specialization of individuals; David Ricardo contradicts Adam Smith. As far as free trade is concerned, economics is not a science.

A policy of "compensated free trade" was proposed in [Masch and Perlman, 2006], [Masch, 2007a] and [Masch, 2007b]. Here is how the proposed policy would work:

- Congress sets annual limits (upper bounds) on the overall US trade deficit in consumer goods and undesirable capital goods.
- The President of the United States allocates the allowed deficit for each of our trading counterparts — countries or groups of countries.
- A country may exceed its limit if its government pays the US Treasury a stipulated percentage (up to the full amount) of the excess deficit, also approved for each country by the President of the US. The President can cap the allowed amounts of intergovernmental payments.

The proposed system promises an unexpected multitude of versatile economic and political benefits. (In addition to fighting the trade deficit, it will, for instance, stop trade war, and fight both the de-industrialization of America and elimination of its middle class, that would have lead to political de-stabilization of the country.) But a major, predominantly important benefit is that it will also be a powerful tool of geopolitical containment, a la Kennan, of potential rivals and adversaries.

Of course, like every radical change, the proposal may have negative consequences, too. But they are unavoidable anyway. Also, the coming choice will be not between free trade and "compensated free trade": it will be between "compensated free trade" and much harsher USA protectionism.

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