Designing a rational process for risk-taking

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Abstract

In this paper, we attempt to invent a new way to understand risk, measure it, and weigh its consequences. We attempt to design a rational process for risk-taking; a process that gives the system dynamicist the ability to define what may happen in the future and then to choose among alternatives.

The two conventional ways to use optimization in system dynamics models are historical data fitting and optimal policy design. In this paper, we propose another use of system dynamics optimization, which is finding the most robust policy under variation (uncertainty) in the underlying model risk-factors. To our knowledge, this usage can be considered a new contribution in the field of system dynamics. Policy robustness is a vital issue that has gained a lot of attention and concern in the system dynamics field. Yet, there is no automatic way to find the most (optimal or near optimal) robust policy.

The Complexity of the Manager's Task

As Jay Forrester puts it "The manager's task is far more difficult and challenging than the normal tasks of the mathematicians, the physicist or the engineer. In management, many more significant factors must be taken into account. The interrelationships of the factors are more complex. The systems are of greater scope. The nonlinear relationships that control the course of events are more significant. Change is more the essence of the manager's environment" (Forrester, 1961, p. 1).

Everyday, the manager must take multiple decisions that can be very crucial to his business or organization. Profiting or losing can rely on making the right decision or not. Smarter decisions mean bigger profits and more market shares. Due to the bounded rationality of human beings relying only on the manager's intuition is not enough. Managers need a software tool that helps them in making the "smartest" decision in a highly competitive environment. Powersim Solver is developed to make the process of decision-making easier.

The presence of many uncertain factors in the external environment makes the manager's task much more difficult. Uncertain factors, are external factors that cannot be controlled by the manager, like for example interest rate, new legislation, inflation, new technology, etc. The only certain thing about the future is that it is uncertain. Managers cannot be very optimistic, and assume that best scenario will take place. The ability to define what may happen in the future and to choose among alternatives lies at the heart of the manager's decision-making process. Risk management is always crucial in any decision-making process, from marketing to waging war, from planning a software project to planting wheat. In fact, the mastery of risk, is the revolutionary idea that defines the boundary between modern times and the past. Powersim Solver can be successfully used in risk management applications.

Also the presence of multiple objectives, which a manager may want to accomplish in a decision, makes the manager's task much more difficult. Sometimes those multiple objectives are conflicting ones. If we try to optimize one of them, we can worsen the others. Like for example increasing the company profits, and in the same time increasing the company market share. The manager can use Powersim Solver to define multiple objectives for a single decision, and to weigh those objectives according to their relative importance to the organization.

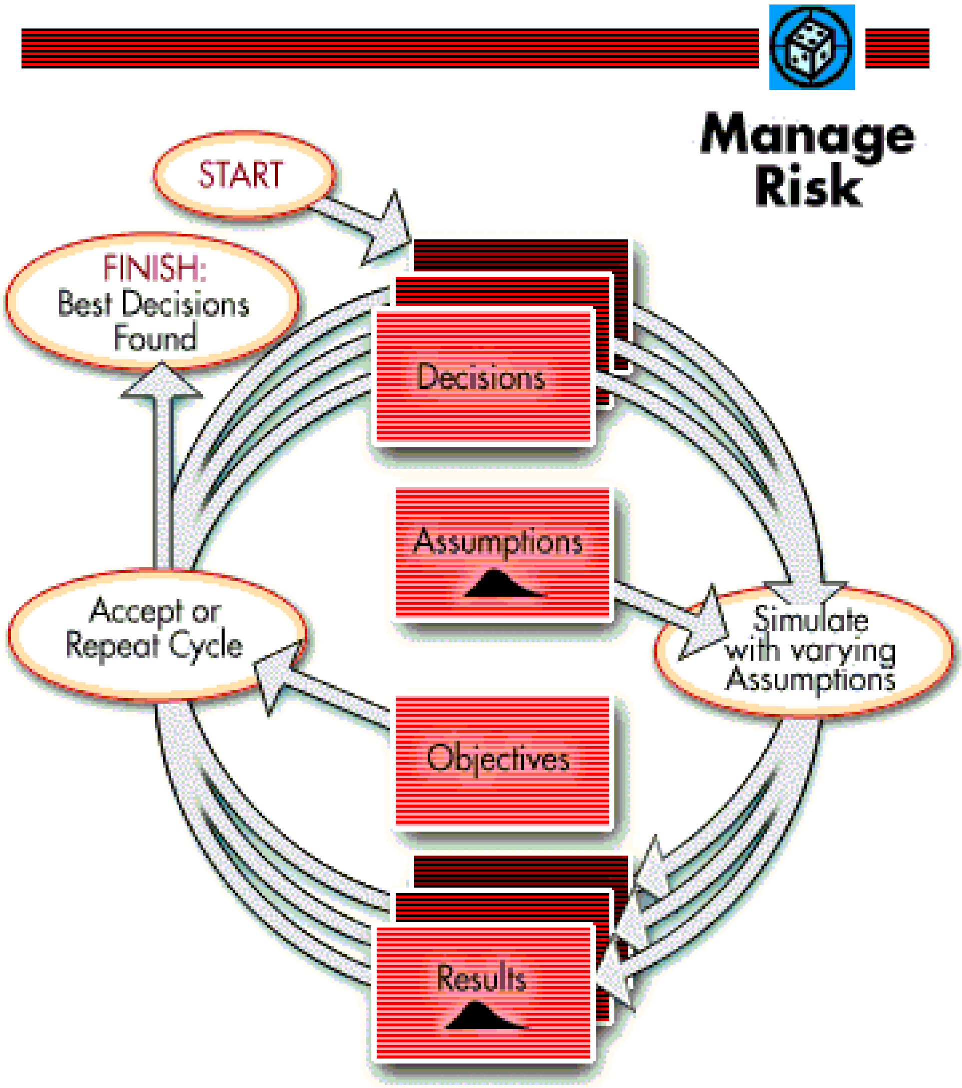
Tasks Performed by Powersim Solver

Powersim Solver provides four tasks that a manager can perform on a system dynamics model:

- *Tune* his model to historical data to verify that the model is a realistic representation of his system (behaviorally validate the model).
- *Optimize* his model through automating the search for a policy that fulfills one or more stated objectives.
- *Assess Risk* to show the effect of any uncertain factors on the results of the model simulation. Through this the manager can disclose risks as well as opportunities.
- *Manage Risk* by optimizing a model to achieve the manager’s objectives while keeping risks within given thresholds.

In this paper we will focus only on the last task, i.e. the “Manage Risk” task.

The Manage Risk Task



The “Manage Risk” task is a combination of the “Optimize” and “Assess Risk” (sensitivity analysis) tasks. Its purpose is to find the most robust policy to changes in assumptions (risk-factors that are represented as probability distribution functions). This policy will be also near optimal. In this way, the manager can find the best set of decisions (variables controlled by the manager, that act as inputs to a policy procedure) to achieve a given objective while keeping risk below a given threshold.

To clarify Solver “Manage Risk” task, we will apply it to a classical inventory management problem. Assume that at the beginning, the manager used a deterministic inventory model (with no uncertainties), and used the “Optimize” task in Solver to find a wholesale inventory policy that ensured an acceptable level of inventory fluctuations, and also maximized the profit. However, through the “Assess Risk” (sensitivity) analysis the manager discovered that supplier delays greatly affect the results. Due to this uncertain external factor, he cannot be sure to reach his objectives with the found policy.

Now the manager wants to take this risk factor into consideration, when optimizing the inventory policy. The “Manage Risk” task allows him to set a confidence level, for example 90%, for reaching an objective. This can for example be used to look for an inventory policy that with 90% certainty will fulfill an objective of minimizing cost.

Defining an objective in the “Mange Risk” task is more sophisticated than in the normal “Optimize” task. An objective in the “Manage Risk” task has two components: the event and the confidence level. The event is defined like the objective definition in the “Optimize” task. That is, an objective event can specify that a value should lie within or outside a given interval, or be above or below a certain threshold. The probability of the event, the confidence level, is the target of the optimization. The manager can assign a certain confidence level that he wants to achieve for each objective event.

The optimization process will compare simulated results to objectives, and determine decisions that make the model behavior fulfill the manager’s objectives within the specified confidence level.

What’s Wrong with the Current SD Optimization Techniques

The current SD optimization techniques are hill climbing ones. The major disadvantages of hill climbing techniques are:

- They do not converge with certainty to the global optimum, but at least to one of the local optima, or sometimes to a saddle point. Hill climbing techniques usually lead to a local optimum (the one nearest to the starting point) and seldom lead to the global optimum.
- The objective function must have some degree of smoothness.
- A further problem faces hill-climbing techniques if the objective function is subject to stochastic perturbations.

Powersim Solver uses an advanced evolutionary search method that overcomes the problems of hill climbing methods. This evolutionary search method is inspired by Darwin's evolutionary theory about the survival of the fittest. For a detailed description of the evolutionary search method, and how it is applied to SD models, the reader can refer to “An Object Oriented Approach to Automate System Dynamics Models Optimization“ (Saleh, 1998).

Advanced Sampling Methods

Powersim Solver uses two sampling methods: The “Latin Hypercube” sampling method, and the “Monte Carlo” sampling method. The “Latin Hypercube” method is the recommended one, as it is tenfold better than the Monte Carlo method. The “Latin Hypercube” method combines the advantages of simple random sampling (like the Monte Carlo case), and a full factorial design, which means that all areas of the sample space are represented. In the current version of Powersim Solver, it is presupposed that the risk-factors (assumptions) are independent of each other, i.e. there is no correlation between them.

Examples of Powersim Solver Usage

Using Powersim Solver managers can easily experiment with future scenarios, and develop the best long-term strategy. The following are several practical examples of successful usage of Powersim Solver.

- Profit Maximizing
  What combination of marketing expenditures and R & D investment will provide the largest profit for our company in three years' time?
- Inventory Optimizing
  What level of production, work force and capital costs will allow us to maintain minimal inventories?
- Productivity Analysis
  Will adopting a flexible time system for our employees have a significant effect on their productivity?
- Risk Assessment
  What is the probability that we will lose substantial market shares under certain combinations of market conditions?
- Risk Management
  What policy will with 90 % certainty ensure acceptable inventory fluctuations and a profit above a certain level?
- Investment
  Which investments maximize products without hurting cash flow?
- Marketing
  What is the likelihood of increasing the market share by 25 % over the next two years?

References

Forrester, J. (1961). Industrial Dynamics. Productivity Press. Portland. Oregon.

Powersim AS (1999). Powersim Solver 2.0 Online Help. Powersim AS.

Saleh, M. (1998). An Object Oriented Approach to Automate System Dynamics Models Optimization. University of Bergen. Norway.