Choosing The Right Tool for Business and Engineering Improvements

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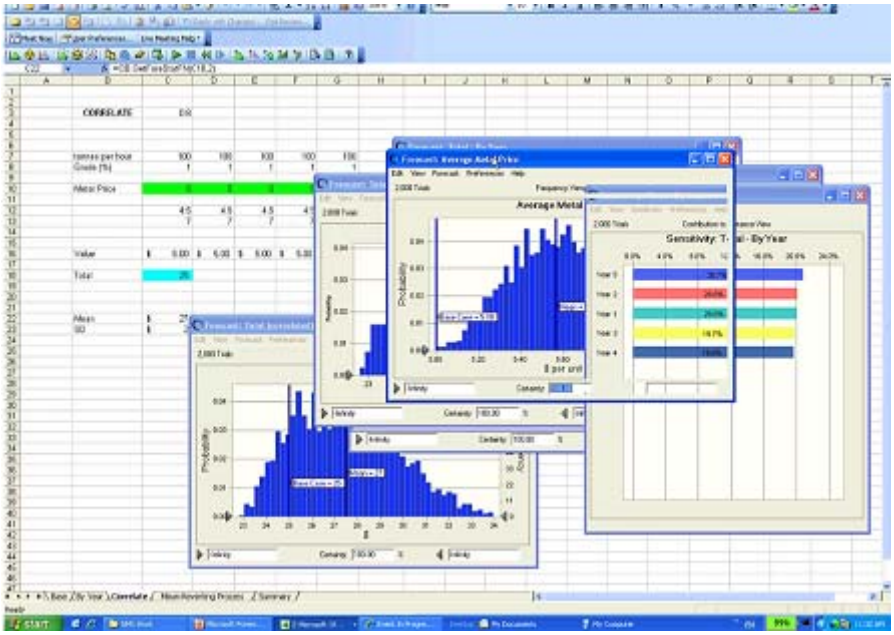
Need to minimise cost, maximise throughput, optimise design, model uncertainty or start other performance improvement projects?

There are a number of philosophies, strategies and tools that can lead to some of these results including Six Sigma, Quality Function Deployment, simulation and others. However, many providers of these tools often market the benefits in general terms such as 'optimised performance' and 'business performance transformation'. Understanding how they work and whether they are suitable for your purpose can therefore be challenging. Furthermore, adopting the wrong tool is quite common and often leads to mediocre results while requiring considerable effort.

This article reviews the most important tools for making decisions in business and engineering. The focus will be on those that are computational in nature, which can forecast detailed and measurable results. These tools are first classified into three general categories: Monte Carlo simulation, optimisation and discrete-event simulation. They cover a wide range of decisions in business and engineering, and have been used in every industry including retail, manufacturing, healthcare, defence as well as government. Benefits such as multi-million dollar cost savings, reduced inventory and lead time have been reported. Next, we'll have a look at a brief description for each type of tool and match them to various situations.

Monte Carlo Simulation

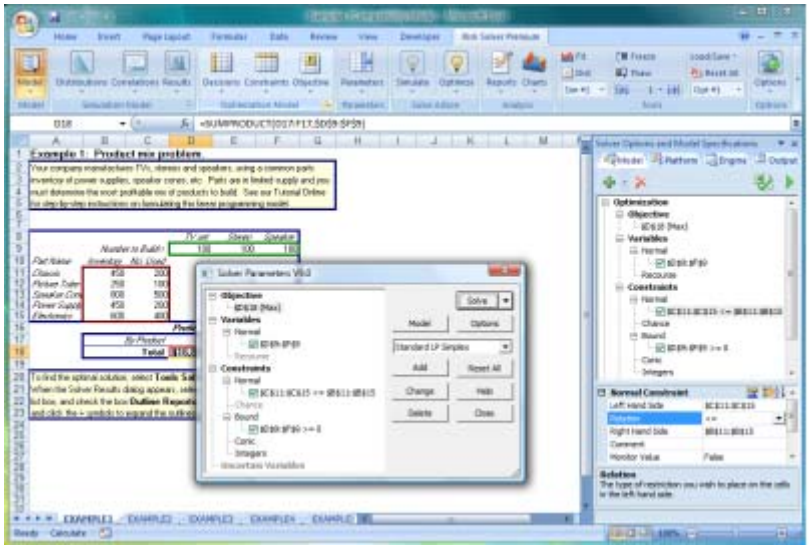


Monte Carlo simulation is a method for studying systems that contain uncertainty. Any system will have at least some associated randomness. For instance, the projected sales forecast or machine reliability cannot be known with certainty and affects the profit as well as throughput respectively. In some cases, the uncertainty is negligible and we do not need to employ Monte Carlo simulation, while in others, it is substantial. When constructing a model, first a set of relationships that relate inputs to outputs is defined. For example, sales forecast, materials and labour costs affect the revenue and profit. Second, probability distributions are assigned to one or more of the inputs.

Often, these models are a snapshot over a period of time. The simulation is then run using a Monte Carlo simulation software such as Crystal Ball. The simulation results give the probabilities of achieving various outputs, thereby providing more complete information for making decisions compared to deterministic models. The analyst can then simulate the effects of changing the input on the output such as reducing product defects by switching to a more reliable production machine. These 'tweaks' to the model are normally performed manually. However, commercial simulation packages typically offer an optional optimiser that help to automate this task.

Monte Carlo simulation should be used when uncertainty plays an important part in the system and when the model can be reasonably represented as a snapshot over time. On the other hand, production systems vary dynamically over time and have accumulating inventory. If these factors are expected to affect the output significantly, then other methods should be considered. The most popular Monte Carlo simulation packages are MS Excel add-ins due to their ease of use and adaptability to existing Excel documents.

Optimisation



Optimisation is a class of methods concerned with achieving some optimal result. Among others, the objective can be to minimise cost/downtime or maximise profit/throughput. The model consists of relationships between inputs and the objective. Some of the inputs are allowed to vary and are known as the decision variables. For example, a transportation model describes how products should be shipped along various routes. Decision variables may include how much product should be shipped along each route in order to minimise transportation costs. The optimisation software is then used to obtain the combination of decision variables that leads to the minimum cost. Instead of the analyst having to ‘tweak’ the inputs until a desirable result is obtained, the solution provides the optimum result.

Optimisation is very flexible and has been used in financial portfolio management, engineering design, capital budgeting, staff scheduling, transportation and capacity planning. Two types of optimisation tools are commonly available: MS Excel add-ins and standalone applications. Excel add-ins such as Premium Solver and What’s Best! are easy to pick up and suitable for analysts who are not familiar with optimisation. Standalone applications and development tools such as LINGO and LINDO API are more suited for those with some experience.

It is also important to distinguish dedicated optimisation suites from optimiser add-ins to Monte Carlo simulation and discrete-event simulation. While optimiser add-ins can provide very good results, it is rare and often impossible to obtain a truly optimal result due to the complexity of combining simulation and optimisation. However, using optimisation software and formulating the model in a particular way, a truly optimal solution can be achieved.

Optimisation should be used when the number of possible ‘tweaks’ is very large and cannot be

effectively performed manually or by optimiser add-ins. Although optimisation is flexible and can be used to model systems with time dependency, this is quite complicated and should be left to optimisation consultants and researchers. A snapshot model over a period of time is favoured. If the system is dynamic and changes over time, then we should look to discrete-event simulation.

Discrete-event Simulation

Discrete event simulation is more specific to modelling repetitive processes such as manufacturing and services operations. First we specify how the system should behave such as part and vehicle routing rules, worker shifts, machine processing rates and downtimes. The discrete-event simulation software then simulates the detailed system operation over time, imitating the actual system. The simulation screen shows the movement and activity of individual elements in the system. The software then provides statistics such as inventory levels, downtimes, throughput, vehicle/people movements and costs. Through these statistics, we can track the performance of individual elements in the system. It is also possible to consider uncertainty by assigning probability distributions to various parameters such as machine processing time and routing.

To improve the system, we can perform virtual experiments by tweaking various parameters such as adding vehicles or shortening distances for vehicle travel and observing the effect on some parameter of interest such as manufacturing cost or defect rate. Alternatively, there are also optimiser add-ons that can help to automate this. These capabilities make discrete-event suites well suited for Six Sigma and Lean projects.

Discrete-event simulation software, such as, ProModel, MedModel and ServiceModel suites provide by far the most detailed representation of the actual system, and therefore have the potential to yield more accurate results. Expectedly these tend to be more costly than Monte Carlo and optimisation software. However, cheaper, stripped down versions such as the Process Simulator provide a convenient starting point. Discrete-event simulation should be used when it is important to model the behaviour of the system over time and when it is necessary to model the intricacies of the system operation in detail.

This review provides a brief background of each type of decision tool and how they are suited for different situations. There are however, numerous software available for each type of tool. Feel free to contact Hearne Scientific Software for advice on modelling your system or on selecting an appropriate tool.

Hearne provides training in Monte Carlo simulation, optimisation and discrete-event simulation as well as model development consultancy services in optimisation and discrete-event simulation.