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Validation of Management Simulation Model

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Abstract

The method of a business simulation project implementation is described in the paper. It is intended for extensive projects within the framework of DSS (Decision Support System) or EIS (Executive Support System). The main objective of the method is to reduce two of the most pressing problems related to business simulation projects: the problem of validation and the problem of scenario formulation.

Keywords: simulation, modelling, verification, validation, business system

Introduction

The effective decision making is very much based on modern computer and information technology. Increasing power of hardware and software makes it possible to apply a variety of models for solving management problems. Models are useful presentations of real objects or situations as they reflect the reality without dealing with every detail of it. Even if some aspects of reality are missing in models they still retain enough information to support an effective decision making process. There are two particularly important models in business decision making which are closely related. These are mental and mathematical models.

Mental models are unwritten assumptions and beliefs that people use in thinking process. They determine what information should be used and how should it be interpreted. This is how mental models play a central role in the acquisition and use of knowledge. Mathematical model is a series of equations or graphs that describe precise relationship between variables. The relationships in the mental model could be stated precisely via mathematical model. They can consist of hundreds of equations which is important to know, because people are unable to pay attention to hundreds of things at the same time.

Computer Simulation

There are three important uses of mathematical models: generating information by evaluating tentative decisions, generating information by identifying optimal solutions, and generating knowledge by analysing a model. A mathematical model which is used to represent the behaviour of a system and which calculates the outcomes of particular decisions and assumptions is called a simulation model. Most current simulation models for financial decisions are built by using spreadsheet software, which non-programmers can use and which is well suited to many planning and budgeting decisions. Many other software products are available for developing models that are more complex or that do not fit well into a spreadsheet format. Examples of these products include IFPS, Simscript, and GPSS. Many simulation software products are moving in the direction of visual interactive modelling, a technique that creates a pictorial representation of a system.

Computer simulation is one of the methods used in the quantitative analysis process as a part of decision-making process (which is a part of problem solving process). It is defined [2] as a technique used for modelling the operation of a system over time. This method employs a computer program to model the operation and perform simulation computations. So it can be used to study the performance of a real-world system. First, a computer simulation model is developed, which "behaves like" or simulates the real system. At this stage a great care is taken to ensure that the computer simulation model presents the real system. Then, through a series of computer runs or experiments, we learn about the behaviour of the simulation model.

Although there are many relevant papers describing the method of model building and methodology of its application [4,5,6,7], there are no commonly accepted rules of their validation that would guarantee the model quality and its acceptance. When developing and using computer simulation models for business decision support we are faced by the issue of validation [3].

Validation

The simulation model is implemented as a computer program. According to Kleijnen [8] it is necessary to carry out the verification of the program before the validation of the model. Verification is determining that a simulation computer program performs as intended, in the sense that the computer code has no programming errors left. The result of verification is an error-less computer program. Validation, however, is concerned with determining whether the conceptual simulation model is an accurate presentation of the system under study. It cannot be assumed to result in a perfect model, since the perfect model would be the real system itself. The simulation model can only be good enough, which depends on the purpose of the model.

To obtain a valid model, we should try to measure the inputs and outputs of the real system, as well as the attributes of intermediate variables. In practice, data are available in different quantities.

Suppose we have succeeded in obtaining data on the real system, we should then feed real-world input data into the model in historical order. After running the simulation program, we get a time series of simulation output and compare it with the historical time series of the existing system. The model is valid if both outputs match. If they don't, we have to change the model and repeat the whole procedure. The simulation model as a whole can consist of many individual models or modules. Validation of individual modules with observable inputs and outputs proceeds in exactly the same way as validation of the simulation model as a whole.

The model cannot gain credibility by the mere fact that it is formulated by a computer program which cannot be fully verified. However, the probability of hidden errors in the program is reduced by the length of program application and can ultimately be ignored. The problem of validation concerns the fact that it is not possible to check the response of the model to all probable combinations of input data. Moreover, especially in the case of business systems models, it is not completely certain that the laws that apply to a particular system are not going to change during the time which is covered by the simulation.

Method

In one-shot application models we can expect a greater reduction in building time. Since we deal with unique situations, there are no historical data available that could be used in the validation of the model.

In models which are expected to be used more frequently the building time is not the main restrictive factor and the validation can be based on historical data. A more frequent application can be expected with the models of standard decision-making situations. These are the ones that the managers need to face daily, weekly, monthly or yearly at the operational and tactical management level where the problems are so well-structured that they can be represented by mathematical models. A number of such problems are developed by the users themselves.

They can be presented by applying analytical, simulation and optimisation models. In the following we will mainly examine simulation models serving as support to decision-making in business.

The method which is adjusted to the building and application of simulation models for a multiple use will be called the prototype method of simulation project implementation. We have decided to refer to it as a prototype method because creating the prototype model is a key step of the simulation project. The method consists of two basic stages: the stage of model building and the stage of model application.

This method is similar to the classical one but the process of validation is quite specific. An important step in the model building stage is the connection with TPS. A number of models are created by managers themselves applying the method of end-user computing. However, the close connection of the model to TPS, which is anticipated in the prototype method of simulation project implementation (briefly: prototype method), requires co-operation with professional data-processing specialists, who are able to create more extensive models.

The prototype method is based on the assumption that the most serious problem, especially in the case of extensive models, lies in the verification and validation of the model. The verification and validation of models frequently used over a longer period of time can be very precise so it is likely that the model will give a fairly good presentation of the real system. In this case the verification and validation can be run continuously all the time the model is being applied. However, it needs to be connected to TPS. In connection with TPS it is possible to feed the model with real inputs for the randomly selected period in the past. The procedure of defining the differences between the real or simulated outputs can be fully automated.

TPS does not always generate enough data to meet the requirements of the simulation. On the other hand it might happen that there is too much data available. When TPS does not provide the data of the real system with necessary precision but this would be possible within certain cost limits, the existing corporate data base needs to be adjusted to the requirements of the simulation. When TPS generates abundance of information for the purpose of validation and simulation model application, it is possible to establish the connection between TPS and simulation models through an interface realised by SQL.

The connection between the model and TPS is important not only from the viewpoint of validation but also from the viewpoint of its application. The method is based on the assumption that it is much easier to formulate scenarios in what-if analysis when they are based on a well tried-out model, which describes the current state of the system or the state during a particular past period. The reference model from the past, which can serve as the initial pattern, can be called a prototype. For example, we are dealing with a simulation project of cost allocation. As a prototype we choose the model of costs containing data from the past which mostly suit the supposed situation. Then we change, e.g. among few hundred parameters, only those which differ in the supposed situation.

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