Využívanie matematicko-štatistických modelov pri inováciách komplikovaných reálnych systémov

The use of mathematical-statistical models in innovation of complicated real systems

Zuzana Krátka

Abstrakt: Modely sú zjednodušeným obrazom komplikovaných reálnych systémov a modelovanie je často jediným prostriedkom umožňujúcim ich pochopenie. Tento článok je zameraný na analýzu výhod a nevýhod využívania matematicko-štatistických modelov pri inováciách komplikovaných reálnych systémov.

Abstract: The models are simplified images of complicated real systems and modeling is often sole instrument for their understanding. In this paper we will concentrate on the analysis of the advantages and disadvantages of the use of mathematical-statistical models in innovation of complicated real systems.

Kľúčové slová: inovácie, matematicko-štatistický model, deterministický model, stochastický model

Keywords: inovation, mathematical-statistical model, deterministic model, stochastic model

JEL classification: O31, C19

1. Introduction

Mathematical modeling is becoming an increasingly important subject as computers expand our ability to translate mathematical equations and formulations into concrete conclusions concerning the world, both natural and artificial, that we live in. A mathematical model is a description of a system using mathematical concepts and language. The process of developing a mathematical model is termed mathematical modeling. Mathematical models are used not only in the natural sciences (such as physics, biology, earth science, meteorology) and engineering disciplines (e.g. computer science, artificial intelligence), but also in the social sciences (such as economics, psychology, sociology and political science). Physicists, engineers, statisticians, operations research analysts and economists use mathematical models most extensively. A model may help to explain a system and to study the effects of different components, and to make predictions about behaviour. Mathematical models can take many forms.

The models are simplified images of reality and their main advantage is possibility to express indefinitess of real world by random variables. The models are used to search for common and generally relevant patterns and relationships of real systems. It is meaningful and adequate reduction of reality. The models are simplified images of complicated real systems and modeling is often sole instrument for their understanding. The model should retain only these aspects which are relevant during solving proper problem and other should be abandoned. The quality of model is measured by its explanatory value, and not according

to its abnormalities from reality. Despite of many models are built on antirealistic premises, but their application leads to excellent estimative solutions. At first the models are created as very simplified picture of reality. In case of need there is possible to achieve detailed description of real system by their subtilization. This process is called the method of decrease abstraction.

2. Process of modeling

The modeling is process with several phases. The basic phases of mathematical-statistical modeling are shown in Fig.1. At first is neccessary to specify problem which has to be solved. The formulated model is literal and numerical picture of problem. This model is translated into mathematical model which is solved by standard procedures. The solution of mathematical model is solved by avaliable softwares. Very important phase is interpretation of solutions and their verification. Then it is possible to implement the model within the analysed real system.

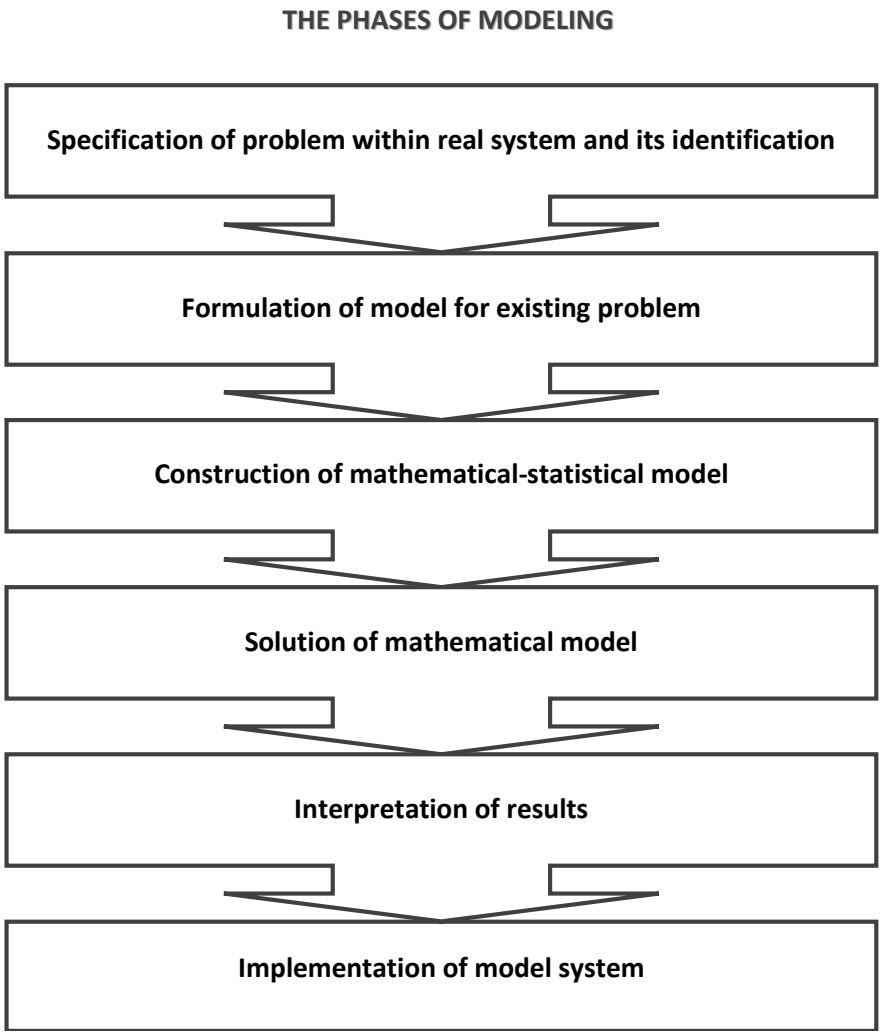

Fig.1 The phases of mathematical-statistical modeling
Source: Čermáková, H. modified by author

The specification of problem within real system and its identification

The single formulation of problem needs some measure of simplification in sense split it off the real system. The model has to be assembled like simplified image of real system with essential items and relations between them. There should be defined the tools for solving this problem.

The formulation of model for existing problem

The real system is very complicated for model and often the formulated problem has not connections with all of areas in real system. There is very important to make right decision about the aspects which are neccessary to make provision for creating of model in actual situation. The most important issue of decision making is the purpose of using the model. The included issues and excluded issues have relation on purpose of model. The model has to respect the goal of analysis. We should know the goal of real system when we are creating the model.

The model has to include:

- Description of processes which are the part of real system – we understand the process as each activity of system which can influence final status,
- Description of elements which have influence processes – each process passes with proper intensity and its realization is influenced by many elements which have to be respected,
- Description of connections – correlative connections and relations among processes of real system, its elements and goals.

Construction of mathematical-statistical model

The formulated model is literal and numerical description of problem. Before resolution of problem there is neccessary to transfer model to mathematical model which is solved by standard procedures. The mathematical model follows the formulated model in every detail, but the formulation is different. The mathematical speach is clear. The specific mark of mathematical model is the abstraction of aspects which are not connected with its quantitative and space forms and relationships.

The solution of mathematical model

The solution of mathematical model is sort of technical job. There is many of software tools nowdays, which effective solve the typical tasks of method of operation analysis. There was created software system ICFRS (Interactive Claims Reserving Forecasting System) in Australia. There are made the softwares for modeling of insurance clamis and other softwares developed and used by actuarial consulting companies.

The interpretation of results

The interpretation of results is important part of application of models of operationg analysis. The difference from above-mentioned step, which is sort of routine issue, is difficulty in interpretation at the begining. The interpretation is not satisfactory, the results of

models is neccessary to verify. The analysis of results confirms also the right formulation of model and mathematical model.

The implementation of model system

When the verification of system runs correctly, there is possible to implement the model into the analyzed real system. The successful implementation should contribute toward improvement of functioning of modeled system in relation to goal defined in model.

3. The deterministic and stochastic approach to modeling

In innovation are used the deterministic and stochastic models which are connected with two different approach to modeling of real systems.

The deterministic approach predicts the stability when accidental variantions of system can be neglected. All of future decisions flow from fundamentals of system. There are all of variables given in the deterministic model or there are easy calculated. The presence nad future are interlacing only on former times. This type of modeling is useful, but it is not always adequate in connection to uncertainty of complicated real systems.

The stochastic approach assumes at least one of variables has values which we not know in advance. The changes occur with certain probability. In comparison to simple deterministic models, the stocastic models present dynamic approach of modeling. The main tool is accidental processes which can be defined as set of accidental quantities depending on certain number of parameters and each of parameters is defined on set of real numbers. The procedure of accidental process is always different. There are many processes with one parameter defined on discret or linear sets in practical applications. There is often time this parameter.

4. Innovation and Innovation Process

Innovation, according to Schumpeter (1934), covers:

- the introduction of a new good or a new quality of the good,
- the introduction of a new method of production,
- the opening of a new market,
- the conquest of a new source of supply,
- the carrying out of the new organization of an industry.

The “newness” need not necessarily involve “new” knowledge thereby effectively implying that the “newness” may also concern advancement or modification of existing knowledge. Innovation, according to Rogers (2003), is “an idea, practice, or object that is perceived as new by an individual or other unit of adoption”.

The Oslo Manual, developed jointly by Eurostat and the OECD and currently in its 3rd edition, defines innovation as "the implementation of a new or significantly improved

product (good or service), or process, a new marketing method, or a new organisational method in business practices, workplace organisation or external relations." It differentiates between 4 types of innovations, namely "Product Innovation", "Process Innovation", "Marketing Innovation", and "Organisational Innovation" (OECD, 2007).

The innovation process encompasses several systematic steps, beginning from problem/requirement analysis to idea generation, idea evaluation, project planning, product development and testing to finally product marketing. The steps may overlap each other. These steps may be categorised into three broad phases, which represent a simplified innovation process.(Fig.2)

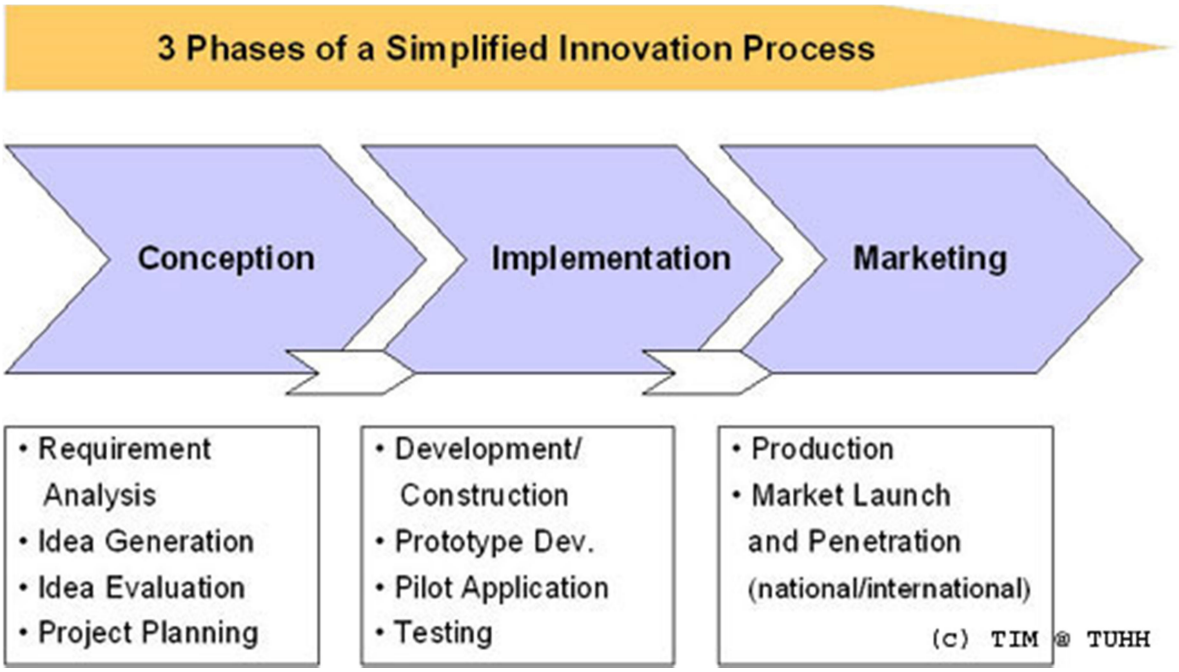

Fig.2: Three phases of a simplified innovation process
Source: Tiwari, R. 2007

5. Advantages and disadvantages of modeling in innovation of complicated real systems

The main advantages of modeling, which is often only tool for study of real system, are following:

- Premise of creation of any model of real system is structuralization of system, which leads to generally knowing of system, all of its basic factors, relations and coherences. The contruction of model is specific method for observation of

reality, which would be very multiform for deduction of required conclusions (often numerical), whereas the model is confined on sufficient segment of reality built by properly chosen system of premises;

- The analisys of system specifies possible variants of estate of modeled real system (there can be infinite amount of estates);
- The models allow the analysis of complicated real system behavior in significantly shorter time;
- It is possible to experiment and realize different operations by changes of parameters in models. The creators or users can express their different projections of reality by setting up the parameters;
- There are always the costs of model realization lower than costs of experiments with real system;
- The work with model allows avoid the real experimentation which can lead to unacceptable estate.

There are some negative issues which have influence on modeling, in spite of importance of modeling in innovation, as follows:

- Problem with adequate group of authors (their qualification and expertise). It can be strong advantage, but also weakness when the creation of fine model can fall in begining;
- A crucial part of the modeling process is the evaluation of whether or not a given mathematical model describes a system accurately. This question can be difficult to answer;
- Relatively long time neccessary to create model is also restricting factor;
- The costs for creation and improvement of models may be high.

6. Conclusion

The development of new technologies and informatization allows increase the requests in creation of the statictical-mathematical models, but there are also increased requests in understanding of processes and results of models. The capacity and rapidity computer techniques allows construct such large models which were not considered before.

There are not unificated opinions what is more useful the simply modeling or complex modeling in practice in spite of their advantages. The advantage of simple models are lower costs of realization, bigger transparency in comparison to more complex models and lower number of mistakes. There is recommeded to begin with simply model with less number of demands. There is recommended also to improve the level of models from time to time, recover the aspects which were not implemented yet by current control of existing results. On the other side there are opinions that the complex reality needs complex models from the begining and during whole process.

There is neccessary to remember that the key to succesful modeling is also accession to right information. The modeling, if it should be exact, has to work with sufficient data. Because of decrease of costs connected to records archive and database making, it will be not problem in future.

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Author's address:

Mgr. Ing. Zuzana KRÁTKA, PhD.
Institute of Management of the Slovak University of Technology
Vazovova 5, 812 43 Bratislava
e-mail: zuzana.kratka@stuba.sk

This paper presents partial results of the research conducted within the VEGA project number 1/1164/12.