INNOVATION MODELLING METHODS USING FOR INVESTIGATION OF BEHAVIOUR OF REAL SOCIO-ECONOMICAL SYSTEMS

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Abstract

Economical researches using imitation statistical modelling methods have numerous challenges and opportunities in the waiting for the twenty-first century, calling for increasing numbers of non-traditional statistical approaches. Imitation statistical modelling is one of the most widespread methods of research of economic systems. Imitation modeling is usually applied for researching economic processes and systems. The selection of methods of modelling of the economic systems under consideration depends on a great number of conditions (modeling components), e.g. complexity of the system being researched: the character of behavior of the system; the character of behavior and the impact of the factors on the changes of the entity or economic system being investigated; other similar conditions. The method of imitation modelling allows developing (imitate) different scenarios of functioning of the investigated economic systems. Imitation modeling may be used for tackling a wide range of economic problems (design and analysis of industrial systems, stock management, balancing of production capacities, allocation of investment funds, optimization of investment funds, optimization of flows of services etc.). Imitation modeling is frequently associated with the factor of uncertainty, whose description goes outside the confines of the traditional statistical modeling, which, in its turn, complicates the imitation modeling process. However, most of the economic processes and systems are complex entities, consisting of a great number of interrelated subsystems (which in their turn also are complex objects and require a detailed study), changing their positions in space and time. For researching such economic systems it is impossible to create an absolutely accurate effective model by applying analytical methods. In such cases it is necessary to use the methods of imitation modeling. In the process of imitation modelling the most frequently method used to model multivariate distribution incidental values is the parametric method of modelling. In this case it is necessary to establish parameters of common distribution of incidental values characterizing the factors under consideration. Usually this is done by means of evaluation of parameters of multivariate distribution, i.e. by establishing the most suitable distribution (copula), deriving from the available empirical data. The main objectives of the paper are: to describe the main ideas of using of imitation statistical modelling methods for investigation of economical systems; to describe imitation statistical modelling methods using for investigation of economical systems functioning process.

Key words: innovation, imitation statistical modeling, economical systems, behavior

Traditional methods of imitation statistical modeling for investigation of economical systems

Using traditional methods of imitation statistical modelling for investigation of economical systems it is possible to set the task of creating an efficient procedure for generating incidental parameter values constituting factors of an imitation model, to consider the asymmetric distribution of model factors, to create an adequate model of non-linear dependence between the factors, to effectively use up-to-date information technologies, to ensure continuous control of the behaviour of the specific economic system that is being researched. Fig. 1 presents a process of creation of an imitation model.

In economic systems models, where the relations between separate components forming the model are comparatively simple and can be accurately described (fig.1), analytical models can be used for obtaining the required information.

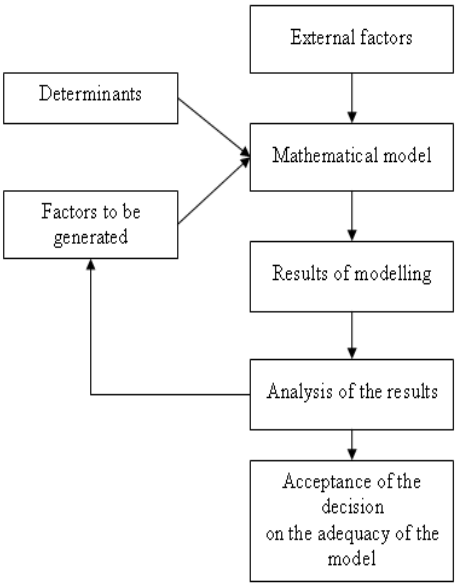

Fig. 1. Process of creation of an imitation model

The traditional scheme of imitation modelling is the formation (generation) of a mass of incidental parameter values featuring the changes of model factors.

The algorithm of generation of incidental continuous value X, having continuous distribution function F, can be described in the following steps:

1. Let us generate, within an interval (0.1), an evenly distributed incidental parameter u ~U(0.1).
2. Let us calculate X = F^{-1}(u).

The value of F^{-1}(u) will always be definite, since $0 < u < 1$, but the area of defining the function F is the interval [0,1]. The figure below presents the essence of the algorithm graphically; here incidental value may be assumed to be either positive or negative. This depends on the specific value of parameter u. In the figure, the value of parameter u_1 produces a negative incidental value X_1, but parameter u_2 yields a positive incidental value X_2.

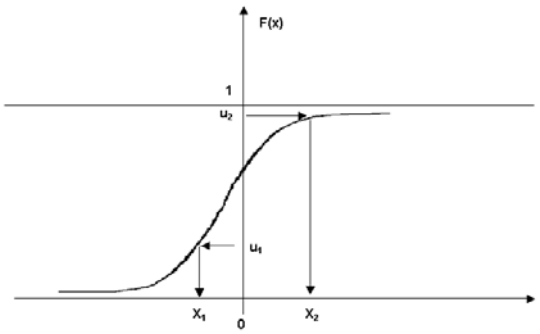

Fig. 2. Scheme of reverse transformation

The method of reverse transformation may be also used if value X is discrete. In this case the distribution is as follows:

$$F(x) = P\{X \le x\} = \sum_{x_i \le x} p(x_i), \quad (1)$$

where p(x_i) is probability $p(x_i) = P\{X = x_i\}$.

It is admitted that incidental parameter X may have only such values as x_1, x_2, ..., for which $x_1 < x_2 < \ldots$.

Thus the algorithm of developing the values of incidental parameter X will have the following consequences:

- Let us generate, within the interval (0.1), uniform distributed incidental parameter u ~ U (0. 1);
- Let us establish the least positive round value I, for which u < F(x_i), and assume that X = x_i.

Both options of the method of the reverse transformation for continuous and discrete values (at least formally) can be combined in one formula:

$$X = \min P\{x : F(x) \ge U\}, \quad (2)$$

which is true also for mixed distributions (i.e., containing both continuous and discrete components). In contrast to commonly used direct methods of generating incidental values (the method of the reverse transformation composition and implosion), for imitating the factors of the imitation model it is recommended to use the so-called indirect methods, namely, the acceptance-refusal method. This method may turn out to be suitable if due to certain reasons it is impossible to apply direct methods or if these methods are inefficient.

The "acceptance-refusal" principle is rather common. If the aforementioned algorithm is looked upon from a slightly different perspective, it is clear that it may be extended for generating incidental points in areas having higher dimensions – i.e. in multi-dimensional areas.

This is relevant in modeling real economic systems by applying the Monte Carlo method. When using the MS Excel program, users usually apply standard functions for modeling incidental parameter values in a dynamic regime.

Example of stochastic modeling of industrial stock in nonlinear case

The purposes of modeling are:

1. To define an optimum strategy of updating of industrial stocks and reductions of the expenses connected to their storage;
2. To combine the modeling process with the real information describing the process of industrial stocks management in real time;
3. To take to account the nonlinearity dependences of factors of the model;
4. To construct the management process in online regime.

In the first scenario for incidental values modeling is used traditional methods, in particular, the method of the reverse transformation the Bellman's method (receipt-refusal). In the second scenario of modeling the authors have used

modeling methods that allow to consider specific characteristics of changes of value P - order frequency (is measured as units of orders per unit of time), namely, irregularity of consumption intensity, different lengths of intervals between order points, inability to select an appropriate rule of distribution of value P for the whole modeling time interval.

For resolving the problem under given conditions, traditional methods of statistical modelling was applied, which allows to develop (imitate) different options of organization of the process of stock management, taking into account the specific characteristics of the particular scenario. The above algorithm of optimization and calculation of order point is traditionally and most frequently used in real-time planning. In reality the function, from the point of view of order TCU (total cost per unit time), is to a great extent dependent on the value of P – frequency of orders. In order to consider this impact, the authors make an assumption about the incidental character of behavior of value P. Two modelling scenarios are considered: Given the value P, the rule of distribution is known as F, i.e. P∼F (F – distribution function). There is the following interdependence:

$$TCU = \Phi(P, t, t_0, \omega), \quad (3)$$

where: t_o – order cycle time (measured in units of time);
t – modelling time;
w – incidental parameter.

The rule of distribution of value P is not known and it is necessary to model a different character of behavior of value P. In the first scenario there is a sufficiently well developed mathematical mechanism of modeling and it is necessary only to implement and analyze the data obtained to meet the goals of optimization. When modeling incidental values, traditional methods are applied; in particular, the method of the reverse transformation the Bellman's method (receipt-refusal). For theoretical modelling the authors have used MS Excel and the special programs for modelling. The analysis of the modeling results allows to choose the most optimum dynamic mode of replenishing the stock, required raw materials and materials, as well as to minimize total costs TCU, i.e. to choose an optimum strategy for stock management in a stochastic case (the first modeling scenario). In the second scenario of modeling the authors have used modeling methods that allow considering specific characteristics of changes of value P, namely, irregularity of consumption intensity, different lengths of intervals between order points, inability to select an appropriate rule of distribution of value P for the whole modeling time interval. The process of development and implementation of the imitation model implies the following simplified algorithm (see fig. 3):

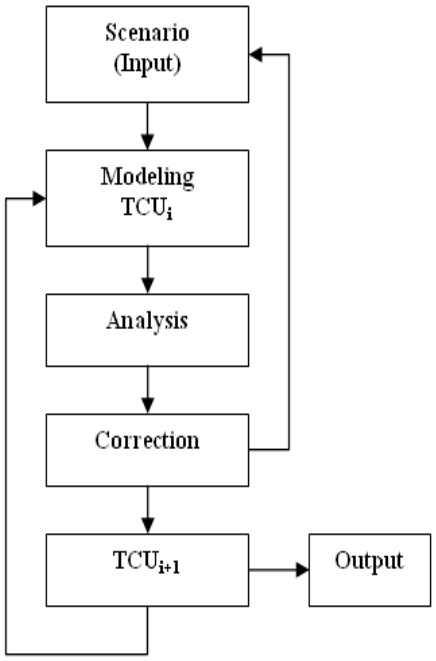

Fig. 3. Algorithm of the implementation of the second scenario

The modern economic analysis basing on the using of information technologies shows that in the real systems the parameters describing the economic objects, not always have the Gauss distribution. The nonlinear dependence exists between various factors. In these cases it is impossible to use the linear correlation coefficient for evaluation of measure of dependences between factors. It requires using another method for evaluation the measure of dependences between factors.

Conclusion

In our days, designing real economic systems very much popular is becoming the use of copulas, which fully characterizes the nonlinear connection between main factors of the model and allows uniting margin functions into multivariate distribution function.

The application of modelling is connected with the fact that frequently it is not possible to provide a definite description of the behaviour of the economic system being investigated. When investigating the dynamic behaviour of the economic system, i.e. by making definite changes of parameters of the system under investigation, we frequently observe the existence of incidental factors affecting the character of the behaviour of the system. In addition, it should not be forgotten that the very character of the research also brings its incidental elements into the research process. The modelling process of economic system stability is implemented using a set of alternative strategies of economic system performance applying the dynamic programming and benchmarking method. The introduction of a set of alternative strategies supports stable functioning of economic system in the conditions of uncertainty.

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