USE OF INFORMATION TECHNOLOGY IN TEACHING ECONOMICS

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Abstract

Information technologies provide an opportunity to create, collect, save, process and efficiently use information in the processes under investigation. In contemporary world information technologies are most frequently linked with modelling making use of computer technology and information networks. Modelling is considered to be an indirect investigation method for originals of objects used while researching the substitutes of the objects. The information image of the object (information model) may be used as the object substitute. In economic studies it is important to create a business model. The term business model describes a wide variety of informal and formal ranges of models to be used in economics to reflect different aspects of business, such as mass servicing systems, production and management processes, organisation structures, financial forecasts, planning and management, as well as other similar economic processes. The model may be created as a determined model or in case of uncertainty or under conditions of risk it may be presented as a stochastic model. Information technologies allow multiple repetition of modelling processes (process imitations) under different conditions. The imitation model may be used for detailed analysis of sophisticated problems (with many mutually linked variables) in the teaching process.

Key terms: model, statistical information, modelling, teaching process, optimization.

Introduction

In scientific literature the analytic models characterizing the economic processes may become too sophisticated and in research information technologies should be applied. For research purposes the imitation model developed is much more convenient and safe than investigation of the real object making use of analytic methods. Moreover, it is relatively simple to change the scenarios in the imitation model to observe their impact on the performance indicators of the system. Information technologies and methodology of modelling have turned into most significant components of the teaching process and for training specialists in economy it has offered an opportunity to use new knowledge more efficiently as well as enhance the competitiveness of the new specialists in labour market. The main objectives of this article are:

1. to examine the main constituent parts of the economic system and imitation modelling of processes;
2. to show the practical application of information technologies and methodology of modelling in the teaching process;
3. to demonstrate the possibility to practically apply the information technologies, including special modelling programmes in the teaching process;
4. to show the possibility to expand the use of information technologies.

Approach to task modelling

Modelling is usually used to model real events. The term imitation modelling may be referred only to particular dynamic models which include information about the sophisticated probability system in a fixed period of time. For example, this article deals with modelling of discrete events. This modelling method is usually used in situations when individual elements of the event are examined, the probability distribution of which is broken down (e.g., a model that follows up the interest rate of loan basis in a fixed period of time). The model may be built as a usual determined model or, in case of uncertainty as a continuing imitation model. The discrete modelling of events is usually used when it would be desirable to clarify the impact of every event onto the model. Another example could be the linear programming model or decision analysis model. Using these models it is possible to plan the production of goods and the amount of the necessary resources in a fixed period of time. However, it is rather difficult to include detailed decisions into these models that influence the production process. Such models may include planning of the number of the employed, assembling or dismantling of production equipment, supply with raw materials, entry of semi-finished and finished products in the accounts, as well as the decisions referring to repairs of the equipment and shortage of labour force. The imitation model of discrete events may be used for solving complicated problems (with many mutually linked variables) for detailed research of smaller parts. Most often the imitation modelling of discrete events is used for modelling of real systems that consist of conflicting processes which occur parallel and may simultaneously demand the lacking resources. Queuing modelling may serve as an example of the kind of modelling that consists of tasks that are waiting for execution (e.g., people queuing up at the cash-register or the flow of completing parts to the assembling conveyor). The imitation model built is much more convenient and safer for research than modelling of real life situations. Moreover, it is relatively simple to change the scenarios in the model to examine their impact on the performance indicators of the system. The parameter calculation of the system modelled (in this case the system with refusals and three servicing devices) and modelling and optimization of its performance, as an example, are presented in the article.

Let us assume that there is a simple servicing system (AS) with refusals and three servicing devices, for example, a service station where three maintenance masters are responsible for regulation of the lights of cars. The flow of demands enters the servicing system with the intensity **λ**. The average time for servicing one demand is t_{apk}. The values of parameters of the servicing system(AS) modelled for the variant A are presented in Table 1.

Table 1. Initial data of the servicing system modelled (AS)

	Number of variant									
	1	2	3	4	5	6	7	8	9	10
λ	1,2	1,4	1,3	1,5	1,7	2,0	2,6	2,9	3,0	1,7
s	4,0	3,0	2,0	5,0	3,0	3,0	4,0	4,0	5,0	2,0
t_{apk}	0,8	0,7	0,5	0,6	0,4	0,5	0,7	0,6	0,6	0,4
C_m	5,0	6,0	7,0	8,0	9,0	8,0	5,0	7,0	6,0	10,0
C_{apk}	2,0	3,0	2,5	2,4	2,6	3,2	3,4	3,0	2,2	2,8
C_{eksp}	1,0	1,5	2,0	1,5	1,8	2,0	1,7	1,5	1,1	1,4
C_d	0,2	0,25	0,3	0,25	0,35	0,42	0,35	0,26	0,36	0,45

where

λ – intensity of incoming demands into the system to be modelled;

s – number of servicing devices (AI) in the system to be modelled;

t_{apk} – average time for servicing one demand;

C_m – price for servicing one demand, in lats;

C_{apk} – costs for servicing one demand, in lats (including the price for the parts changed or added in cases, when AS is connected with repairing device and/or with operation of any device or consumer goods, as well as the costs which may be linked with servicing of the demands, for example, with consultancy services of specialists involved, costs that are linked with assessment and technical appraisal that is made extra according to the client's desire, etc.);

C_{eksp} – operational costs of one servicing device in one unit of time (including the wages of the operator of the servicing device (AI), in lats;

C_d – costs linked with the idle time of one servicing device (AI) in one unit of time, in lats.

Graphical representation of functioning of the servicing system (AS) to be modelled for variants A and B is shown in Figure 1.

When modelling, it is to be stated whether it is efficient to organize the operation of the system to be modelled in such a way that all three servicing devices would immediately serve the incoming demands, taking into consideration that the average servicing time would be reduced threefold (Variant B**).**

Technical parameters characterizing the servicing system to be modelled

Technical parameters of the functioning of the servicing system (AS) to be modelled are the following:

λ – intensity of incoming demands into the system to be modelled;

μ – intensity of servicing of the demands in the system to be modelled;

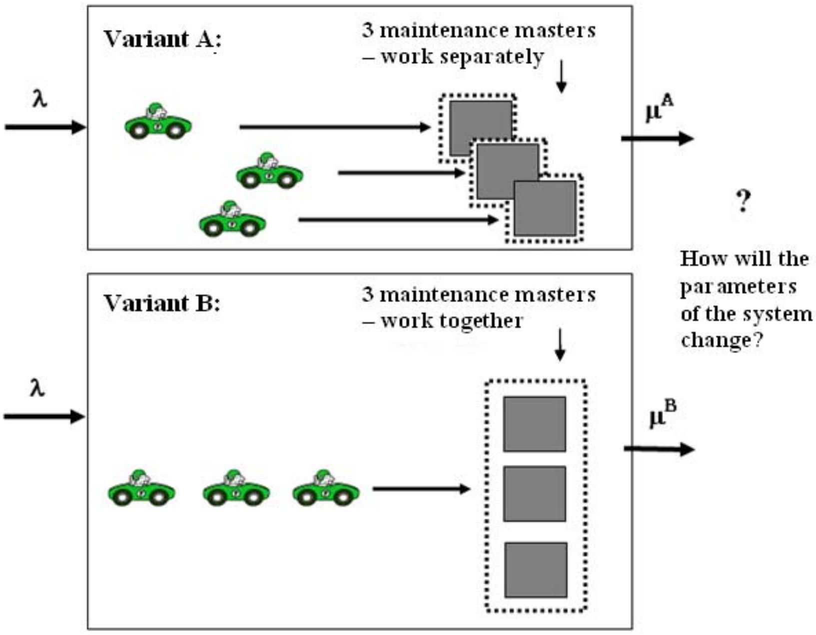

Fig. 1. Functioning schemes of servicing systems to be modelled for variants A and B.

v – intensity of the demands not serviced and leaving the queue;

s – number of servicing devices (AI) in the system to be modelled;

λ_{ef} – effective throughput capacity of the system to be modelled.

The effective throughput capacity of the system to be modelled is the average number of demands that have entered the system to be modelled that could be serviced in the system in one unit of time;

m – maximum length of the queue in the system to be modelled;

ρ – reduced intensity of the demand flow (the average number of demands entering the system per average servicing time of one demand);

ρ*– intensity of the demand flow (number of average incoming demands per one servicing device in the system per average servicing time of one demand);

ρ_v – reduced intensity of the demand flow that was not serviced (the average number of demands not serviced that leave the system per average unit of time per one demand);

q – relative throughput capacity of the system to be modelled.

Relative throughput capacity of the system to be modelled is the proportion of the average number of demands to be serviced in the system in one time unit against the average number of incoming demands to be serviced during that time;

P_0 – probability that the random incoming demand in the servicing system (AS) will enter the system when all the servicing devices are free (probability that the servicing device (AI) is free);

P_k – probability that k servicing devices are occupied in the servicing system;

P_{att} – probability that random incoming demand in the servicing system (AS) will enter the system when all servicing devices (AI) are occupied (refusal probability in AS with refusals);

P_{gaid} – waiting probability in waiting queueing servicing system (AS);

$P_{att+neapm}$ – probability that random incoming demand in the servicing system (AS) will leave the system unserviced (the demand may leave the system because of the length of its limited queue or in case the expected waiting time in the queue exceeds its personal possible waiting time limit – "neutral demand");

W_{sist} – average time of incoming demands in servicing systems (AS) (both when servicing and queueing);

W_q – average waiting time for demands in the queue;

L_{sist} – average number of demands in the servicing system (AS);
L_q – **average** length of the demand queue to be serviced;
L_{apk} – average number of the demands to be serviced in the servicing system (AS);
L_{briv} – average number of the free servicing devices (AI) in the servicing system (AS);
K_{tg} – idle time coefficient of the servicing devices (AI) in the servicing system (AS);
K_{sl} – load coefficient of the servicing system (coefficient of the load of all servicing devices (AI) in the servicing system (AS)).

Economic parameters characterizing the servicing system to be modelled

The economic efficiency for functioning of technical economic systems may be expressed by fixed performance parameters of the servicing system (AS), for example, by income received from the performance of the servicing system (AS). In such a case the optimization of AS should manifest itself as maximization of the income from its business performance. However, in refusal servicing systems one part of demands leave the system subserviced, the result of which is that the AS which is a technical and economic system (e.g., a store, saloon, hairdressers', etc.) loses part of their potential clients. Alongside one part of income of the technical and economic system (the so-called lost income) is lost, the amount of which should be calculated.

Optimization of performance efficiency of the servicing system (AS) to be modelled is closely linked with the increase of throughput capacity of AS, reduction of the length of the queue leaving impact on the process of losing the potential clients not wishing to queue up for a long time. Such optimization may be reached by increasing the number of the servicing devices in the servicing system to be modelled. On the other hand, a question arises to what limit the number of the servicing devices should be increased in the servicing system to be modelled. As a rule, too many servicing devices may bring about idle time in the servicing system, thus causing not only the increase in costs linked with installation of additional servicing devices, but also losses due to idle time. To find answers to the issues mentioned above and to increase the efficiency of the AS performance, the servicing system itself should be examined identifying the main economic indicators of its performance.

The economic parameters of the performance of the servicing system (AS) to be modelled are as follows:

C_m – servicing price for one demand, in lats;
C_{apk} – servicing costs of one demand, in lats (including the price for replaced and additionally installed parts in cases when MS is connected with repairing and/or maintenance of some devices or consumer goods, as well as costs which are linked with servicing of some demands, such as consultancy services of experts, costs linked with providing assessment and expertise that is made additionally according to the clients wish, etc.)
C_{gaid} – costs linked with queuing up, in lats;

These costs include: direct costs of the servicing system in cases when to attract the clients, settlement of the telephone bills, water bills, subscription to newspapers and magazines and other similar services are offered for those clients (demands) queuing up, as well as other costs;

C_{eksp} – costs of maintenance of one AI per one unit of time (including the wages for the AI operator), in lats;
C_d – costs linked with the idle time of one AI per one unit of time, in lats;
I_t – income from AS during its performance in the period of time t, in lats;
P_t – profit from AS during its performance in the period of time t, in lats;
$P^{att}_{nesanem,t}$ – lost or "missed" income in the period of time t linked with the fact that demands leave the system, in lats;

Income gained from performance of **AS** in the period of time **t** may be calculated using the formula:

$$I_t = C_m \cdot \lambda_{ef} \cdot t, \quad (1)$$

where **λ_{ef}** – effective throughput capacity of **AS** (average number of demands serviced in the period of time t).

The effective throughput capacity of **AS** may be calculated using the formula:

$$\lambda_{ef} = \lambda(1 - p_{att}) \quad (2)$$

To achieve rational organization for AS performance, the function of cash expenditure **C_z**

that is linked with the performance of AS may be identified. The function used is made including all costs linked with the performance of **AS,** functioning parameters of **AS,** as well as the working regime of **AS** and the number of **AI.** The cash expenditure function $\mathbf{C_z}$ that is linked with the performance of the servicing system in the period of time **t** may be expressed in the following way:

$$C^{apk}_{z(s),\,t} = \left(C_d \cdot L_{briv} + C_{eksp} \cdot L_{apk} + C_{apk} \cdot \lambda_{ef} + C_{gaid} \cdot L_q\right) t \qquad (3)$$

where

- **t** – the performance time of **AS** (modelling time not taking into consideration the transition period);
- **λ** – the intensity of incoming demands in **MS** per one unit of time;
- $\mathbf{L_{apk}}$ – average number of the demands to be serviced in **AS**;
- $\mathbf{L_{briv}}$ – average number of free **AI**;
- $\boldsymbol{\lambda_{ef}}$ – effective throughput capacity of **MS** per one unit of time.

In the servicing system with refusals in the period of time **t** the expenditure function $\mathbf{C^{att}_{z(s),t}}$ may be expressed in the following way:

$$C^{att}_{z(s),\,t} = \left(C_d \cdot L_{briv} + C_{eksp} \cdot L_{apk} + C_{apk} \cdot \lambda_{ef}\right) t \qquad (4)$$

In this case it should be taken into consideration that the flow of unserviced demands may be present in the **AS** with refusals. This causes „lost income" $\mathbf{P^{att}_{nesan,\,t}}$, , the amount of which in the period of time **t** may be calculated using the formula:

$$P^{att}_{nesan,t} = P^{att}_0 \cdot (\lambda - \lambda_{ef}) \cdot t \qquad (5)$$

where $\mathbf{P_0^{att}}$ – lost or „missed" income in **AS** linked with the fact that one demand leaves the system, in lats. The value $\mathbf{P_0^{att}}$ is calculated by the formula:

$$P^{att}_0 = C_m - C_{apk} - \frac{C_d \cdot L_{briv} + C_{eksp} \cdot L_{apk} + C_{gaid} \cdot L_q}{\lambda_{ef}} \;. \qquad (6)$$

The average number of the demands to be serviced in **AS** ($\mathbf{L_{apk}}$) is calculated using the formula:

$$L_{apk} = s - L_{briv} \qquad (7)$$

where **s** – the number of existing **AI** in **AS**.

Income received during the performance of **AS** in the period of time **t** (before paying taxes) may be calculated using the formula:

$$P_t = I_t - C^{att}{}_{z(s),t} = C_m \cdot \lambda_{ef} \cdot t - C^{att}{}_{z(s),t} \qquad (8)$$

Using the formula (8) the optimization requirements for **AS** may be formulated as follows:

$$P_t = I_t - C^{att}{}_{z(s),t} \to \max \qquad (9)$$

In the servicing systems with refusals the optimization requirements for **AS** are as follows:

$$P_t = I_t - C^{att}_{z(s),t} \to \max \qquad (10)$$

$$P^{att}_{nesan,t} = P^{att}_0 \cdot p_{att} \cdot \lambda \cdot t \to \min \qquad (11)$$

In cases, when **AS** performance optimization may be solved by using one of the optimization tasks (see formulas 12 and 13):

$$I_t \to \max \qquad (12)$$

i.e., maximization of income gained from **AS** performance in the period of time **t**, or,

$$C^{att}{}_{z(s),t} \to \min \qquad (13)$$

i.e., the minimization of expenditures linked with **AS** functioning in the period of time **t.**

Imitation modelling MS Excel

Let us make the calculations of the technical and economic parameters of the system to be modelled in MS Excel environment.

The results of modelling of technical parameters are presented in Table 2.

The results of modelling of economic parameters are presented in Table 3.

Table 2. Technical parameters of the system to be modelled (MS)

	A	B
1	**Modelled servicing system (AS) with refusals**	
2		
3	**Technical parameters of the servicing system to be modelled (AS)**	
4	**λ,** intensity of incoming demands	**2,00**
5	**μ,** intensity of servicing demands	**2,00**
6	**ν**, intensity of demands leaving the queue not serviced	
7	**s,** number of servicing devices (AI) in the modelled system (AS)	**3**
8	$\mathbf{t_{apk}}$**,** average time for servicing one demand	**0,5**

(continued)

9	**t, AS** total working time	**1,00**
10	**λ_{ef},** effective throughput capacity of AS	**1,8750**
11	**m,** maximum length of the queue	
12	**ρ,** fixed (rationed) intensity of the demand flow **(λ/μ)**	**1,0000**
13	**ρ*,** special intensity of the demand flow **(λ/(μs))**	**0,3333**
14	**ρ_v,** fixed (rationed) intensity flow of demands not serviced	
15	**q,** relative throughput capacity of AS	**0,9375**
16	**P_0**, probability that the AI is free	**0,3750**
17	**P_{att}**, refusal probability	**0,0625**
18	**P_{gaid}**, probability that the demand would queue up for servicing	
19	**$P_{att+neapm}$,** probability that the demand would leave AS not serviced	**0,0625**
20	**W_q,** average time for queuing up	
21	**W_{sist},** average time spent in the servicing system	**0,5000**
22	**L_{sist},** average number of demands present in the servicing system	**0,9375**
23	**L_q,** average length of the queue	
24	**L_{apk},** average number of the demands to be serviced in the servicing system	**0,9375**
25	**L_{briv},** number of AI idle in AS	**2,0625**
26	**K_{tg},** coefficient of idle time in AS	**0,6875**
27	**K_{sl},** AS load coefficient	**0,3125**

Table 3. Economic parameters of the servicing system (AS) to be modelled

	A	B
29	**Economic parameters of MS performance**	
30	**C_m,** price of servicing one demand, in lats, Ls	**8,00**
31	**C_{apk},** costs of servicing one demand, in lats, Ls	**3,00**
32	**C_{gaid},** queuing costs of servicing one demand per unit of time, in lats, Ls	
33	**C_{eksp},** maintenance costs of servicing one device per unit of time, in lats, Ls	**2,00**
34	**C_d,** costs of servicing one device linked with the idle time per unit of time, in lats, Ls	**0,40**
35	**$C^{gaid}_{z(s),t}$,** function of losses due to queuing up in AS in the period of time t, in lats, Ls	
36	**$C^{att}_{z(s),t}$,** function of losses in AS with refusals in the period of time t, in lats, Ls	**8,33**
37	**$C^{jaukt}_{z(s),t}$,** function of losses in mixed AS in the period of time t, in lats, Ls	
38	**P^{att}_0,** lost profit of one not serviced demand, in lats, Ls	**3,56**
39	**I_t**, income from AS performance in the period of time t, in lats, Ls	**15,00**
40	**P_t**, profit from AS performance in the period of time t, in lats, Ls	**6,68**
41	**$P^{att}_{nesan,t}$,** lost profit from AS performance in the period of time t, in lats, Ls	**0,45**

Let us show the possibility to make graphic modelling of changes of some parameters. Let us make a graphic model which characterizes the changes of the parameter **P_t** (profit to be made from **AS** during the period of **t,** in lats) depending on the changes of the parameters **s** un **λ** see Fig. 2).

The analysis of the modelling results testify that there exists relationship of changes of economic parameters (**P_t**) in AS functioning depending on some of the changes of technical parameters of the model **(s, λ)** The results show that there is no necessity to introduce corrections into the system.

Conclusion

Economic modelling allows to obtain a large variety of solutions which should be analysed and only on the basis of such analysis economically viable solution may be made. The result to be achieved during the process of economic modelling may change dynamically alongside with the changes in the parameters entered into the system, thus giving an opportunity for the researcher to observe the behaviour of the real object in the given range of the parameter changes. The economic modelling may be compared with compiling „the road map", where the main roads and other information characterizing the internal and external environment of the system are

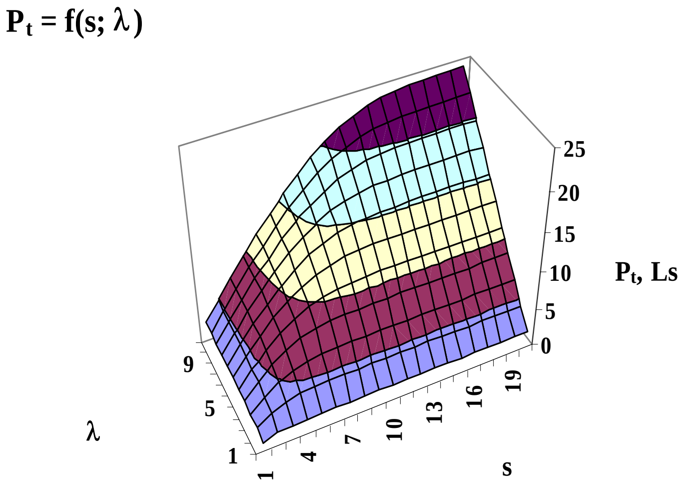

Fig. 2. Graphic model of the function $P_t = f(s, \lambda)$ of the system to be modelled

presented. Having mastered the process of economic modelling and having acquired the skills to analyse the results, students will be able to choose the right way to be used in every specific situation. The modelling process described in this article may be used as a teaching material in different levels of courses, including the beginning level of imitation modelling, for students with previous knowledge in such study subjects as applied mathematics and computer technologies, as well as for a more advanced course in imitating modelling for students with previous knowledge and master programme students. Having acquired this course the students will be able to apply the method of imitating modelling independently for solving economic tasks. The analysis of modelling results testify once again the extremely important role of the specialist (manager) in decision-making under conditions of complicated technical and economic systems. Decision-making on economic purposefullness of increasing the number of AI in AS is justified only taking into consideration the possible changes in the values of the other parameters of the model (system) in the range of the given parameter changes.

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