ORIGINAL ARTICLE

INTERNATIONAL JOURNAL OF ARTIFICIAL INTELLIGENCE

ISSN: 2692-5206, Impact Factor: 12,23
**American Academic publishers, volume 05, issue 03,2025**

Journal: https://www.academicpublishers.org/journals/index.php/ijai

# MODELS OF ECONOMIC PROCESSES: THEORETICAL APPROACHES AND JUSTIFICATIONS

***Chorshanbiyev Anvar***

*Tashkent State University of Economics*

*chorshanbiyevanvar555@gmail.com*

**Annotation:**Modern economic and financial sciences actively use modeling methods as a tool, with the help of which a person can visually imagine the ongoing processes, predict the further development of events and, if necessary, make corrections to the initial parameters to prevent crisis situations. The requirements that parameters and methods of economic process modeling should meet are considered and justified.
**Keywords:**model, economic process, control parameters, controlled parameters, modeling principles, modeling methods.

**Annotatsiya:**Zamonaviy iqtisod va moliya fanlari modellashtirish usullaridan vosita sifatida faol foydalanadi, uning yordamida inson davom etayotgan jarayonlarni vizual tarzda tasavvur qiladi, voqealarning keyingi rivojlanishini bashorat qiladi va kerak bo'lganda inqirozli vaziyatlarning oldini olish uchun dastlabki parametrlarga tuzatishlar kiritadi. Iqtisodiy jarayonlarni modellashtirish parametrlari va usullari javob berishi kerak bo'lgan talablar ko'rib chiqiladi va asoslanadi.
**Kalit so'zlar:**model, iqtisodiy jarayon, boshqaruv parametrlari, boshqariladigan parametrlar, modellashtirish tamoyillari, modellashtirish usullari.

**Аннотация:**Современные экономические и финансовые науки активно используют методы моделирования как инструмент, с помощью которого человек может наглядно представить происходящие процессы, спрогнозировать дальнейшее развитие событий и при необходимости внести коррективы в исходные параметры для предотвращения кризисных ситуаций. Рассмотрены и обоснованы требования, которым должны соответствовать параметры и методы моделирования экономических процессов.
**Ключевые слова:**модель, экономический процесс, параметры управления, контролируемые параметры, принципы моделирования, методы моделирования.

## Main part

Simulation is a powerful tool for studying economics. It allows you to visualize ongoing processes, predict further developments, and, if necessary, make adjustments to the initial parameters to prevent crisis situations. However, an analysis of the scientific and educational literature shows that to date there have been no attempts to systematically generalize the requirements that economic models must meet. Some aspects of this issue were touched upon in the work of Ya. Tinbergen [6]. He noted the observability, predictive power, and completeness

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of economic models, but criticized the overly simplified approach of D.M. Keynes and V.V. Leontiev, later Nobel laureates.

Next, a generalization of the requirements for models is made and their significance for considering economic processes is assessed.

The development of any model is based on a set of specific rules and requirements that its parameters must satisfy. In this regard, it is interesting to consider their generality and develop principles that should serve as a basis for building a model. For example, examples from specific economies are given. However, at the same time, it is hoped that the recommendations given may also be interesting and useful in other areas of scientific activity.

If we refer to the definition of the term “model” given in various sources [3,4,5], it is as follows: a model is a simplified representation of a certain material object or phenomenon, preserving its essential properties. In other words, a model is an object or phenomenon that sufficiently reproduces the properties of the modeled object that are important for specific modeling purposes and omits non-essential properties that may differ from the object. Any model consists of what can be called, in a very general form, parameters and a method of its implementation. In addition, parameters can be controlled and manipulated. Control parameters are the initial data that is set to correct the operating conditions of the model. As a result of the operation of the model, the controlled parameters have certain values, with which both the model itself and the object or phenomenon being studied with its help are evaluated. Thus, the controlled parameters represent the response of the model to the control action (Figure 1).

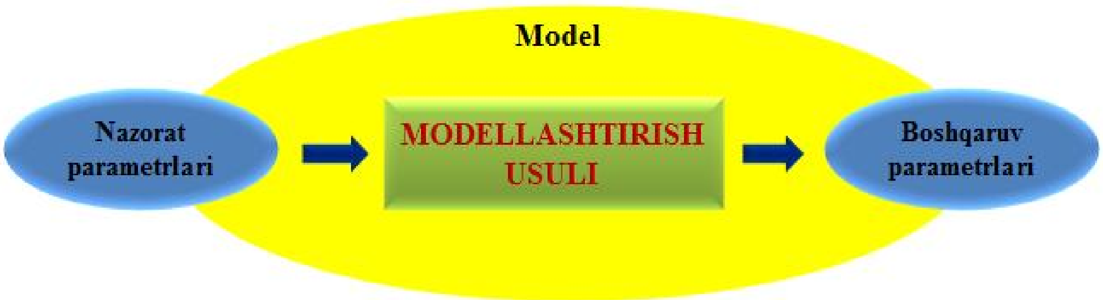


**Figure 1. Model structure and its components**

For example, $PT$ in a two-factor model that relates $P$ sales volume, $H$ number of employees, and their labor productivity, the control parameters $H$ and $PT$ are the $P$ control parameters. In this case, the algebraic expression of the method for implementing the model is:

$$P = HHPT \tag{1}$$

## Analysis and results

Now let's consider the requirements that the components of the model must satisfy. The main requirement that any model must satisfy is the correspondence of the parameters considered in the model to the process under study. This also applies to the control and management parameters. The adequacy of the control parameters is that they must correspond to

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the factors that determine the behavior of the real process and can be changed in one way or another. As for the control parameters, it should be noted that they should correspond to the characteristics of the model, which the observer can control. In this case, the control parameters should allow for simple and natural interpretation and should be observable. For example, consider the mercantilism model, which relates the volume of money in circulation to the value of the mass of goods. In a concentrated form, the mercantilism model can be expressed by equation [2].

$$MV \quad PT \tag{2}$$

where $M$ - the amount of money; $V$ - the number of transactions that change the ownership of money over a certain period of time; $P$ - the average prices of goods; $T$ - the total volume of the mass of goods.

The $T$ volume of the supply of goods is determined by natural factors, and the velocity of circulation of the money supply is determined by the $V$ specific characteristics of the payment system and the financial institutions of the economy. In this case, $M$ and $P$ are proportionally changing parameters when the initial and final states of the economic system are in equilibrium. It is clear that these parameters are observable and correspond to the process under study. It should be noted that each of them can act as a control parameter, and the other parameter is controlled.

The requirement of observability for control parameters is not mandatory. There may be objects or phenomena for which the researcher does not know the set and nature of the influence of the control parameters. In this case, by assigning values to different sets of control parameters, the model response is studied, that is, the behavior of the controlled parameters and comparing them with the actual process. If the model response is adequate to the real process, this is a basis for assuming that the initial set of control parameters and their values are appropriate and consistent with the real impact. An example of such a model is an investment planning model, where the initial parameters are the completion time of an investment project and its final cost, and it is necessary to determine the investment plan for the entire financing period.

The principle of adequacy also applies to the modeling method. This, the chosen modeling method, which describes the influence of control parameters on the observed parameters, must correspond to the real process in terms of the nature of the influence. In this case, the model must respond in such a way that a change in the model's control parameters within reasonable limits should lead to such a change in the control parameters that allows for an explanation that corresponds to the actual behavior of the process. The last rule is closely related to the requirement of internal consistency of the model.

The internal consistency requirement implies that when the control parameters change within limits that correspond to the true values, the changes in the controlled parameters also occur within limits that correspond to the true values. This requirement is satisfied when modeling embedded processes that describe the interaction of model elements. Moreover, the same model with different ranges of change of the variables included in it can be both internally consistent and internally inconsistent. For example, we consider the Malthusian model,

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according to which the population growth rate is proportional to its current size. The differential equation describing this model is:

$$\frac{dx}{dt} = \alpha \quad x \qquad (3)$$

where is $\alpha$ - a certain parameter determined by the difference between the birth rate and the death rate; $x$ - is the population size.

The solution to this equation is in the form of an exponential function of the following form:

$$x(t) = x_0 \quad e^{\alpha t}$$

where is the $x_0$ - initial population size.

Thus solution $\alpha > 0$ increases exponentially. When compared with the real process, it becomes clear that this is true for a small population and a significant amount of natural resources. Obviously, with increasing population, limited natural resources begin to affect it, and over time, the population change deviates from the exponential. In other words, the model does not take into account the effect of limited resources on population growth rates. An improvement of the Malthusian model can be the logistic model, expressed by the Verhulst differential equation:

$$\frac{dx}{dt} = \alpha \quad x \quad 1 - \frac{x}{x} \qquad (4)$$

where is the $x$ - maximum possible population.

The solution to this equation is as follows:

$$x(t) = \frac{x \quad x_0 \quad e^{\alpha t}}{x \quad + x_0 \quad (e^{\alpha t} - 1)}$$

the $x(t)$ graph of the function is shown in Figure 2:

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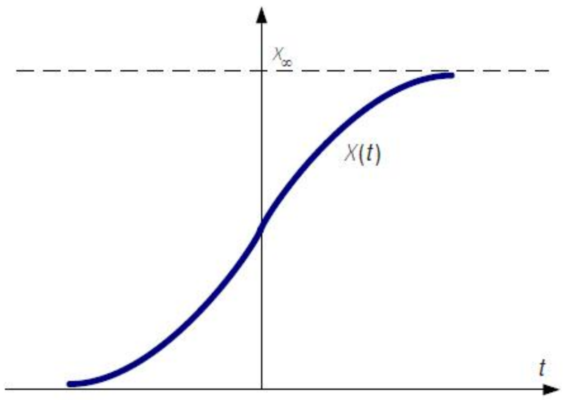


**Figure 2. Population change over time in the logistic model**

When describing complex processes close to crisis situations [1], it turns out to be impossible to fulfill the principle of internal consistency. However, the violation of this principle should not lead to the achievement of any arbitrary value of the controlled parameter. Taking into account the possibility of modeling crisis events, we can give a broader definition of the principle of internal consistency, which reads as follows: “The response of the model to control actions should be adequate to the process being modeled.” In this case, the principle of internal consistency and the principle of model adequacy are practically equivalent.

The model describing the process under study should be sufficient. This principle is based on the fact that, on the one hand, the set of control parameters used in the model ensures the modeling of all the effects of interest to us, and on the other hand, the set of control parameters reflects the processes under study to the necessary extent. However, the model should not be redundant, since in this case the model itself corresponds in complexity to the process under study. This makes it meaningless to use it to study the process of interest to us. In other words, the model should be simple enough that its use facilitates the study of the process under study and allows for the analysis of the results obtained. As the outstanding Soviet theoretical physicist Y.I. Frenkel said: “A good theory of complex systems should represent only a good “caricature” of these systems, exaggerating their most typical features and deliberately ignoring the rest - the insignificant ones.” A vivid example of the combination of the principles of sufficiency and simplicity in building an economic model is Karl Marx’s theory of surplus value.

The functional elements that make up the model should be presented in relationships that reflect the integrity of the process being modeled. This means that the model should not consist of groups of small processes that are not functionally related to each other. If the model is divided into groups of small processes that are not related to each other, then it is necessary to analyze how adequately the model reflects the process being studied. If the principle of adequacy is observed, then it is recommended to divide the model into submodels with several components. In further research, it is necessary to either select the submodel of greatest interest and focus on its study, or to consider the submodels separately and combine the results obtained for each submodel into a single result using some integrated generalizing model. An example of adhering to the principle of integrity is the model of building the infrastructure of the stock exchange market.

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Ensuring the adequacy, integrity and simplicity of the model creates the necessary conditions for the implementation of another principle of the developed model, its effectiveness. Effectiveness is understood as the ability to obtain results using a model that describes the behavior of the object or process under study. In addition, the results obtained from its application must allow for verification, that is, the principle of model verification must be fulfilled. The fulfillment of this principle is achieved by monitoring the controlled parameters. In its most rigorous form, the principle of testability of a model is formulated as the principle of the predictive power of the model. An example of a model with predictive power is the model for assessing the role of the stock exchange in the world economy. This showed in 2003 that economically weak countries will never catch up with strong countries through the processes of financial market globalization alone.

An important part of the model creation process is the method used to model the process under study. Currently, various modeling methods are used. Let us briefly describe the most popular and frequently used methods. The most popular and largest group of modeling methods is the verbal modeling method. With the verbal modeling method, the initial premises, the way the model works, and the results obtained are presented in the form of a story. Until the middle of the 20th century, this modeling method was the main one in economics. Since the second half of the last century, mathematical models have been gaining increasing popularity.

A mathematical model is a mathematical representation of reality, and in life, economic reality. Depending on the process being studied and the tools used, they can be different, that is, its description in the language of a particular branch of mathematics is compared with the process being studied. Conclusions are drawn from the obtained description or a selected system of equations is solved. Then, the actual parameters of the process being studied are compared with the conclusions obtained. If their behavior corresponds to the actual observed results, then the model is considered successful.

The mathematical apparatus used to build the model depends on the process being studied. When modeling the processes or dynamics of system behavior, a differential equation or system of differential equations is used, the graph of which depends on the nature of the processes being described. For example, equation (3) (Malthusian model) is given, and the logistic model (4) determines population growth.

Modeling using probability theory is used in cases where the process under study is fundamentally probabilistic and it is necessary to optimize the parameters of a random process. As an example of an economic model using the probabilistic modeling method, we can cite the method of forming an optimal investment portfolio proposed by G. Markovits, or a model of increasing the efficiency of a business process by forming the optimal composition of its constituent activities.

An algebraic method is used to describe the stationary behavior of the modeled system. Examples of such models include the two-factor model, expressed as (1), which relates the volume of trade, the number of employees and their labor productivity; the mercantilism model, expressed as (2), or the national economic efficiency model.

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The analog modeling method involves the use of processes similar to the process being studied in the model. For example, with this modeling method, we can suggest using electrical circuits to describe the solution of differential equations. In this case, capacitors act as analogs of differentials, inductance properties are integrals, resistances are dissipative elements, and voltage sources are actively acting forces. In this case, the solution to the equation can be seen by observing the voltage change over time on an oscilloscope at the corresponding element of the electrical circuit. Another example of analog modeling is computer modeling of the behavior of competing teams. With this modeling method, the screen area is divided into clusters. Clusters corresponding to one team differ in color from clusters corresponding to another team. The behavior of two competing teams is described as follows: if there are three or more interconnected clusters near a cluster, then this cluster creates a new one, that is, "multiplies". If there are two or fewer interconnected clusters nearby, it "dies". As a result of modeling on a computer monitor, you can observe the dynamics of interaction between competing teams. The analog modeling method is used to study the dynamics of system behavior in cases where it is difficult or simply technically impossible to obtain an exact mathematical solution to a mathematical model.

One of the most popular and frequently used modeling methods is the algorithmic method. Using this method, the modeled process is represented in the form of actions performed in a certain sequence. Moreover, the sequence of actions is determined by the researcher. During the execution of the algorithm, branching cases of the process, that is, decision-making cases, are possible. The decision-making case is modeled by a conditional operator, which, depending on the value of the conditional parameter, directs the process algorithm along one path or another. If the algorithm implementation produces a verifiable result and the verification is confirmed by experience, then this algorithmic model is considered to reflect the real behavior of the simulated process. This modeling method is used for processes that require rational organization of the execution of certain actions or the design of new methods for implementing the process under study. An unexpected example of algorithmic modeling of economic processes is Karl Marx's work "Capital". Although the verbal method is used throughout the work, formulas are used to describe the formation of surplus value:

– to describe the exchange of goods:

$$T - D - T \qquad (5)$$

– to describe the production process:

$$D - T - D \qquad (6)$$

In fact, expressions (5) and (6) represent enlarged blocks of the algorithmic description of the relevant economic processes.

A variation of the algorithmic method is the morphological method. This method was used to construct the optimal organizational structure of a company in which the economic process under study is carried out. With this modeling method, the organization's work process is described as a set of actions. A matrix element is included in the map to describe each action. The set of all elements of the matrix represents the set of all actions performed by the

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organization in implementing the process under study. By counting the number of matrix elements corresponding to the activities of each division of the organization and comparing these indicators for different divisions with each other, it is possible to estimate the relative numerical composition of these divisions.

**Conclusion**

Thus, the requirements that must be met by models describing economic processes are presented in the table.

Some requirements are desirable to follow, and some requirements do not apply to all components of the model (see table). In the future, the authors plan to review economic models known to them and compare them with the previously stated requirements.

**Requirements for parameters and methods of modeling economic processes**

| **Demand** | **Components of the model** | | |
|---|---|---|---|
| | **Parameters** | | **Modeling Method** |
| | **Supervisor** | **Managed** | |
| Adequacy | Necessary | Necessary | Necessary |
| Tracking ability | As much as possible | Necessary | – |
| Internal consistency | Necessary | Necessary | Necessary |
| Success | Necessary | Necessary | Necessary |
| Simplicity | As much as possible | As much as possible | As much as possible |
| Integrity | – | – | As much as possible |
| Efficiency | – | – | Necessary |
| Possibility of verification | – | Necessary | – |
| Predictive power | – | Necessary | – |

**References:**

1. Арнольд В.И. Теория катастроф. М.: URSS. 2008.
2. Блауг М. Экономическая мысль в ретроспективе. М.: Дело Лтд. 1994.
3. Мышкис А.Д. Элементы теории математических моделей. М.: КомКнига. 2007.
4. Самарский А.А., Михайлов А.П. Математическое моделирование. М.: Физматлит. 2001.
5. Советов Б.Я., Яковлев С.А. Моделирование систем: учебник для вузов. М.: Высшая школа. 2001.
6. Тинберген Я. Использование моделей: опыт и перспективы: нобелевские лекции – 100 лет: экономика. Т. 1. М.: МАИК «Наука/Интерпериодика». 2006.
7. Sotvoldiyev A.I., Turdiyev Sh.R. Hayot sifatini baholashning optimal usullari. Ilmiy tadqiqot va innovatsiya jurnali. Toshkent. 2022. 1-tom, 6-son. 31-35 betlar.
8. Sotvoldiyev A.I., Xidirov N.G‘. Dinamik modellarni iqtisodiyotda qo‘llanilishi. Science and education scientific journal. Tashkent. 2022. Vol. 3, No. 3. pp. 1-10.
9. Sotvoldiyev A.I., Yuldashev S.A. Matematik modellashtirish va matematik model qurish

ISSN: 2692-5206, Impact Factor: 12,23
**American Academic publishers, volume 05, issue 03,2025**

Journal: https://www.academicpublishers.org/journals/index.php/ijai

metodlari. Pedagog respublika ilmiy jurnali. Uzbekistan. 2023. 5-son. 44-50 betlar.
10. Sotvoldiyev A.I. Mathematics of economic processes nature and methods of modeling. Science and education scientific journal. Uzbekistan. 2023. Vol. 4, No. 3. pp. 829-835.
11. Sotvoldiyev A.I. Kobb-Duglas ishlab chiqarish funksiyasi haqida. Journal of New Century Innovations. Uzbekistan. 2023. Vol. 34, Issue 1. pp. 102-105.
12. Sotvoldiyev A.I., Kamoldinov S.M. Iqtisodiy masalalarni chiziqli dasturlash masalasiga keltirish va grafik usulda yechish. "PEDAGOGS" international research journal. Uzbekistan. 2023. Vol. 48, Issue 2. pp. 68-77.
13. Sotvoldiyev A.I. Some Economic Applications of Differential Equations. Diversity Research: Journal of Analysis and Trends. Chile. 2023. Vol. 1, Issue 4. pp. 22-27.
14. Sotvoldiyev A.I., Ostonakulov D.I. Mathematical Models in Economics. Spectrum Journal of Innovation, Reforms and Development. Germany. 2023. Vol. 17, pp. 115-119.
15. Sotvoldiyev A.I., Ostonakulov D.I. About Game Theory and Types of Games. Texas Journal of Engineering and Technology. USA. 2023. Vol. 23, pp. 11-13.
16. Sotvoldiyev A.I., Kamoldinov S.M. Iqtisodiy masalalarni chiziqli dasturlash masalasiga keltirish va simpleks usulda yechish. Wire Insights: Journal of Innovation Insights. Chile. 2023. Vol. 1, Issue 7. pp. 14-21.
17. Keunimjaev M.K., Chorshanbiyev A.A., Bebutova Z. Matematikani o`qitishda interaktiv metodik yondashuvlar. Journal of new century innovations. Uzbekistan. 2023. Vol. 42, Issue 1. pp. 277-280.
18. Sotvoldiyev A.I., Chorshanbiyev A. Kvadratik formalar va ularni kanonik ko'rinishga keltirish haqida. "PEDAGOGS" international research journal. Uzbekistan. 2024. Vol. 52, Issue 1. pp. 36-43.