Computer Simulation Model of the Organization at the Stage of Transformation for the Purpose of Adaptation to New Projects

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Abstract

The article is devoted to the topical issue of creating a computer simulation model that allows optimizing the transformation processes of the organization in order to adapt to new projects. The purpose of the article is to increase the efficiency of large organizational structures by creating computer models that, on the one hand, have a sufficient level of adequacy, and on the other hand, have a visual interpretation of the main input parameters, which allows them to be easily determined on the basis of empirical data. In the work, the analysis of existing studies is performed, the relevance of the problem is substantiated. The concept of elementary atomic structural model is introduced, its inputs and outputs are considered. Mixed and hierarchical structural models of the organization are considered. Examples of different levels of the hierarchy of the structural model of the organization, ways of building up hierarchical structural models, as well as ways of transforming mixed models into hierarchical models are considered. The relationship between model errors and its complexity is considered. Recommendations on the level of complexity of the model are provided. Analysis of existing exponential and linear models was performed. Reasoned adequacy of logistic models. Logistic models are defined as the most universal development models that allow modeling development processes in various fields of human activity. The differential form of logistic models is considered. The ordinary differential equation of the logistic model is solved in order to obtain the integral form of the logistic equation. Computer model parameters are introduced that are easily determined numerically based on empirical data. A mathematical model of the useful effect of the organization in the conditions of transformation was created. It establishes the dependence of the useful effect on the input resource (time). The model is created as a combination of several logistic dependencies, each of which is responsible for increasing or decreasing the useful effect. The model takes into account the dependence of the growth of the useful effect for the main and new technologies, the decrease of the useful effect due to the moral obsolescence of the technology, and the gradual decrease of the useful effect due to the directive shutdown of the old technology. The structure of the model allows its scaling to more complex development scenarios. The concept of the degree of insensitivity of the useful effect to small amounts of input resources at the initial stages of the organization's development is introduced. Investigate the dependence of the initial result on the degree of insensitivity. The model is implemented in the MatLab algorithmic language

Keywords

Computer model, simulation model, logistic dependence, useful effect, resource, management decision support, automation, optimization

1. Introduction

Each organization implements its own business processes within the existing organizational structure. In turn, the projects of the organization are usually implemented within the framework of the existing structure of the organization and within the framework of the existing structure of business processes. This is not always the rule. For example, during the implementation of

14th International Scientific and Practical Conference from Programming UkrPROG'2024, May 14-15, 2024, Kyiv, Ukraine

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Enterprise Resource Planning (ERP) systems, it has long been concluded that the successful implementation of an ERP project is possible only on the condition of preliminary study, analysis and correction of the enterprise's business processes, taking into account the limitations and additional capabilities of ERP systems [1]. Some adjustments to business processes entail adjustments to the organizational structure of the enterprise.

It is also common knowledge that in each class of tasks (projects), different organizational structures of the enterprise have different effectiveness. Therefore, the transition to new classes of tasks (projects) may also require a change in the organizational structure of the enterprise. Small projects are usually carried out within the framework of already existing organizational structures. But for the implementation of large projects, based on the scale of financing and possible losses in case of failure, new organizations are often created or organizations that already existed are transformed. The goal of the transformation is to obtain the most effective organizational structure within the framework of a specific large project. Decisions about transformation paths in the latter case are often made based on experience, feeling, inspiration, etc. The larger the scale of the organization and the scale of the project, the more difficult the task will be. A very deep justification of decisions is needed in order to convince the people on whom the financing of transformation and development projects of organizations depends. The problem is aggravated by the fact that the losses of large projects in case of failure are too great. The presence of fierce competition with external organizations and among the organization's insiders does not make the issue any easier. That is why the issue of optimization and justification of decisions regarding the directions and ways of transformation of organizational structures when opening new projects is an urgent task. Accordingly, the urgent task is to create computer models of the transformation of organizations that would be part of software systems for supporting management decisions.

2. Analysis of existing studies

The creation of a computer model should begin with a thorough study of the modeling object, that is, the main types of organizational structures, their development and transformation processes.

The works [2, 3] analyzed the main types of organizational structures: hierarchical, matrix, mixed, project, etc. Disadvantage: there are no numerical estimates and even approaches to creating numerical characteristics of the considered types of organizational structures of enterprises.

General methodological approaches to the selection of the organizational structure of the project, a detailed analysis of the characteristics and options for using possible organizational structures are given in [4]. In [5], in addition, a structured sequence of factors that should be paid attention to when choosing the organizational structure of the project is provided. But, as before, there are no numerical estimates in these works. The way out of the situation should be the creation of models that take into account the dependence of the useful effect of the project depending on the type of project structure

General approaches to building computer models of dynamic processes are considered in [6]. Corresponding numerical methods in [7, 8, 9]. Disadvantage: general approaches do not take into account the specifics of modeling organizational structures, as well as the resources consumed by the organizational structure.

In [1], an approach for analyzing the effectiveness of various organizational structures in the dynamics of development over time is proposed. Disadvantage: abstract structures that do not correlate with standard types of structures were considered: hierarchical, matrix, mixed, etc. [2]. In addition, the possibility of a sudden change in the structure of the project (organization) over time is not taken into account.

Optimization modeling of a sudden change in the structure of a dynamic system was considered in [10]. Disadvantage: as objects of structural changes, dynamic systems were considered using the example of aircraft, the dynamics of which, by their very nature, are significantly different from the dynamics of projects and organizational structures.

Thus, the analysis of existing research revealed a contradiction between the need for a methodical apparatus of decision-making support software systems for the transformation of organizational structures and the absence of a single approach that would guarantee obtaining the best decision for transformation. The main tool for supporting such decisions is computer simulation.

The purpose of the article: to increase the efficiency of large organizational structures through the creation of computer models. These models should have a sufficient level of adequacy to the simulated processes. On the other hand, the models should have a visual interpretation of the main input parameters, which would allow them to be easily determined on the basis of empirical data.

3. Structural and logical model of the organization

Organizational structures are complex large systems. Practical verification of the consequences of management decisions in the real operation of such systems can be risky and cost a lot. Therefore, to forecast the development of such organizations and predict the consequences of certain management decisions, it is appropriate to use simulation modeling. An additional advantage of computer simulation modeling is that it is based on mathematical models that are universal for the development processes of organizations, technologies, projects, etc. The patterns of development of the organization (technology) according to the stages of the life cycle are usually described as the dependence of the useful effect of the organization on the input resources spent on its creation (Figure 1).

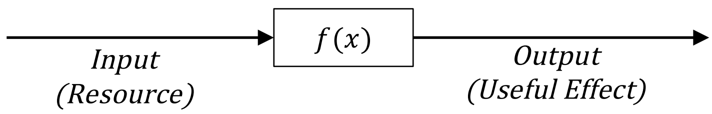


Figure 1: An elementary atomic model of the development of technologies and organizations, as a process of transforming input resources into an output useful effect.

We upload some or a combination of resources (such as materials, money, personnel, information, know-how, reputation, experience, time, etc.) to the input. At the output, we receive a useful effect from the application of technology or from the activities of the organization (for example, income, profit, volume of production, volume of mineral extraction, reputation, experience, level of quality according to various indicators, speed of solving problems, etc.). Some indicators at the input and output are related or coincide completely. This suggests that the output values of one model can be input to another. It can also be argued that the considered model of transformation of input resources into an output useful effect using a certain procedure $f(x)$, can be used as an elementary atomic model from which more complex models can be created.

For example, the general structural and logical model of the organization can be presented in the form of a hierarchy (Figure 2), in the nodes of which there are atomic models of the efficiency of the use of various types of resources (personnel, production equipment, materials) (Figure 1). Atomic models are useful because they are easier to create than creating a detailed model of the entire organization at once. After that, you can increase the complexity of the model, add new levels of the hierarchy, expand the number of atomic models at each level of the hierarchy, etc. Atomic models significantly simplify the creation of complete structural-logical models due to better structuring. And already on the basis of a structural and logical model, we can create a computer simulation model of activity, development or transformation of an organization or technology.

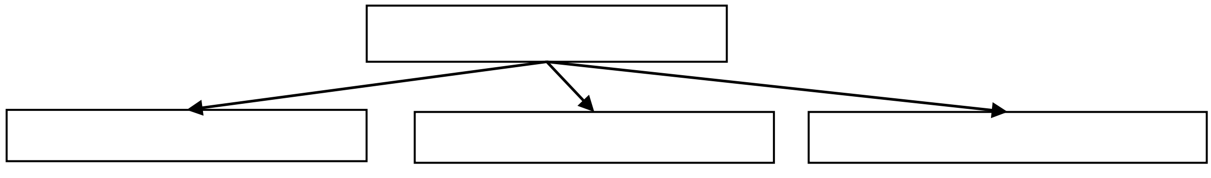


Figure 2: Structural and logical model of the organization: 2 levels

In addition to the hierarchical model (Figure 2), other variants of hierarchical organization models are possible, in which models of the effects of development (activity) of individual units are used as atomic models of the second and subsequent levels. And if we have enough information about the dynamics of the development of subdivisions depending on input resources, then such a model can also be adequate and useful. But, unfortunately, most often the task is precisely to develop a simulation computer model to the level at which the useful effects of units and the organization as a whole are related to the input resources. These relationships should be represented by clear mathematical or algorithmic dependencies that allow full-fledged simulation modeling. The difficulty lies in the fact that in order to implement the last thesis, the complexity of the model has to be increased, in particular by the levels of the hierarchy, both vertically and horizontally (Figure 3).

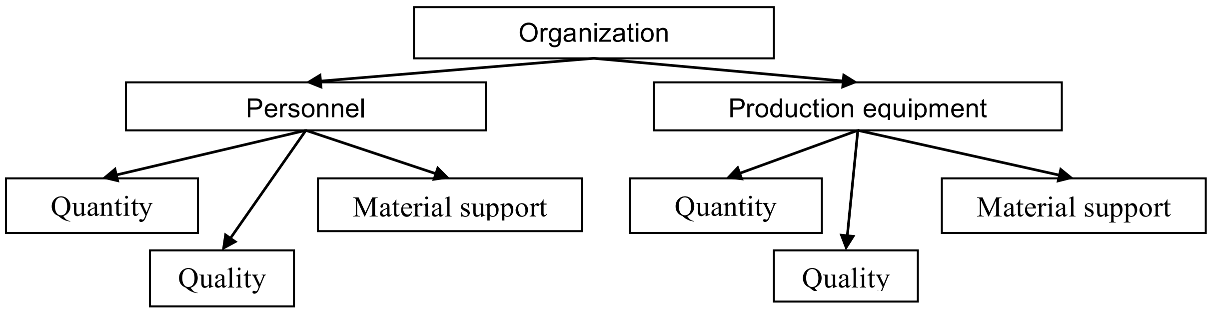
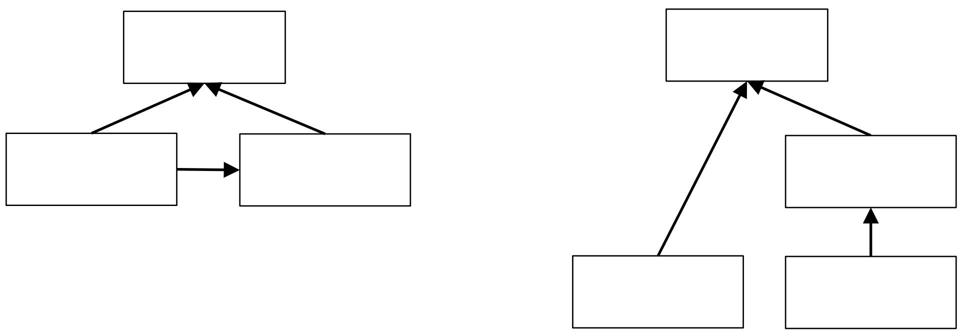


Figure 3: Structural and logical model of the organization: 3 levels.

The approach of using hierarchical models is not ideal because real objects are not often pure hierarchies. More often, they contain additions to the existing links of the hierarchy. For example, a number of horizontal connections can be added at one level (Figure 4a). Or there can be the addition of connections from the higher levels of one branch to the lower levels of another branch of the hierarchy (Figure 5a), like the well-known "thick tree" topology of telecommunication networks. Such structures, in contrast to purely hierarchical ones, will be called mixed. But the authors' research showed that almost any mixed architecture (except for the one with cyclic sections) can be transformed into a purely hierarchical structure. At the same time, the primary mixed and transformed to a hierarchical structure will be identical from the point of view of the regularities that connect the inputs and outputs of these models (Figure 4b, Figure 5b).



a) b)

Figure 4: Transformation of a mixed model with horizontal connections a) to a hierarchical model b) by increasing the depth of the hierarchy.

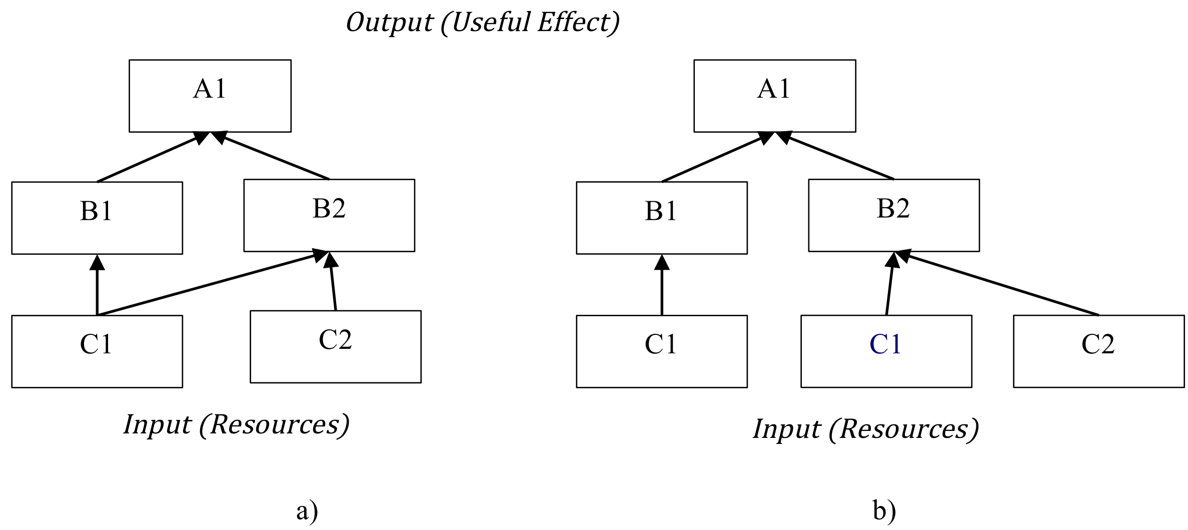


Figure 5: Transformation of a mixed model of the "thick tree" type a) to a hierarchical model b) by horizontal expansion at certain levels of the hierarchy.

The appearance of mixed models is often the result of trying to take into account as many influencing factors as possible (in this case, internal). But excessive model complexity also reduces accuracy. Works [11] show that the dependence of the square of the error on the complexity of the model has the form of a parabola (Figure 6). That is, with a model that is too simple, the error is large because many important influencing factors are not taken into account. And with an overly complex model, errors increase because:

1. It is difficult to provide a complex model with representative input data.
2. Calculation errors are increasing.
3. Secondary factors receive an influence that is commensurate with the influence of the main factors.

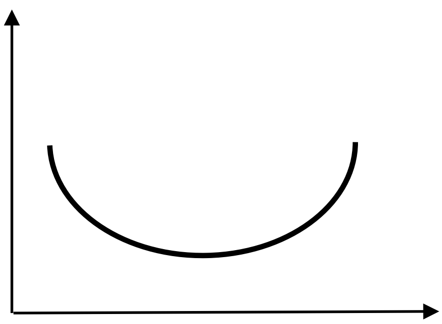


Figure 6: Dependence of the modeling error on the complexity of the model.

Thus, for any model there is an optimal level of complexity at which modeling errors are minimal. It is easy to implement when the complexity is ensured, for example, by increasing the order of polynomials of the model [12]. But things become much more complicated when the complexity of the model is ensured by the choice of the depth of model detail, in particular the detail hierarchy. The depth of detailing of the hierarchy depends on the set of influencing factors that are representative of the process under study. To create an adequate model, it is necessary to select a representative set of factors that will be taken into account. For this, it is always necessary to implement at least the following points of the system approach:

Identification of influencing factors.

1. Building a rating of influencing factors.
2. Discarding secondary factors that have a minor impact on the processes being modeled.
3. Numerical assessment of influencing factors and their importance.

Depending on the specifics of the problem formulation, points 3 and 4 may change places. That is, the rejection of secondary factors can occur not only on the basis of expert assessments, but also on the basis of objective numerical indicators that are calculated.

Since any model is created in order to improve the management of certain processes, the issue of optimizing this management may arise. In this case, it is necessary to formulate quality criteria, according to which optimization will be carried out. In a significant number of cases, certain initial values of the model can be directly taken as quality criteria. In other cases, aggregated indicators, which are a combination of initial values, may appear as quality criteria. Aggregated indicators can be abstract, or they can have a specific physical meaning that was not taken into account when creating the model. In the latter case, the question arises of expanding the model to a state in which physically understandable aggregated indicators will be calculated in certain blocks of the model. In this case, the model will become completer and more adequate.

Modern processes of managing complex objects are based on well-known, so-called best practices. In most cases, all the factors on the surface have already been taken into account. Therefore, in order to obtain competitive advantages, the organization has to take into account an increasing number of factors that were not taken into account before. For example, with regard to personnel (Figure 7), the great potential of such factors is in the humanitarian sphere and requires evaluation of not only objective, but also subjective indicators: morale, psychological type, emotional intelligence, etc.

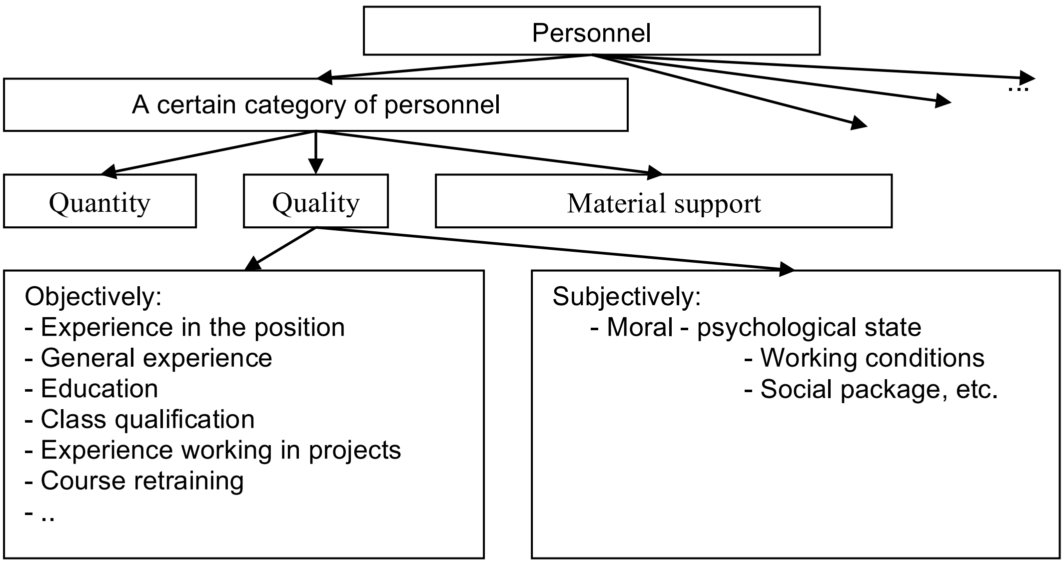


Figure 7: Structural and logical model of the organization: Personnel - 4 levels.

The problem is that models from the humanitarian sphere are very difficult to mathematical formalization. Therefore, it is important to choose atomic models that are equally effective in simulating processes in technical, economic, and social fields. The analysis of existing research showed that logistic models are one of the most adequate models that can be equally successfully applied in various fields of human activity.

4. Logistic models of development

Let's start with simpler models. In the conditions of the absence of restrictions on the technologies used by the organization, the dependence of the useful effect on the spent resources most often has the character of an exponent in the growth zone [1] (for example, the growth of money placed on deposit or Moore's law - the growth of computing power). If the technology has development limitations: due to limitations of the technology itself, limitations of production scaling, limitations regarding accompanying input resources (for example, personnel), regulatory limitations, etc., then the regularity of development often also has the character of an exponent, but now it is already in the saturation zone, that is, approaching the asymptote, to which the development process approaches from below. In general, part of the life cycle of development consists of the stage of exponential growth and the stage of exponential entry into the saturation zone. The transition between these two exponents is almost linear. To emphasize this property, sometimes a separate section of linear development is added between the exponents, when the useful effect on the output is strictly proportional to the amount of input resources. As mentioned above, inputs can be materials, finances, personnel, intellectual property, image, etc. That is, the input resource can be anything that can be turned into a useful effect.

If not limited to only one stage of the life cycle, researchers usually try to use more generalized laws that cover both the stage of exponential growth and the stage of exponential saturation. In this case, S-shaped dependencies are used, the most adequate, among which is considered logistic dependence [1] (Figure 8). This dependence lies between two asymptotes and has the property of central symmetry.

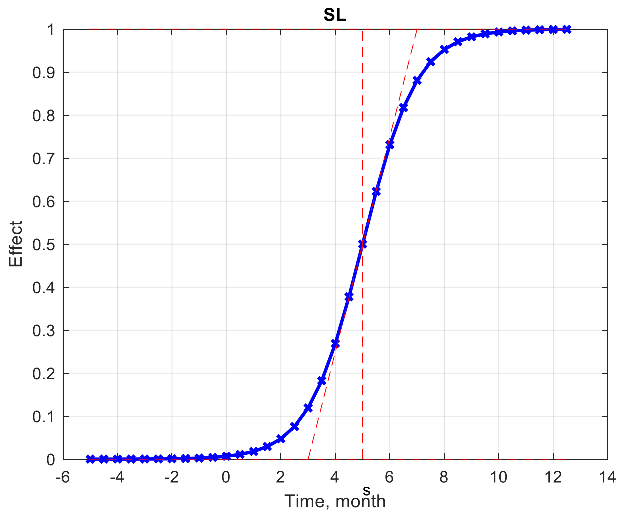


Figure 8: Logistic dependence of the useful effect of business (organization) depending on the cost of the time resource.

Logistic dependence in differential form

$$\frac{dy}{dt} = m\,(y - Y_{min})(Y_{max} - y) \tag{1}$$

has a clear physical interpretation. The left side of the equation $\frac{dy}{dt}$ corresponds to the growth rate of the useful effect y. The input resource is selected as a free variable. In our case, it is time t.

In the equation, there are two asymptotes Y_{min} and Y_{max}, which are located parallel to the abscissa axis. The logistic dependence increases from the lower asymptote Y_{min} to the upper asymptote Y_{max}. The growth rate of y is proportional to the product of the distances y from the lower $(y - Y_{min})$ and upper $(Y_{max} - y)$ asymptotes. The scale of speed and, accordingly, the angle of inclination of the logistic curve at the point of symmetry is determined by the coefficient m.

If the coefficients m, Y_{min}, Y_{max} do not change with respect to the free variable (time), then the ordinary differential equation that specifies the logistic dependence has analytical solutions. To do this, we will separate the variables, that is, we will place all the elements with the free variable t to the right of the equal sign, and we will place all the elements with the useful effect variable y to the left.

$$\frac{dy}{(y - Y_{min})(Y_{max} - y)} = m\,dt. \tag{2}$$

Let's transform the expression so that tabular integrals can be used

$$\frac{d(y - Y_{min})}{y - Y_{min}} - \frac{d(Y_{max} - y)}{Y_{max} - y} = m\,(Y_{max} - Y_{min})\,dt. \tag{3}$$

Integrate

$$\ln(y - Y_{min}) - \ln(Y_{max} - y) = m\,(Y_{max} - Y_{min})\,t + c. \tag{4}$$

Convert to a more convenient look

$$\ln\frac{(y - Y_{min})}{(Y_{max} - y)} = m\,(Y_{max} - Y_{min})\,t + c. \tag{5}$$

Find the exponent of both parts and write down the expression for the useful effect

$$y = \frac{Y_{max} + e^{-(m\,(Y_{max} - Y_{min})\,t + c)}}{1 + e^{-(m\,(Y_{max} - Y_{min})\,t + c)}} = Y_{min} + \frac{Y_{max} - Y_{min}}{1 + e^{-(m\,(Y_{max} - Y_{min})\,t + c)}}. \tag{6}$$

Write the constant integration through already known constants

$$\mathrm{c} = -(m\,(Y_{max} - Y_{min})\,\Delta t). \tag{7}$$

Here, Δt is the shift of the symmetry point along the abscissa axis. After substitution, we get the expression for logistic dependence in integral form

$$y = Y_{min} + \frac{Y_{max} - Y_{min}}{1 + e^{-(m\,(Y_{max} - Y_{min})(\,t - \Delta t))}}. \tag{8}$$

In the future, we will use the generalized notation for part of the expression

$$SL_0(t - \Delta t) = \frac{1}{1 + e^{-(m\,(Y_{max} - Y_{min})(\,t - \Delta t))}}, \tag{9}$$

which corresponds to the so-called SL-function [1]. The SL-function can be considered a normalized logistic dependence that increases between asymptotes from 0 to 1.

Let's pay attention to the fact that the logistic dependence in the integral form also contains many physically understandable components. But some of them are not quite convenient to find on the basis of empirical data. Let's introduce additional notations:

a - upper asymptote,
d - lower asymptote,
s - the abscissa of the point of symmetry,
T - a logistic dependence constant.

The first three coefficients are only marked more succinctly. But the introduced additional coefficient T significantly simplifies the calculation of the angle of inclination of the logistic dependence at the point of symmetry. The coefficient T is equal to the lengths of the segments of both asymptotes, that cut the perpendicular to the abscissa axis at the point of symmetry and the tangent to the logistic curve at the point of symmetry. It is clear that under the condition of central symmetry of the logistic curve, the lengths of these segments of both asymptotes are the same (Figure 8).

This formalization of the integral form of recording logistic dependence significantly simplifies finding the numerical values of the coefficients for the computer model of the organization's development based on logistic dependence.

5. A computer model of the dynamics of the organization's development in conditions of transformation

We will use logistic dependencies to build a general model of the development of the organization at all stages of the life cycle: as at the stages of growth of the useful effect of the organization

$$y = d + (a - d) \cdot SL_0(t - s), \tag{10}$$

as well as at the stages of falling of the useful effect of the organization

$$y = d - (a - d) \cdot SL_0(t - s). \tag{11}$$

In the second case, the logistic dependence is constructed with a negative value of the amplitude $(a - d)$.

In expanded form, the logistic dependence of the useful effect y on time t has the form

$$y = SL(t) = d + \frac{a - d}{1 + e^{-\frac{2}{T}(t-s)}}. \tag{12}$$

The resulting useful effect of the organization's activity at any part of the life cycle (at any time t of the life cycle) is found as the sum of various logistic components with positive and negative signs.

$$SL_{\Sigma}(t) = SL_{+}(t) + SL_{-}(t) + SL_{1-}(t) + SL_2(t), \tag{13}$$

where

$SL_{+}(t)$ - the dependence of the growth of the basic technology.

$SL_{-}(t)$ - the dependence of the decline of the basic technology due to depreciation and moral obsolescence.

$SL_{1-}(t)$ - the dependence of the decline of the basic technology as a result of the management decision to stop it to replace it with a more progressive one.

$SL_2(t)$ - the dependence of the growth of new technology.

In this case, the argument of all dependencies is time t. Although in other cases, any other input resource or a combination of different resources (material, financial, human, etc.) can be used as an argument for the logistic dependence of the useful effect.

The general picture of the life cycle in the form of the dependence of the useful effect on the input resource contains stages of growth of the useful effect, stages of decline, stages of repeated growth after transformations aimed at eliminating the effects of moral obsolescence of the technologies used by the organization. The moral obsolescence of technologies can be associated with the appearance of new, more progressive technologies, with the actions of competitors, with the effect of consumers getting used to certain technologies and the corresponding loss of interest, etc.

Computer simulation of the life cycle of the organization was performed for different initial conditions and for different parameters of development dependencies. The main modeling scenario included the growth of the useful effect of the organization after the introduction of certain innovative technologies, the stage of saturation (the exit of the technology to the maximum of its possible development), the fall of the useful effect due to moral aging, transformations regarding the change of technology to a more progressive, repeated stage of saturation, a repeated drop in the useful effect. More complex development scenarios in this model can also be implemented in a similar way. The mathematical model was implemented in the form of a simulation model in the MatLab algorithmic language. An example of simulation results is shown in Figure 9.

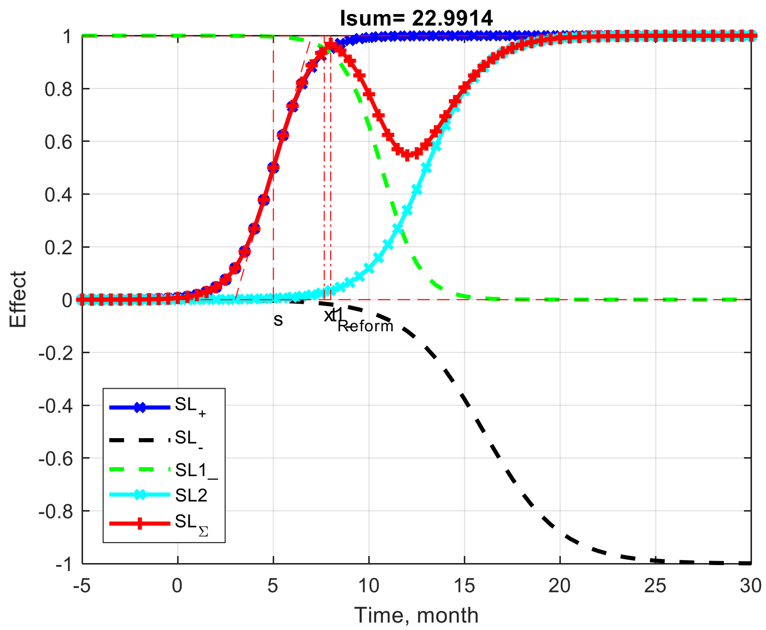


Figure 9: Constituent and resulting dependence of the useful effect of business depending on the expenditure of the time resource.

As we can see, at the first stage of the growth of the effect, the dependence almost does not differ from the usual logistic curve, since the main component of the development of the basic technology $SL_+(t)$ has the largest values. But already at this stage, the negative logistic dependence of moral aging $SL_-(t)$ technology is working, although its influence is still not very noticeable. In a certain period of time, this leads to a local decrease in the resulting effect. This decline could last almost to zero, but at a certain point in time, the transformation of the organization begins, which also implies a change in technology to more advanced ones. That is, the new technology $SL_2(t)$ starts working, but at the same time the old technology $SL_+(t)$ is turned off in a directive manner. At the software level, this is implemented by adding the same value, but with a negative sign $SL_{1-}(t) = -SL_+(t)$. As a result, the influence of the old technology is excluded $SL_+(t) + SL_{1-}(t) = 0$.

The depth of the drop in the useful effect due to the moral obsolescence of the technology depends on the time of the beginning of the transformation of the organization t_{Reform} (transition to a new technology). With the help of simulation, you can choose the moment of time $t_{Reform} \in [t_0, t_1]$, which will ensure the smallest drop in the useful effect

$$I_1 = \max_{t_{Reform}} \min_{t} SL_\Sigma(t) \quad (14)$$

or the largest total useful effect during the period of operation $[t_0, t_1]$ under the conditions of transformation.

$$I_2 = \max_{t_{Reform}} \left\{ \int_{t_0}^{t_1} SL_\Sigma(t)\, dt \right\}. \quad (15)$$

6. A study of insensitivity to small inputs

The initial periods of growth in the first stages of the life cycle have very slow growth. At the same time, the reaction of the system to small amounts of input resources is almost the same as to zero. For example, if there is an investment in the development of software production at the level of 100 or 1000 dollars, then the output effect will be the same as for 0 dollars. To ensure at least some noticeable useful effect at the level of the organization, the initial investment should be at the level of several thousand or tens of thousands of dollars. This minimum investment will be different for each type of technology. Similarly, spending time at the level of several hours or days, most likely, will not bring a noticeable useful effect either. That is, there is a certain kind of insensitivity of the system to small costs of input resources (financial, material, personnel, time). To study the impact of insensitivity to small input values of resources, we will introduce the concept of insensitivity, which will be measured as a percentage of the maximum possible useful effect. That is, in fact, we will analyze not the value of the input resource, but the value of the useful effect $SL_{\Sigma}(t)$ to which it should lead. In the first stage of initial growth $SL_{+}(t)$ can be used instead of $SL_{\Sigma}(t)$.

For example, the insensitivity of the system is defined at the level of Insensitivity = 0.1, and the maximum possible value of the useful effect is equal to $y_{max} = a$. To simplify the interpretation of the result, $y_{min} = d = 0$ was taken.

If for a certain input time resource, the useful effect is equal to $SL_{\Sigma}(t) = 0.05\, y_{max}$, then the initial value of the useful effect is taken to be equal to $SL_{\Sigma}(t) = 0$.

If for a certain input time resource, the useful effect is equal to $SL_{\Sigma}(t) = 0.2\, y_{max}$, then the initial value of the useful effect is taken to be equal to $SL_{\Sigma}(t) = 0.2\, y_{max}$.

Research on the dependence of the integral useful effect

$$Effect = \int_{t_0}^{t_1} SL_{\Sigma}(t)\, dt \qquad (16)$$

from the amount of insensitivity to small input resources Sensitivity for the entire period of transformations $[t_0, t_1]$ showed (Figure 10), that for Insensitivity = [0,0.5] the initial useful effect almost does not change (it changes by no more than 4%). For setting development tasks at the strategic level, errors are assumed at the level of 10-20% without a significant loss of the quality of management decisions [1]. Therefore, a change in the useful effect at the level of 4% can be considered equal to zero.

In the range of values of Insensitivity = [0.5,0.9], the change in the useful effect is very noticeable and almost linearly decreases by 30%. The last 70% of changes in the useful effect of the system occur in the range of Insensitivity = [0.9,1]. Most real projects correspond to the range of Insensitivity = [0,0.5]. Very rarely, the development of projects can take place in the range of Insensitivity = [0.5,0.9]. And almost never occurs in the range Insensitivity = [0.9,1].

Let's pay attention to the fact that the simulation results shown in Figure 9 correspond to the indicator of Insensitivity = 0.

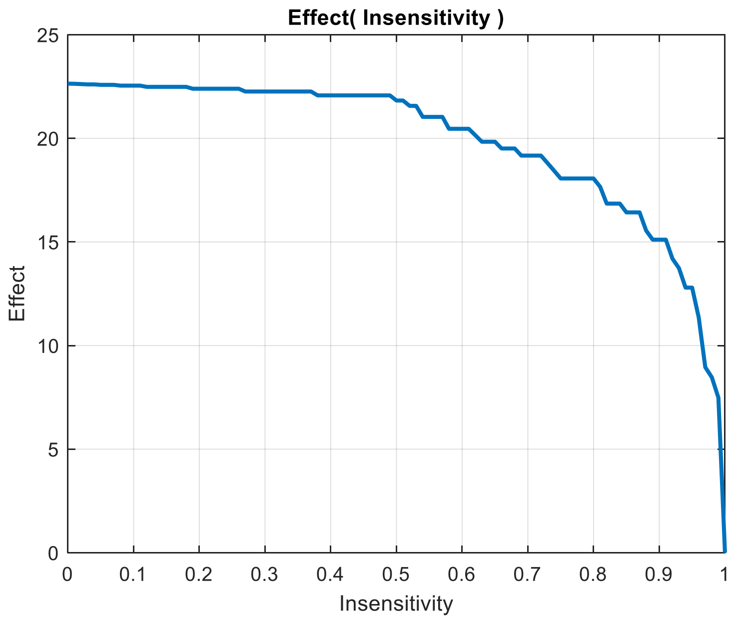


Figure 10: Dependence of the integral effect over a period of time on the level of insensitivity of the system goal of development to small levels of the initial useful effect

7. Conclusions

The paper examines the main approaches to creating a computer model of the organization's development in conditions of transformation of its structure (technological changes). The model is intended for forecasting the development of the organization and finding optimal solutions for the beginning of the transformation period.

It was found that computer models based on logistic dependencies are the most adequate for the adopted formulation of the problem. Such models make it easy to find numerical values of parameters based on empirical data.

The model as part of the management decision support software system allows to predict the consequences of various management decisions in order to choose the best one.

The paper uses the criterion of maximizing the lowest level of the organization's useful effect over the entire forecasting period. The integral criterion of the total useful effect that the organization will receive in the event of the implementation of a specific transformation scenario is also used.

The computer model is implemented in the MatLab algorithmic language.

Directions for further research: improvement of the model by expanding the list of factors taken into account during modeling.

8. References

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