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Modeling the implementation of investment projects with energy-saving orientation

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Abstract. One of the main ways to shape the competitiveness of an enterprise is to reduce production costs. A significant component of such costs are the costs of energy consumption. Therefore, the ability to control energy saving in the economic activity of the enterprise is a task of great importance. The development of energy-saving technologies, which are low-cost for this type of resource of energy-consuming machine systems, is conducted, as a rule, on a project basis, and the implementation of such projects must be carried out according to certain rules. An important principle is the need to determine the rational volumes of all types of resources attracted to the project. The solution to this problem is very difficult and time consuming. The use of economic and mathematical models of various classes can help reducing the risks and complexity of solving the problem. One of the promising types of design modeling of the development of both energy producing and energy consuming enterprises is S-modeling or modeling based on logistic dynamics. Today, undeservedly little attention is paid to this type of model. The proposed article presents methodological developments that can increase the interest in using this type of modeling in practice. Methods and models proposed in the work were tested on a really implemented project of organizational development, which increases their value.

1 Introduction

The conditions of operations in modern economy are characterized by very high dynamics. Everything changes: products (design, functional content, construction, etc.); technologies (production method, materials, energy consumption and energy saving ... Today it is one of the most variable production factors); forms and methods of organizing production (based on the use of new automated and automatic machine systems, a single type of production becomes as economically justified as the mass type); methods and tools for motivating the personnel of enterprises to efficient production activities (replacement of motivation mechanisms oriented towards the collective with mechanisms of individual influence ...), etc. The increasing weight for management decisions related to the development of an organization is acquired by the issues of energy management, energy saving, energy efficiency. It is obvious that in such conditions management decision-making by the organization's management becomes an ever more conditional, complex, uncomfortable for a manager. If the problems of

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the strategic definition of further development of the organization are solved, which by definition have a high degree of uncertainty, then the whole complexity of the problems to be solved becomes clear, and the uncertainty of the conditions in which they are solved. It is clear that management of the enterprises and the scientific community are taking certain steps to develop tools that can reduce the influence of environmental factors when making management decisions [6]. One of these tools, of course, is the forecasting function, implemented in the organization as a permanent management function. However, in the performance of this function, expert assessments alone, which carry a powerful subjective charge, are not enough today. A system of advanced modeling of various processes in the economic activity of an enterprise is required. Only then can we hope for fairly accurate estimates obtained in real time. It is modeling that is able to provide new, more accurate information that complements the picture of the organization's world, its internal features and individual characteristics.

2 Materials and Methods

We have attempted to substantiate the use of methodological developments based on S-modeling, which, in our opinion, provide a significant amount of useful information for making management decisions on the effective implementation of enterprise development investment projects related to reducing energy consumption in a high price environment for energy, electricity tariffs, etc. [5-8]. Theoretical methodological developments are verified on empirical data of the implemented project.

It is known that a rational amount of investment in the implementation of energy saving projects of an industrial enterprise must lie within a certain range of enterprise capabilities and has limitations both from below and from above [6,13-14]. The boundaries of this interval are determined on theoretical models quite simply. What can not be said about the real implementation of these results in the practice of the economic activities of the organization under study.

So, it is known that the return on investment in the project can be described with the involvement of S-curves or logistic dependencies [9, 11,12]. The classical notation of such a dependence is the Ferhulst model (see formula 1) [11].

$$Y = C + \frac{A}{1+10^{a-b*x}} \tag{1}$$

, where Y - value of the investigated function (in the conditions of the problem being solved - return on investment);

x - factor with respect to which the behavior of the function is investigated (in our case, the amount of investment in the project implementation);

A - distance between the upper and lower asymptotes;

C - characterizes the lower asymptote, i.e. the lower bound of the function from which its research begins;

a, b - coefficients that determine the slope, bend and inflection points on the model graph.

Graphic display of the model is shown in Fig.1.

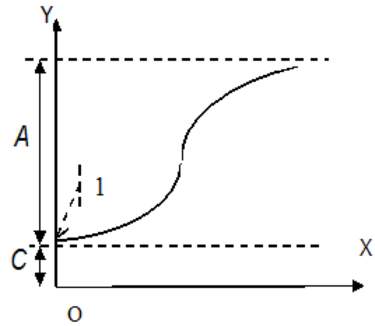

Fig. 1. S-curve corresponding to the Ferhulst equation

As follows from Fig. 1, the beginning of the S-curve is determined by point 1, which is not quite usual for a researcher. It would be desirable, and sometimes it is necessary, that the S-curve leaves the origin of coordinates. In order to obtain a logistician formula coming from the origin, it is necessary to determine the value of C from the condition Y = 0 for x = 0. It is parameter C that determines the shift of the curve along the ordinate axis (vertically) and can be selected in the way that the curve passes through the origin.

Then, perform the consecutive transformations of the Ferhulst function (or logisticians) with the value x = 0,

After that,

$$Y = C + \frac{A}{1+10^{a}} = 0, \;\; \mathrm{C} = -\frac{A}{1+10^{a}} \tag{2}$$

Substitution of the parameter C into the Verhulst formula will lead the function to the following form (3). Let's call it a modified model of logistic dynamics.

$$Y = -\frac{A}{1+10^{a}} + \frac{A}{1+10^{a}} = \frac{A*10^{a}}{1+10^{a}}\left(\frac{1-10^{-bx}}{1+10^{a-bx}}\right) \tag{3}$$

In studies of the real process of return on investment, it is necessary to carry out the selection of the constants included in the Verhulst model, namely A, C, a, and b [10].

The resulting model adequately describes the process of return on investment in an organizational development project. At the same time, the volume of investments in the development of an enterprise is deposited along the abscissa, and the return on investment is along the y-axis.

If a straight line drawn at an angle of 45^{0} from the origin of coordinates is superimposed on the obtained S-curve, then several interesting points are defined that are formed by the intersection of the proposed lines. Of course, in the information plan the most interesting (.) 1 and (.) 2 (Fig. 2). These points characterize the equality of the volume of funds invested in the development of the company and their return as a result of economic activity [13].

In addition, it becomes obvious the answer to the question about the rational volume of investments in the ongoing project of development of energy systems of the enterprise, this volume is limited to the bottom by I1, and from above by I2. Only such investments will be returned to the investor [6]. If the amount of invested funds is less than I1 or more than I2, their return is not guaranteed (see Fig. 2). In addition, the ability to determine the optimal investment amount, which in the models (Fig. 2) corresponds to the value I3, and can be calculated as the value concluded between the S-curve and the straight line in the interval I1 - I2 has maximum possible value.

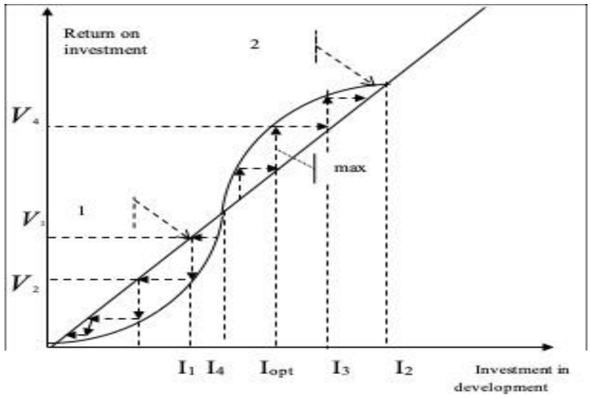

Fig. 2. S-model of possible development options of managed object

Thus, application of logistic dynamics models in modeling organizational development processes allows solving problems. Namely:

1. make a quantitative assessment of the boundaries of the interval of rational inv
2. estment in the engineering project of organizational development;
3. determine the amount of investment, i.e. ensuring maximum profitability of funds raised in the project.3. to determine the magnitude of the greatest losses that the company may incur as a result of an ill-considered investment policy, as well as the maximum amount of income that a firm will receive if the investment policy is correctly chosen;
4. to evaluate quantitatively the second break-even point when implementing an investment project in a given company.

The first task is solved by forming a system of equations (4) describing an S-curve and a straight line constructed from the origin with a slope of 45 degree to the coordinate axes, and its further mathematical solution.

$$\begin{cases} Y = \dfrac{A * 10^{a}}{1 + 10^{a}}\left(\dfrac{1 - 10^{-bx}}{1 + 10^{a-bx}}\right) \\ Y = x \end{cases} \tag{4}$$

Unfortunately, the implementation of this approach is hampered by the transcendence of the Verhulst equation [14]. The solution can be obtained based on empirical data on the development project implemented by the company. The hypothesis is that the shape of the S-curve is largely determined by the characteristics of the organization and is relatively stable. Such calculations were carried out by us on the data on a real construction project. Given the universal nature of the proposed tools, this approach is quite acceptable and useful. The project involved the construction of a cottage settlement in the Leningrad Region with the subsequent delivery of houses for long-term rent. This project is called Timeshare - project and the service itself is called Timesharing (by analogy with Car-sharing, renting a car). The lease term is limited to 30 years. The financial goals of the project are focused on obtaining in one year the level of employment at home up to 90%, while revenue should be at least 300 million rubles. The unit of the product is characterized by the week of renting the house. Part of the information contained in the business plan of the project, as well as the results of calculations in the Excel software environment is presented in Table 1.

Graphic display of the results of calculations in the coordinates of "The volume of investments - Return on investments" is presented in fig.3.

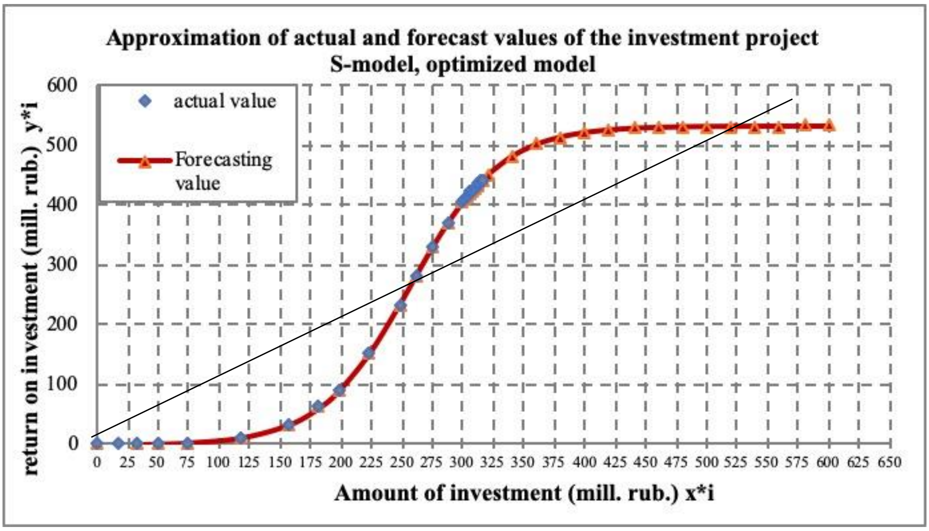

Fig. 3. Approximation of actual and forecast values of the investment project S-model, optimized model

Table 1. Initial and forecast values of the S-shaped model of an investment project

Sequence number of measurment i	Baseline values (rub.)		Converted values (mill. rub.)		Predicted values (mill. rub.)
	Size of investment x_i	return on investment y_i	Size of investment $x'_i = \frac{x_i}{M}$	Return on investment $y'_i = \frac{x_i}{M}$	Return on investment $Y = \frac{A * 10^a}{1 + 10^a}\left(\frac{1 - 10^{-bx}}{1 + 10^{a-bx}}\right)$
1	0	0	0.00001	0,00001	$1.39265 \cdot 10^{-7}$
2	16551294.93	290614.42	16.55129493	0.290614424	0.290508876
3	33102589.87	744464.88	33.10258987	0.744464883	0.744211552
4	49653884.8	1452683.23	49.6538848	1.452683239	1.452225993
5	73756367.24	3246953.69	73.75636724	3.246953694	3.246066016
6	117945427.4	11703228,32	117.9454274	11.70322832	11.70103207
7	157566995.2	33626303.71	157.5669952	33.62630371	33.62274154
8	181803390.2	61529680.85	181.8033902	61.52968085	61.52607789
9	198258535.2	90351376.74	198,2585352	90.35137674	90.34862959
10	223525837.7	153629268.7	223.5258377	153.6292687	153.6294387
11	247893140.3	234110086.7	247.8931403	234.1100867	234.113029

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12	261472942.8	282891486.3	261.4729428	282.8914863	282.8944109
13	274602745.3	329059650.2	274,6027453	329.0596502	329.0607583
14	287282547,8	370198836	287.2825478	370.198836	370.1964474
15	299512350.4	405064688.8	299.5123504	405.0646888	405.0576395
16	301179652.9	409401644.3	301.1796529	409.4016443	409.3938905
17	302846955.4	413635183.1	302.8469554	413.6351831	413.6267127
18	304514257.9	417764819.5	304.5142579	417.7648195	417.,755622
19	306181560.5	421790297	306.1815605	421.790297	421.7803634
20	307848863	425711577.8	307.848863	425.7115778	425.7009003
21	309516165.5	429528831.6	309.5161655	429.5288316	429.5174042
22	311183468	433242425.1	311.183468	433.2424251	433.2302429
23	312850770.6	436852909.5	312.8507706	436.8529095	436..839969
24	314518073.1	440361009.2	314.5180731	440.3610092	440.3473085
25	316185375.6	443767610.1	316.1853756	443.7676101	443.7531482
26	320000000	-	320		451.1694228
27	340000000		340		482.1522765
28	360000000		360		502.2412113
29	380000000		380		514.7334109
30	400000000		400		522.3007528
31	420000000		420		526.7926184
32	440000000		440		529.4763625
33	460000000		460		531.0407176
34	480000000		480		531.9562547
35	500000000		500		532.4910315
36	520000000		520		532.8030468
37	540000000		540		532.9849714
38	560000000		560		533.0910039
39	580000000		580		533.1527898
40	600000000		600		533,1887881
min.	-	-	0.00001	0,00001	
max.	-	-	316.1853756	443.7676101	

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The accuracy of the calculated data when using the model turned out to be very high (see Table 2).

Table 2. Estimated characteristics

Name of the calculated characteristics (unit)	Value
The sum of the squares of the difference between the predicted and actual values of return on investment $S_i(y'_i - y^{\sim}_i)^2$	0.00138543
Coefficient of determination R^2	0.999999998

As a result of the use of the constructed logistic model, the characteristics of a rational investment process were obtained, summarized in Table 3.

Table 3. Optimized features

Optimaized charachter-isitc name		Initial value v^0	Optimal value v	Forecasting value return on investment $y^{\sim}$	The difference in return on investment and their volume $y^{\sim}-v$	The square of the difference in return on investment and their volume $(y^{\sim}-v)^2$
approximatoin coefficient	Scale coefficient A	7625.4801	533.75	-	-	-
	Form coefficient a	1.1901572	3.0143343	-	-	-
	Form coefficient b	0.001	0.01173434	-	-	-
Value of rational investment (mill.rub.)	max. x^{max}_{ef}	500	532.931538	532.931538	-	3.15592E-14
	min. x^{max}_{ef}	250	241.622033	241.622033	-	0
The most profitable amount of investment x^{max+} (mill. rub.)		375	349.885338	493.229383	143.344045	-
Least profitable investment x^{max-} (mill. rub.)		125	163.87768	39.4937163	-124.38396	-

Appliactoin of models of logistic dynamics in the process of studying the behavior of the object of modeling with the variation of input parameters will provide a significant amount of additional information for making management decisions, improve the efficiency of the use of limited resources of the organization.

3 Results

A modified practical model for the implementation of an investment project has been built on the the logistic dependence basis of the level return on investment on their volume in conditions of high environmental dynamics.

A rational interval of investments in the implementation of a company's development project has been defined, limited both from below and from above.

The volume of investment in the project, giving the maximum value of return on investment and the maximum possible loss of the company as a result of ill-considered investment policy, has been deduced.

The next step in the theoretical determination of the upper limit of the interval of rational investment in the development of the organization (the second point of self-sufficiency) has been made.

4 Discussion

Studies of the problems of using models of logistic dynamics revealed certain difficulties in the selection of coefficients in the modified model of logisticians. The development of a robust algorithm for the procedure of such a selection is the next stage of the study.

Approaches to the formation of such an algorithm are clear, but the selection procedure should be simple and convenient.

From a theoretical point of view, the problem of determining the top break-even point, which closes the interval for rational investment of the project, remains very interesting. There is still no clarity in the method of its quantitative evaluation.

The problem of the convergence of S-curves of different projects of the same organization has not been solved, although the essential basis of their construction is common and is determined by the characteristics of the enterprise.

6 Conclusions

The logistics model proposed in our developments, built on the basis of the Ferhulst model, allows us to combine the starting point of the model with the origin of coordinates in a given field, which is convenient when studying a wide range of processes with saturation. The obtained model was tested on the experimental data of the business venture implemented in real life and showed high accuracy in displaying the actual information about the project.

The study showed the possibility of obtaining the most important characteristics the process of investing in the development of an organization, which provides top management with very important information when making management decisions on organizational development in the context of resource-saving technologies, and the accuracy of such decisions increases.

The resulting model and methodological approaches to its use make it possible to rationally use the organization’s strategic resources, effectively solving the problem of allocating limited resources across a complex of ongoing projects, including with energy saving directivity.

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