UDC 517.977.5:334.71
DOI: 10.15587/2312-8372.2018.123580

Ostanina A.,
Ershova N.,
Shibko O.,
Velmagina N.

DEVELOPMENT OF THE DESIGN METHOD OF THE ENTERPRISE FOR THE RELEASE OF NEW PRODUCTS

Описано методику проектування підприємства для випуску нової продукції, основу якої складають сучасні математичні методи. Математичний апарат дозволяє визначати: раціональний об'єм випускаємої однотипної продукції, оптимальне місце розташування підприємства та точку беззбитковості. Перша задача вирішена за допомогою критеріїв гри з природою, друга задача – методом аналізу ієрархій. Методику доцільно застосовувати при проектуванні підприємств.

Ключові слова: *проектування підприємства, математичні методи, однотипна продукція, місце розміщення підприємства, точка беззбитковості.*

1. Introduction

The life cycle of an organization is the totality of stages that an organization passes through the period of its life: birth, childhood, adolescence, maturity, aging, revival [1].

The birth of any organization is associated with the need to meet the interests of the new client, with the search and ignition of a free market niche. The main goal of the organization at this stage is survival, which requires the leadership of the organization such qualities as belief in success, readiness to take risks, high working capacity. Characteristic for the birth stage is a small number of companions. Particular importance at this stage should be given to everything new and unusual.

Solve the issue of drastic reduction in the timing of development and development of high-performance products and technology can be done with the help of automation systems for design work. Fig. 1 presents a qualitative picture, typical for the traditional form of product design [2].

Analysis of the graphs confirms the importance of a thorough and detailed initial search, absorbs only a few percent of the total project cost, but affects all subsequent stages.

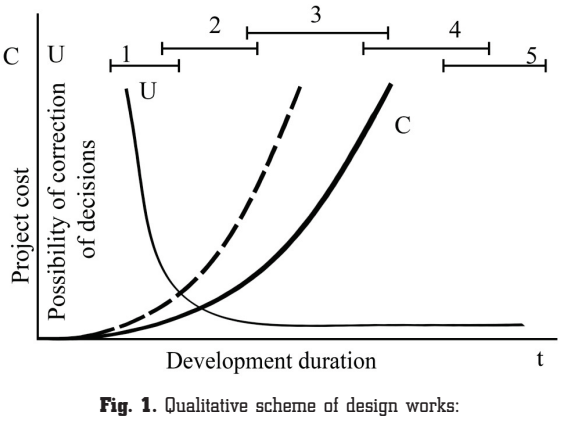

Fig. 1. Qualitative scheme of design works:
1 – search for a design solution; 2 – sketch design; 3 – technical and working design; 4 – manufacture of a prototype; 5 – finishing of the product

In Fig. 1 dotted line shows the tendency to accumulate information about the project as it is processed. It is evident that the information should be maximally enriched with the initial point of the project, until final decisions are made on its implementation, as long as it is possible to review and discard many competing options.

Designing the enterprise is carried out at the first stage of the life cycle, an important role should be assigned to the search for design solutions of the enterprise and the products.

At the stage of designing an enterprise for release of the products it is necessary:

– to choose the type of new products;

– to establish output that would not be less than the level of demand, so as not to lose the potential income from the sale of products, and not more than the level of demand, otherwise the enterprise will incur losses mainly due to a decrease in price;

– to plan the shops of the enterprise in accordance with the technology of manufacturing products and determine the area of the land for location of the enterprise;

– to choose the optimal location for the company according to the criteria: the compliance of the land plot, the opportunity to recruit the necessary personnel from the surrounding areas, access to material resources and transport;

– to determine breakeven sales volume and the security zone of the enterprise.

At present, mathematical methods for solving some problems have been developed, but they are performed only in the educational process. Therefore, the problem of applying mathematical methods in the design of enterprises for the production of new products is very urgent, which makes it possible to build competitive enterprises and products.

2. The object of research and its technological audit

The object of research is the method of designing an enterprise for the release of new products, the basis of which is played with nature and the method of analyzing hierarchies. The sustainability of the project is determined by the break-even point.

ISSN 2226-3780

With the help of the game's criteria with nature, the task of determining the optimal output of paving slabs is solved. The criteria of Wald, Bayes, Laplace and Savage are used.

The method of analyzing hierarchies is used to determine the optimal location for an enterprise. The criteria are the compliance of the land plot, the opportunity to recruit the necessary personnel from the surrounding areas, access to material resources and transport. As alternatives, let's consider 3 sites in different regions of the Dnieper, Ukraine.

The break-even point is determined by analytical and graphical methods.

One of the most problematic places is the use of only two mathematical methods when designing an enterprise. There are still many design problems that can be solved with the help of modern mathematical methods and information technologies.

What is important is that the methodology has been developed that extends the scope of using mathematical methods in the design of enterprises for release of new products.

3. The aim and objectives of research

The aim of research is development of a methodology for designing an enterprise for the production of new paving slabs.

To achieve this aim, the following tasks are formed:

1. To establish a rational output of paving slabs by using the game's criteria with nature.

2. To choose the optimal place for the company location according to the criteria: the compliance of the land plot, the opportunity to recruit the necessary personnel from the surrounding areas, access to material resources and transport.

3. To determine breakeven sales volume and the security zone of the enterprise.

4. Research of existing solutions of the problem

After a detailed analysis of the theory of the organization, the models and methods used at the design stage of manufacturing enterprises came to the conclusion that enterprises that develop new products face an extremely difficult dilemma. On the one hand, the result of innovation should be perfect products that correspond to real market needs, on the other – potential users of innovation have usually limited the ability to determine their needs and the expected ways to meet them. In work [1] it is shown that the enterprises, the development of which is based on the content of a high level of innovation, should make great efforts to incorporate the knowledge and experience of customers into the development of products.

However, to date, there are works in which solutions are given to individual tasks:

– solution of the problem of determining the volume of output with the help of playing with nature is given in [3];

– selection of the optimal location for the company location by the hierarchy analysis method in the study [4, 5];

– methods for calculating break-even sales and security zones of the enterprise are considered in [6];

– the tasks of the first two works and the technology of their implementation are summarized in the environment of spreadsheets in [2].

In Ukraine, the following problems have not been solved so far [7, 8]:

– there are no mechanisms for supporting innovative activities, the effectiveness of which has been confirmed by the experience of many countries;

– there is no corresponding financial and credit, tax and depreciation policies;

– conditions are not created that promote broad attraction of extra-budgetary investments to the innovation sphere, first of all from Ukrainian commercial structures and banks;

– the customs policy is regulated. Conclusions and prospects for further research.

According to the author [9], innovations are very important for development of the enterprise, since they lead to an increase in its potential. However, today there are significant problems in the implementation of innovations in Ukrainian enterprises, so we must look for optimal solutions.

Authors [10] provide examples of the use of mathematical methods and models of enterprise design and analysis of the stages of its life cycle.

Thus, the results of the analysis allow to conclude that the design of the enterprise for the release of new products, based on modern mathematical methods is the result of the introduction of an entrepreneurial approach in the activities of the enterprise. The entrepreneurial approach primarily involves establishing proactive relationships with customers who already at the initial stages of product development have the ability to influence the requirements for it and make changes to its intended characteristics as a result of testing and test use. Thus, the design process should include identifying the important needs of consumers and meeting those needs earlier and better than competitors.

5. Methods of research

5.1. Establishment of a rational output of paving slabs by means of game criteria with nature. *Gross product*. The function of each enterprise is release of the products in the quantity and quality required by consumers to provide people, society with material means of life and development. Processes of production are carried out in the workplace. Here, the main economic results of enterprises are formed, first of all, output and related costs. The volume of output is estimated by several economic indicators: the amount sold commodity, gross output. Products sold to customers (on received money) are called sold products. Products produced for sale are called marketable products. The sum of the volume of products produced for sale and products intended for consumption within the enterprise (intra-factory turnover) is called gross output.

Usually, at the initial stage of the release of new products, the technology has not been sufficiently developed and the costs are relatively high. Then, as production improves, costs gradually decrease and after a while stabilize at a lower level. In some cases this pattern is more noticeable, while in others it is smoothed out. The costs of production change under the influence of the volume of manufactured products. When the volumes increase and the amount of constant expenditure is unchanged, then their value per unit of output is reduced in inverse proportion (Fig. 2).

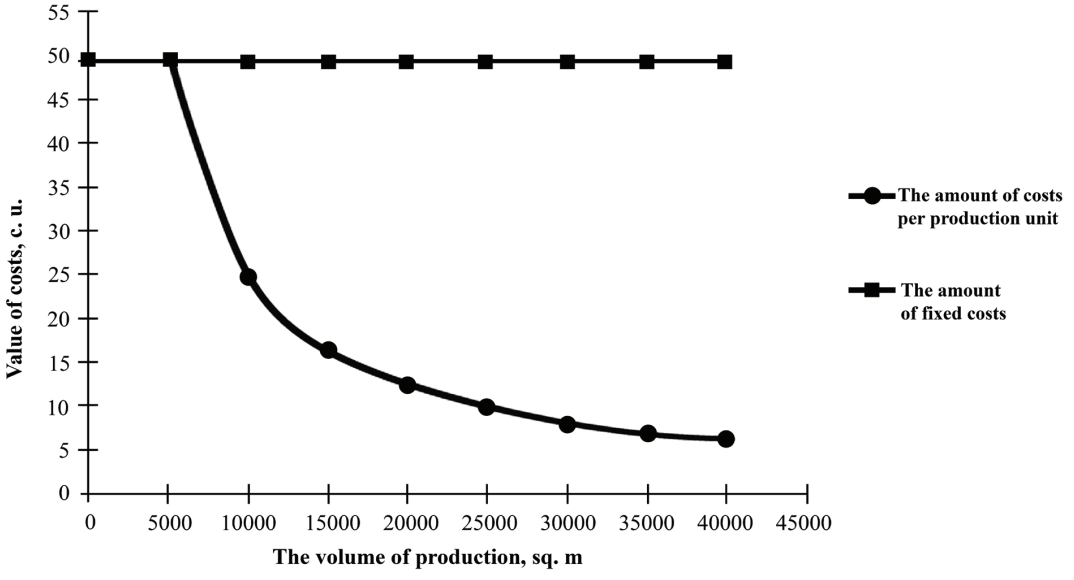

Fig. 2. Dependence of fixed costs on the volume of production

General formulation of the problem [3]. In accordance with the demand for products of the g-th assortment in the city, it is planned to build an enterprise for the production of these products. Uncertainty of demand in the period t leads to the need to calculate the volume of output V_g. It should be no less than the level of demand S_g, so as not to lose the potential income from the sale of products, and not more than the level of demand, otherwise the enterprise will incur losses associated with the markdown. It is assumed that within a year (by quarters) the demand for these products is expressed in volumes a_1, a_2, a_3, a_4. In this case, the marketing service of the enterprise can take one of the solutions – to build an enterprise that could meet the demand of consumers a_1, a_2, a_3, a_4 of g-th products. From the experience of work of such enterprises, expenses from unrealized unit of production and market price are known c.

The elements of the payment matrix are always positive, therefore the payment function can be represented as:

$$L(S_g, V_g) = \begin{cases} f_1(V_g - S_g), \text{ if } V_g > S_g; \\ f_2(S_g - V_g), \text{ if } V_g < S_g. \end{cases}$$

When studying the work of similar enterprises, the marketing service received additional information that reduces the uncertainty of the situation:

– probabilities of demand for this product are known by quarters of the year;

– demand for products in each quarter is exactly probable;

– about the likelihood of demand for this product by quarter, nothing definite can't be said.

Require:

– provide the described situation with a game diagram;

– make up a payment matrix;

– on the basis of the application of the criteria, give justified recommendations for the construction of an enterprise that could provide consumers with the demand for products.

The calculated formula of the elements of the payment matrix:

$$a_{ij} = b_j \cdot c - |a_i - b_j| \cdot d, \; i = 1,2,3,4; \; j = 1,2,3,4, \tag{1}$$

where a_i, b_j – the volume of supply and demand; c, d – market price and production costs.

According to the Bayesian and Laplace criteria, first, it is necessary to determine for each line the sum of the products of the payment matrix elements by the given probabilities by quarters, and then select the maximum value from the values obtained. Since in the Bayes criterion the given probabilities are different in value, let's obtain the maximum average income.

Thus, the calculated formulas have the form:

$$L_i = \sum_{j=1}^{4} a_{ij} p_j, \; i = 1,2,3,4; \; L = \max_{i=1,2,3,4} L_i. \tag{2}$$

According to the Wald criterion, the optimal strategy for which the profit reaches the maximum value from the minimum, that is:

$$L = \max_{j=1,2,3,4} \min_{i=1,2,3,4} a_{ij}. \tag{3}$$

The Savage criterion is calculated in the following sequence: a risk matrix is formed on the payment matrix, each element of which is determined by the formula:

$$r_{ij} = \left| \max_{k=1,2,3,4} a_{ik} - a_{ij} \right|, \; i = 1,2,3,4; \; j = 1,2,3,4, \tag{4}$$

and the minimax criteria applies, that is

$$R = \min_{i=1,2,3,4} \max_{j=1,2,3,4} r_{ij}.$$

Statement of the real problem. In accordance with the demand for paving slabs (pavers), it is planned to build an enterprise for the production of this paving slabs. It is assumed that within a year (by quarters) the demand for tiles is expressed in volumes of 24, 29, 34, 39 thousand m^2. From the experience of work of such enterprises, expenses of 72.02 c. u./m^2 and the market price is 160 c. u./m^2. When studying the work of similar enterprises, additional

ISSN 2226-3780

information was obtained that reduces the uncertainty of the situation:

– probabilities of demand for this tile are known by quarter of the year: 0.06; 0.35; 0.47; 0.12;

– demand for this paving stone in each quarter is equiprobable;

– there is nothing definite to say about the probability of demand for a given paving stone.

Decision. The first player is an enterprise, the second player is nature. The company's strategies:

– A_1 – to build an enterprise for the production of paving slabs in the amount of 24 thousand m^2;

– A_2 – to build enterprises for the production of paving slabs in the amount of 29 thousand m^2;

– A_3 – to build enterprises for the production of paving slabs in the amount of 34 thousand m^2;

– A_4 – to build enterprises for the production of paving slabs in the amount of 39 thousand m^2.

Nature strategies:

– B_1 – consumer demand for paving slab is 24 thousand m^2;

– B_2 – consumer demand for paving slab is 29 thousand m^2;

– B_3 – consumer demand for paving slab is 34 thousand m^2;

– B_4 – consumer demand for paving tiles is 39 thousand m^2.

The solution is executed in the Excel environment and is shown in Fig. 3. It is clear from the calculation that according to the Bayes criterion, the strategy A_3 is optimal in this case, and according to the Laplace criterion, strategies A_2 and A_3 are optimal and, since they correspond to the maximum profits of 4,679,900 c. u. According to the Wald criterion, the strategy A_1 is optimal. The strategy A_1 provides the maximum profit from the minimum, the size of which is 3,840,000 c. u. Optimal by the Savage criterion are strategies A_2 and A_3. As a result, as an optimal strategy, it is necessary to use strategy A_3 build an enterprise for the production of paving slabs in the amount of 34 thousand m^2 per year.

5.2. Choosing the optimal location for an enterprise based on the hierarchy analysis method. In recent years, large corporations have begun to realize the importance of choosing production facilities. However, this problem is also significant for small enterprises, since the right choice of production facilities is equally important for customers, and for suppliers, and for their own employees.

The main factors influencing the choice of the location of industrial enterprises and warehouses:

1. Proximity to consumers. For example, the Japanese company NatSteel Electronics has built the two largest enterprises in Mexico and Hungary – so that they are as close as possible to the main markets in the US and Europe. Buyers in these markets want the goods that interest them to be available in the shortest possible time. In addition, the proximity of producers to potential customers allows for the development of new products rather to take into account the needs of these customers.

2. Total costs. The goal of the optimal location of enterprises is choosing a place with a low total cost. In addition to production costs, their number includes regional costs, as well as internal and external distribution costs. Regional costs are composed of the cost of land, facilities, labor, taxes and energy. In addition, there are hidden costs that are difficult to account for. These include:

– expenses due to transportation of material resources over long distances between different intermediaries and to the end user;

– weakening the response of the consumer in the case of a remote location of the consumption market.

3. Infrastructure. It is vital to have an extensive transport system (road, rail, sea and air transport), as well as to meet the needs for electricity and telecommunications.

4. Quality of vocational training of the workforce. The educational and professional level of the workforce on the ground must be in line with the needs of companies, and today even more important is the readiness and ability of potential employees to learn.

5. Suppliers. The availability of a highly professional and competitive supplier network is one of the defining conditions for the location of enterprises. The proximity of the main suppliers, among other things, allows the use of lean manufacturing methods.

Let's choose the optimal location of the enterprise from 3 sites:

A – Ukraine, Dnipro, Heroes of Stalingrad str., 31A (Chechelevsky District).

B – Ukraine, Dnipro, Gavansky str., 18 (Samarskyi District).

C – Ukraine, Dnipro, Dniprostalevska str., 22 (Industrial District).

Since rent is an advantageous way to purchase a site, it will be rented with monthly payment.

To solve the problem, we will use the hierarchy analysis method [11, 12].

Building an enterprise for a new type of product										
payment matrix			b1	b2	b3	b4		Criteria		
		supply	24	29	34	39			Wald	
Demand		P	B1	B2	B3	B4	Bayes	Laplace	MIN	
a1	24	A1	3840	4279.9	4719.8	5159.7	4565.835	4499.85	3840	
a2	29	A2	3479.9	4640	5079.9	5519.8	4882.723	4679.9	3479.9	
a3	34	A3	3119.8	4279.9	5440	5879.9	4947.541	4679.9	3119.8	
a4	39	A4	2759.7	3919.8	5079.9	6240	4673.865	4499.85	2759.7	
incomes	outcomes	MAX	3840	4640	5440	6240	MAX	MAX	MAX	
160	72.02	MIN	3840				4947.541	4679.9	3840	
probability of Bayes demand						Wald A1 strategy				
0.06	0.35	0.47	0.12			Laplace A2 i A3 strategy				
probability of Laplace demand						Bayes A3 no strategy				
0.25	0.25	0.25	0.25							
			The calculation by the criterion of Savage					Savage criterion		
Risk matrice			b1	b2	b3	b4		strategies A2 i A3		
		proposition	24	29	34	39				
Demand		R	B1	B2	B3	B4	MAX			
a1	24	A1	0	360.1	720.2	1080.3	1080.3	Conclusion strategy A3		
a2	29	A2	360.1	0	360.1	720.2	720.2			
a3	34	A3	720.2	360.1	0	360.1	720.2			
a4	39	A4	1080.3	720.2	360.1	0	1080.3			
	MIN	MAX	1080.3	720.2	720.2	1080.3	MIN			
	720.2						720.2			

Fig. 3. Calculation of the output of paving slabs in the Excel environment

Let's choose the best option for the following criteria:

1. Conformity of the land plot (LP), which is dependent on:
   – plot size (PS);
   – plot prices (PP);
   – development costs (DC).
2. The ability of the surrounding areas to recruit the necessary staff (Ps), which is associated with:
   – the potential to perform the necessary work (NW);
   – competition in the labor market (CL).
3. Access to material resources and transport (RT) is determined by:
   – transport infrastructure (TI);
   – potential suppliers (PS);
   – potential customers (PC).

The hierarchical model is shown in Fig. 4. In this task, locations are alternatives and form the fourth level of the hierarchy. The criteria are: land, personnel, access to material resources and transport. The criteria constitute the second level of the hierarchy. In turn, the criteria depend on the sub-criteria, which form the third level of the hierarchy.

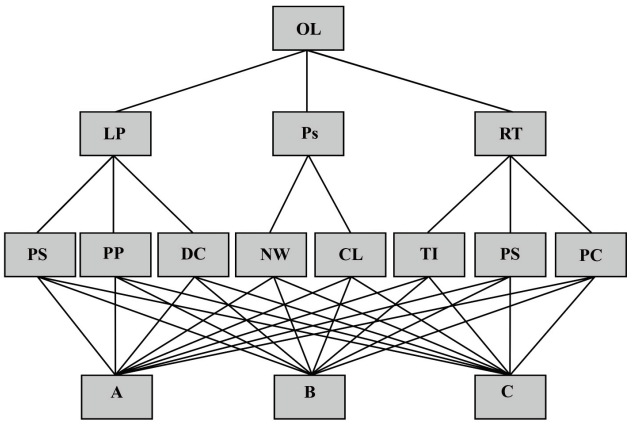

Fig. 4. Hierarchical model of location selection

The top of the hierarchy is the goal – to choose the optimal location for the location of the enterprise. For the hierarchy, 12 matrices of pair comparisons are composed: one for the second level, three for the third and 8 for the fourth one. The matrices are presented in the form of spreadsheets (Fig. 5–8).

Ratio of consistency of the matrix of paired comparisons $B_y \le 0.1$. This indicates good consistency of the initial matrix of paired comparisons of the criteria for LP, P_S and RT. The analysis of the elements of the normalized eigenvector of the comparison matrix shows that the choice of the optimal location of the enterprise is more influenced by:

– possibility of a land plot of railway (47.2 %);
– access to material resources and transport of DC (31.1 %);
– recruitment of staff Ps (21.7 %).

The result, shown in Fig. 6, indicates good consistency of the initial matrix of paired comparisons under the criteria of PS, PP and DC, which ensures the choice of the land area of the r ailway. The choice of the land plot depends on the plot size PS (46.4 %), plot price PP (27.8 %) and development costs (25.8 %).

OL	LP	Ps	RT
LP	1	2.2	1.5
Ps	0.455	1	0.7
RT	0.667	1.4285714	1
Own vector W			
Algorithm 1			
step 1	4.7		
	2.155		
	3.095		
step 2	9.950		
step 3	0.472	control	
W	0.217	1	
	0.311		
consistency check			
	14.083		
A*W	6.458		
	9.306		
	2.996		
λ	2.997		
	3.007		
λ max	3.007		
n	3		
Ic	0.003		
M(Iy)	0.58		
By	0.006		

Fig. 5. Impact of criteria on a common goal in an Excel environment

LP	PS	PP	DC
PS	1	2	1.5
PP	0.5	1	1.2
DC	0.6666667	0.8333333	1
Own vector W1			
Algorithm 1			
step 1	4.5		
	2.700		
	2.500		
step 2	9.700		
step 3	0.464	control	
W1	0.278	1	
	0.258		
consistency check			
	13.650		
A*W1	7.950		
	7.750		
	3.033		
λ	2.944		
	3.100		
λ max	3.100		
n	3		
Ic	0.050		
M(Iy)	0.58		
By	0.086		

Fig. 6. Land plot sub-criteria in the Excel environment

The result, shown in Fig. 7, indicates good consistency of the initial matrix of paired comparisons under the NW and CL criteria, provides recruitment of personnel from surrounding areas. Recruitment depends on the necessary NW specialists (66.7 %) and competition in the market (33.3 %).

Investigation of the influence of others sub-criteria and alternatives is carried out in a similar way. To evalu-

ISSN 2226-3780

ate the effect of alternatives on a criterion, a matrix B is constructed which columns are eigenvectors of sub-criteria (Fig. 9).

The evaluation of the effect of alternatives on the criteria is carried out using the matrix B1 (Fig. 10).

Ps	NW	CL
NW	1	2
CL	0.5	1
Own vector W2		
Algorithm 1		
step 1	3	
	1.5	
step 2	4.500	
step 3	0.667	control
W2	0.333	1
consistency check		
	6.000	
A2*W2	3.000	
λ	2.000	
	2.000	
λ max	2.000	
n	2	
Ic	0.000	
M(Iy)	0.58	
By	0.000	

Fig. 7. Influence of sub-criteria on the personnel criterion in the Excel environment

PS	A	B	C
A	1	3	1.5
B	0.333	1	0.5
C	0.6666667	2	1
Own vector V1			
Algorithm 1			
step 1	5.5		
	1.833		
	3.667		
step 2	11.000		
step 3	0.500	control	
V1	0.167	1	
	0.333		
consistency check			
	16.500		
A1*V1	5.500		
	11.000		
	3.000		
λ	3.000		
	3.000		
λ max	3.000		
n	3		
Ic	0.000		
M(Iy)	0.58		
By	0.000		

Fig. 8. The effect of alternatives on the plot size in an Excel environment

matrix B							
0.500	0.382	0.391	0.428	0.455	0.351	0.529	0.422
0.167	0.204	0.286	0.357	0.364	0.277	0.176	0.115
0.333	0.414	0.322	0.214	0.182	0.372	0.294	0.463

Fig. 9. Assessment of the impact of alternatives on sub-criteria in the Excel environment

matrix B1		
LP*W1	Ps*W2	RT*W3
0.43928	0.43717	0.423326
0.20787	0.35948	0.206780
0.35286	0.20335	0.369895

Fig. 10. Assessment of the impact of alternatives on criteria in the Excel environment

Analysis of the results shows that priority on the criterion of the land plot has a first alternative (43.9 %), if possible recruitment – the first alternative (43.7 %) and for access to resources and transport – the first alternative (42.3 %).

Estimation of the impact of alternatives on the overall goal is performed according to Fig. 11.

matrix B2	
B1*W	
0.43386	
0.24036	
0.32578	

Fig. 11. Assessing the impact of alternatives on a common goal in an Excel environment

So, the first priority for site selection is the alternative A, that is, the land plot, taken with monthly payment, should be rented. Ukraine, Dnipro, Heroes of Stalingrad str., 31A (Chechelevsky District).

6. Research results

The indicators of the maximum level characterize the stability degree of the project in relation to possible changes in the conditions for its implementation. The limiting value of the parameter for the t-th year is the value at which the net profit from the project is zero [13]. The main indicator of this group is the break-even point (T) – the level of the physical volume of sales during the estimated period of time at which the proceeds from the sale of products coincide with the costs of production. The project is generally recognized as sustainable if the break-even point value does not exceed 75 % of the nominal production volume.

Let's define the break-even point according to the data of Table 1, describing the activity of the enterprise for the production of paving slabs per month.

Limitations that must be met in calculating the break-even point:

1. The volume of production is equal to the volume of sales.

2. Constant costs are the same for any volume of production.

3. Variable costs vary in proportion to the volume of production.

4. The price does not change during the period for which the break-even point is determined.

5. The unit price and unit cost remain constant.

The break-even point indicator should be used when:
– introduction into production of a new product;
– creation of a new enterprise.

Table 1

Initial data

Index	Symbol	Value
Production capacity of the enterprise per month, m^2	–	2860
Price of the product, c. u.	P	160
Revenues from all products, c. u.	R	457 600
Constant costs, c. u.	C	246 477.2
Variable costs for the product, c. u.	C_{var}	3.85
Variable costs for all products that are produced, c. u.	CP_{var}	11 011
Profit from the sale of the product, c. u.	PS	200 112.2
Marginal revenue, c. u.	$MR=R-C_{var}$	446 600
The fate of marginal revenue	$F_{MR}=\frac{R-C_{var}}{R}$	0.97

Analytical method of solution. To determine the break-even volume of sales (in value terms), it is necessary:

$$T=\frac{C}{FMR}=\frac{246477.2}{0.97}=254100.2 \text{ c. u.}$$

Break-even sales for one type of product:

$$T=\frac{C}{S}=\frac{C}{P-C_{\text{var}}}=\frac{246477.2}{160-3.85}=1579 \text{ m}^2.$$

To calculate the critical implementation point as a percentage:

$$T=\frac{C}{MR}\cdot 100\ \%=\frac{246477.2}{446600}\cdot 100\ \%=52.8\ \%.$$

The volume of sold products to obtain a specific profit margin:

$$T=\frac{A+PS}{P-C_{\text{var}}}=\frac{246477.2+200122.2}{160-3.85}=2860 \text{ m}^2.$$

The safety zone is the difference between actual and break-even sales. The security zone shows how much the actual sales volume is above the critical one, at which the profitability is zero.

To determine the security zone by cost, it is necessary:

$$SZ=\frac{R-T}{R}=\frac{457600-254100}{457600}=0.44\ (44\ \%).$$

A graphical method for solving the problem is shown in Fig. 12.

Horizontally, the sales volume of paving slabs is shown as a percentage of the production capacity of the enterprise, vertically – the cost of sold paving slabs and profits, which together constitute sales revenue.

According to the graph in Fig. 12 it is possible to establish, at what volume of realization of a pave slabs the enterprise will receive profit, and at what it will not be. It is possible also determine the point at which costs will be equal to the proceeds from the sale of paving slabs. It is called the break-even point of sales of products, or the profitability threshold, or the point of return on costs, below which production would be unprofitable.

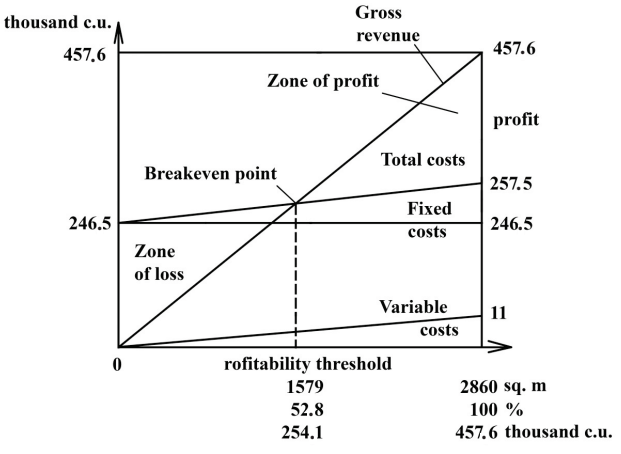

Fig. 12. Determination of break-even point

In the case under investigation, the critical point is located at the level of 53 % of the possible volume of realization of the paving slab. If the package of orders for products of the enterprise is more than 53 % of its production capacity, then there will be profit. If the package of orders is less than 53 % of the actual production capacity, then the enterprise will be unprofitable and go bankrupt. The breakeven point value corresponds to 53 % of the possible sales volume of paving slabs, that is, the project is recognized as sustainable.

7. SWOT analysis of research results

Strengths. By calculations and modeling it is shown that at the design stage of the enterprise it is possible to establish: the optimal volume of output; the optimal location of the enterprise and the sustainability of the project.

Weaknesses. The weaknesses of this method of designing an enterprise are related to the fact that the evaluation of the input parameters of an object occurs using a probabilistic nature. To prevent this shortcoming in the process of designing an enterprise, the marketing service needs to conduct an in-depth analysis of competitive enterprises to determine the needs of consumers.

Opportunities. There are still many design problems that can be solved with the help of modern mathematical methods and information technologies. What is important is that the methodology has been developed that extends the scope of using mathematical methods in the design of enterprises for the release of new products.

The introduction of the methodology will reduce the design of modern enterprises and new products.

Threats. Difficulties with the implementation of the methodology may arise due to the fact that specialists who make decisions on designing an enterprise for the release of new products may not trust mathematical methods. In this case, the main condition for realizing these tasks is the correct description of variables or spatial position.

ISSN 2226-3780

8. Conclusions

1. The determination of the volume of paving slabs was realized by playing with nature with an example with specific input data. At the same time, it was taken into account that this volume should be no less than the level of demand, so as not to lose the potential income from the sale of products. And also no more than the level of demand, otherwise the enterprise will incur losses mainly due to a decrease in the price. As a result, it was found that the rational output of paving slabs is 34 thousand m^2 per year.

2. On the basis of the hierarchy analysis method, the optimal location of the enterprise according to certain criteria was chosen. The choice of the location was carried out from three real sites, and analysis of the results showed that the priority:

– according to the criterion, the land plot has the first alternative (43.9 %);

– if possible recruitment – the first alternative (43.7 %);

– for access to resources and transport – the first alternative (42.3 %).

3. The research of the activity of the enterprise on the production of paving slabs per month was carried out and breakeven sales volume and the security zone of the enterprise were determined by analytical and graphical methods. The safety zone is 44 %. The breakeven point value corresponds to 53 % of the possible sales volume of paving slabs, that is, the project is recognized as sustainable.

References

1. Monastyrskyi H. L. Teoriia orhanizatsii: handbook. Kyiv: Znannia, 2008. 319 p.
2. Yershova N. M. Avtomatyzyrovannaia podhotovka y oformlenye dokumentov: monograph. Dnepropetrovsk: PHASA, 2012. 244 p.
3. Kuznetsov A. V., Sakovich V. A., Kholod N. I. Vysshaya matematika. Matematicheskoe programmirovanie: handbook. Minsk: Vysshaya shkola, 1994. 286 p.
4. Sutyagina N. I. Metod dinamicheskogo programmirovaniya pri prinyatii mikroekonomicheskogo resheniya // Vesnik NGIEI. 2014. Vol. 2. P. 72–76.
5. Vakulina G. M., Timofeeva G. A. Dinamicheskoe programmirovanie s ispol'zovaniem nechetkoy logiki v planirovanii investitsionnykh proektov // Izvestiya Ural'skogo ekonomicheskogo universiteta. 2014. Vol. 2 (52). P. 109–114.
6. Zelosko B., Moshkov M. Yu., Chikalov I. V. Optimizatsiya reshayushhikh pravil, osnovannaya na metodakh dinamicheskogo programmirovaniya // Vestnik Nizhegorodskogo universiteta im. N. I. Lobachevskogo. 2010. Vol. 6. P. 195–200.
7. Chernyshev S. I. Ob ispol'zovanii metoda dinamicheskogo programmirovaniya R. Bellmana v zadachakh ekonomicheskogo soderzhaniya // Biznes Inform. 2013. No. 6. P. 110–119.
8. Grigoriev A. M., Ivanko E. E., Chentsov A. G. Dinamicheskoe programmirovanie v obobshhennoy zadache kur'era s vnutrennimi rabotami: elementy parallel'noy struktury // Modelirovanie i analiz informatsionnykh sistem. 2011. Vol. 18, No. 3. P. 101–124.
9. Golovanova N. F., Golovanov A. A. Metod obiektivnogo matematicheskogo opisaniya problemy vybora v ramkakh teorii statisticheskikh resheniy: proceedings // Sovremennye energo- i resursosberegayushhie tekhnologii SETT. 2017. Vol. 6. P. 1479–1482.
10. Popova O. N. Kalendarnoe planirovanie remontno-stroitel'nykh rabot na osnove tekhnologii poelementnoy ekspluatatsii metodami dinamicheskogo programmirovaniya fizicheskogo iznosa // Sovremennye problemy nauki i obrazovaniya. 2014. Vol. 1. URL: https://www.science-education.ru/ru/article/view?id=12225
11. Serikov A. V., Bilotserkivskyi O. V. Metod analizu iierarkhii u pryiniatti rishen: handbook. Kharkiv: BURUN KNYHA, 2006. 144 p.
12. Ershova N. M. Modeli i metody teorii prinyatiya resheniy: handbook. Dnipropetrovsk: PGASA, 2016. 248 p.
13. Mazur I. I., Shapiro V. D., Olderogge N. G. Upravlenie proektami: handbook / ed. by Mazur I. I. Moscow: ZAO Izdatel'stvo «Ekonomika», 2001. 574 p.

РАЗРАБОТКА МЕТОДИКИ ПРОЕКТИРОВАНИЯ ПРЕДПРИЯТИЯ ДЛЯ ВЫПУСКА НОВОЙ ПРОДУКЦИИ

Описана методика проектирования предприятия для выпуска новой продукции, основу которой составляют современные математические методы. Математический аппарат позволяет определять: рациональный объем выпускаемой однотипной продукции, оптимальное место размещения предприятия и точку безубыточности. Первая задача решена при помощи критериев игры с природой, вторая задача – методом анализа иерархий. Методику целесообразно применять при проектировании предприятий.

Ключевые слова: проектирование предприятия, математические методы, однотипная продукция, место размещения предприятия, точка безубыточности.

Ostanina Nastya, *Department of Applied Mathematics and Information Technologies, Prydniprovs'ka State Academy of Civil Engineering and Architecture, Dnipro, Ukraine, e-mail: nastya.skandi@gmail.com, ORCID: https://orcid.org/0000-0003-3438-0817*

Ershova Nina, *Doctor of Technical Sciences, Professor, Department of Applied Mathematics and Information Technologies, Prydniprovs'ka State Academy of Civil Engineering and Architecture, Dnipro, Ukraine, e-mail: ershovanm@mail.pgasa.dp.ua, ORCID: https://orcid.org/0000-0003-0198-0883*

Shibko Oxana, *PhD, Associate Professor, Department of Applied Mathematics and Information Technologies, Prydniprovs'ka State Academy of Civil Engineering and Architecture, Dnipro, Ukraine, e-mail: prmat@mail.pgasa.dp.ua, ORCID: https://orcid.org/0000-0001-5894-0642*

Velmagina Natalia, *PhD, Associate Professor, Department of Applied Mathematics and Information Technologies, Prydniprovs'ka State Academy of Civil Engineering and Architecture, Dnipro, Ukraine, e-mail: velmagina24@gmail.com, ORCID: http://orcid.org/0000-0002-5584-3748*