Ivakhnik D.E.

RISK MANAGEMENT MODEL FOR BUILDING A COMPANY'S PRODUCTION PROGRAM

Ivakhnik D.E.

Abstract. The paper presents an economic-mathematical model that helps to determine the risk reduction resources at the phase of selecting a variant of the company's production program. Risk reduction is conditioned by the manipulation of sales volumes and selling prices, and by searching for the solution, which allows achieving the maximum risk reduction in the model - «product sales income - financial safety margin". The study demonstrates the practical implementation of the developed model on the basis of a dental clinic services. The practical value of the study has been proved by the possibility of reducing the risks for the clinic by choosing the optimal parameters of sales volume and cost of services.

Key words: risks, production program, financial safety margin, product (work, service) sales income.

Introduction

There are various risk classifications in the economic literature [1, 2, 3, 4, 11, etc.]. However, there is no consensus in the definition of "risk", which can be explained by the variety of approaches to understanding the essence of this definition, numerous methods and techniques of risk assessment and risk management [1, 2, 3, 4, 6, 7, 8, 9, 10, 11, etc.]. In the author's opinion, the classification of risks into manageable (fully or partially) and unmanageable by the company's top management deserves the highest attention, as manageable risks reflect the totality of those conditions and factors that can be manipulated during the process of activity, while unmanageable risks determine both the possibility and effectiveness of these actions.

Unmanageable risks are those whose level cannot be affected by the company's management and the integrated totality of which determines the objective level of riskiness in the environment of the company's activities. Particularly, epidemiological risks, risks of market fluctuations, natural and climatic risks, demographic risks, country risks, regional risks, industry risks, force majeure risks, external digital risks, legal and regulatory risks, scientific and technical risks, resource risks, criminogenic risks, etc. are classified as unmanageable risks.

Manageable risks could be minimized or eliminated through risk management tools and mechanisms. The list of manageable risks includes the risk of incurring losses, the risk of loss of the financial safety margin, the risk of increasing the payback period of investments, risks of resource transportation and storage, risks of interaction with counterparties, software and information risks, time risks, reputational risks and other risks.

Obviously, the actual ways to minimize potential financial losses of the company are in the field of manageable risks. However, manageable risks are unequal in their potential consequences, that is, in their possible effect on the level of aggregate financial losses in the course of the company's operating activities under the influence of the realization of adverse events.

Methods

As the author believes, the issue of ranking company risks by significance is not sufficiently developed and requires further research. Therefore, the author conducted an expert survey among the top managers of dental companies in the Moscow region. There were 148 respondents in the study, and the representativeness of the selection was ensured by the calculation of its minimum volume and the research design.

The research showed that the key manageable risks for these companies are:

Risk of incurring losses on product (work, service) sales

The risk of losing financial safety margin in the company's operating activities.

As a result, the degree of consistency in the opinions of the surveyed top managers is rather high with a concordance coefficient of 0.872.

Indeed, for a particular company, the most important factors in these certain conditions may be other manageable risks and optimization criteria, which had been previously shown by the author in [12, 13]. This fact once again emphasizes the objective dynamic nature of the risk management model, when in the "here and now" situation only certain risks are included in this model, which are significant for the company at the moment and which management will give the highest return.

There are various methods of risk assessment: scenarios method, analogy method, simulation modeling, decision tree, factorial sensitivity analysis, etc. [1, 3, 4, 7, 9, etc.]. Nevertheless, these methods, with a certain degree of error, only allow to evaluate the level of those or other risks, without offering an efficient solution to reduce manageable risks, thereby actualizing the research of this problem. It is important to develop a model to manage the risk of incurring losses on product (work, service) sales and the risk of losing the financial safety margin in operating activities of the company.

The level of manageable risks at each particular point in time is determined by the joint effect of a series of factors. The product (work, service) sales volume and closely related to it price level should be recognized as significant factors, as potential changes of these parameters under the influence of managing actions of the company management determine the amount of product (work, service) sales income, the financial safety margin, payback period and other important financial and economic indicators. Thus, sales volume and selling prices are real factors that can be manipulated to achieve an appropriate level of risk.

The analysis of the dependence between the product (work, service) sales income and the financial safety margin with changes in the sales volume represents a definite scientific and practical interest. The research conducted in this field allowed the author to implement a morphological formulation and prove the following theorem:

THEOREM: If the functions of product (work, service) sales income PR and financial safety margin ZF have extremes, then they are achieved at different product (work, service) sales volumes.

Let us introduce the following symbols:

$P\ (q, x_1, x_2,\ \dots, x_n)$ – a demand function represented as a function of the product unit price depending on the factors affecting it; $x_1, x_2,\ \dots, x_n$ – factors taken into account in the model, n - the number of such factors;

[c + v*q] – function of total costs;
c – fixed costs, rubles;
v – variable costs per unit of product, rubles;
q – products (work, service) sales volume, natural units;
q ∈ [0; qmax];
qmax – production capacity of the company.

Function $P\ (q, x_1, x_2,\ \dots, x_n)$ is differentiable in the internal field of its definition. In the proof, it is just considered the cases in which the functions of product sales income PR and financial safety margin ZF have extremes on the entire range of allowable solutions. It is assumed a priori that the functions PR and ZF are convex upward, and the value of fixed costs does not change at 0 ≤ q ≤ qmax.

PROOF. By using the symbols adopted above, we write down in general form the function of product (work, service) sales income:

$$PR = P\ (q, x_1, x_2,\ \dots, x_n) * q - c - v * q$$

Then we find the partial derivative of the function PR (for the variable q) and equate it to zero:

$$\frac{dPR}{dq} = \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * q + P(q, x_1, x_2,\ \dots, x_n) - v$$

$$\frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * q + P(q, x_1, x_2,\ \dots, x_n) - v = 0$$

$$\frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * q = v - P(q, x_1, x_2,\ \dots, x_n)$$

We find the extreme point of the PR function from this equation:

$$q_{pr} = [v - P(q, x_1, x_2,\ \dots, x_n)] \Big/ \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} \qquad (1)$$

A general view of the financial safety margin function can be presented as follows:

$$ZF = P\ (q, x_1, x_2,\ \dots, x_n) * q - \frac{c * P\ (q, x_1, x_2,\ \dots, x_n)}{P\ (q, x_1, x_2,\ \dots, x_n) - v}$$

We find the partial derivative of the function ZF (for the variable q) and equate it to zero:

$$\frac{dZF}{dq} = \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * q + P(q, x_1, x_2,\ \dots, x_n) - \left\{ c * \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * [P(q, x_1, x_2,\ \dots, x_n) - v] - c * P(q, x_1, x_2,\ \dots, x_n) * \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} \right\} \Big/ [P(q, x_1, x_2,\ \dots, x_n) - v]^2$$

$$\frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * q + P(q, x_1, x_2,\ \dots, x_n) - \left\{ c * \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} * [P(q, x_1, x_2,\ \dots, x_n) - v] - c * P(q, x_1, x_2,\ \dots, x_n) * \frac{dP(q, x_1, x_2,\ \dots, x_n)}{dq} \right\} \Big/ [P(q, x_1, x_2,\ \dots, x_n) - v]^2 = 0$$

From the resulting expression, we find the extremum point of the ZF function:

$$q_{zf} = -\frac{c*v}{[P(q,x_1,x_2, \dots ,x_n)-v]^2} - P(q,x_1,x_2, \dots ,x_n) \Big/ \frac{dP(q,x_1,x_2, \dots ,x_n)}{dq} \tag{2}$$

The general form of the extremum point qpr (1) of the function of product (work, service) sales income PR does not coincide with the general form of the extremum point qzf (2) of the financial safety margin function ZF. The theorem is proven.

The qpr point corresponds to the sales volume, at which the product (work, service) sales income is maximum. Such sales volume minimizes the risk of incurring losses. The financial safety margin is maximum at sales volume qzf. This volume minimizes the risk of losing the financial safety margin. The problem is to find a sales volume that provides a balance between the purposes of maximizing profits and financial safety margin. Essentially, there is a multi-criteria problem, to solve which it is reasonable to use the method of maximizing the weighted sum of the criteria. Such approach allows taking into account the importance differentiation of manageable risks for a particular company.

Accordingly, the author proposes a model of managing the risks of incurring losses and loss of financial safety margin for the i-th type of products (work, service) of the following form:

$$IKAR_i = \{(p_i * q_i - c - v_i * p_i) * \gamma + (p_i * q_i - \frac{c_i * p_i}{p_i - v_i}) * \lambda\} \longrightarrow \max \tag{3}$$

with limitations:
qi ≤ Pti (limit to record the demand for products (work, service));
qi min ≤ qi ≤ qi max (limit on the volume of the output of the product (work, service))
$\sum_{i=1}^{k} a_{ij} * q_{ij} \le B_j + P_j$, j = $\overline{1, m}$ (limit on material and raw resources);
$\sum_{i=1}^{k} q_i * t_i \le T$ (labor resource limit);
qi ∈ I (limit on integrity of variables);
pi > vi (limit on the economic reliability of the model);

where:
IKARi – integral criteria of anti-risk for the i-th type of product (work, service);
pi – price of a unit of the i-th type of products (work, service), i = ‾(1,k) ;
k – quantity of types of product (work, service);
qi – sales volume of the i-th type of product (work, service);
c – fixed costs;
vi – variable costs per unit of the i-th type of product (work, service);
γ, λ - the weights of the risk of incurring losses and the loss of financial safety margin, $\sum(\gamma + \lambda) = 1$;
Pti – market demand for the i-th type of product (work, service);
qi min и qi max - minimum and maximum permissible volumes of production of the i-th type of product (work, service);
aij – the rate of consumption of the j-th type of resource for the production of the i-th type of product (work, service);
Bj – the volume of available resource of type j;
Pj – the volume of resource of type j for the current planning period;
m – the number of resource types used in the production of manufactured product (work, service);
ti - the labor input per unit of production of the i-th type of product;
T – the time fund of the production staff in the current period.

The solution of the problem is determined by the vector q = (q1, q2, ..., qk), which specifies the optimal sales volumes according to the selected criteria. The content of equation (3) shows that the developed model is based on the following reasoning: the higher the mass of product (work, service) sales income and the size of the financial safety margin, the lower the risk of incurring losses and the loss of the financial safety margin, respectively.

In fact, the developed risk management model allows us to determine the optimal price and volume of sales of product (work, service) for the planning period, i.e. sets the basic parameters for the implementation of the company's production program.

IKAR integral anti-risk criteria for the company as a whole is determined by the formula (4):

$$IKAR = \sum_{i=1}^{k} IKAR_i \tag{4}$$

The considered optimization problem should be solved each time before the start of the planning period and at any other time when the external/internal environment of the company changes. Applications such as Statistica, Mathematica, etc. can be used to automate the solution of the problem.

Results and Discussion

The synthesized model (3) was tested on the basis of MigDent Dental Clinic (Moscow, Russia). The initial data for using the model is shown in Table 1.

Table 1 – Initial data for risk management at MigDent dental clinic (for “Dental Hygiene” service)

Demand function	q = 1963,02 – 521,77*lg(p)
Fixed costs (c), rubles	45157
Variable costs per unit (v), rubles	2367
Weight of the risk of incurring losses (γ)	0,65
Weight of the risk of the loss of financial safety margin (λ)	0,35

Table 2 – Results of the risk management model (for “Dental Hygiene” service)

Indicator	Before optimization	After optimization
Sales volume, services/month	149	106
Price per service, rubles	3000	3618
Product sales income (PR), rubles	49160	87449
Financial safety margin (ZF), rubles	232986	252910
IKAR	113499	145360
IKAR1 / IKAR0	X	1,28

The demand function for the "Dental Hygiene" service was formed according to the results of market research with the help of correlation and regression analysis tools. The choice of the most appropriate form of correlation was based on the criterion of the minimum residual variance of the resultant indicator. The correlation index was 0,902, which indicates a close correlation between the price of the service and its sales volume. The calculated value of Fisher's F-criterion indicates statistical significance of the regression equation - demand function. The division of costs into fixed and variable was carried out by means of the least squares method. The linear correlation coefficient was 0.942, which confirms the reliability of the obtained values of fixed and variable costs; Student's t-test showed statistical significance of the regression parameters and the closeness of the relationship. The calculated value of Fisher's F-criterion indicates statistical significance of the regression equation - cost function.

Conclusions

Table 2 shows the results of the risk management model using data from MigDent dental clinic. Table 2 shows that this clinic for the "Dental Hygiene" service has reserves to reduce risks through the choice of the optimal option of production program. The calculations show that the application of the proposed model to the service in question reduces the risk of incurring losses and loss of financial safety margin by a factor of 1.28.

References

1. A.G. Badalova, A.V. Panteleev, Industrial risk management, textbook, Moscow, (2018)
2. R.M. Kachalov, S.G. Oparin, Y.A. Sleptsova, A.E. Stasishina-Olshevskaya, V.K. Ridzak, J.D. Trebeski, P.V. Gerasimenko, V.V. Budner, L.G. Selyutina, N.V. Chepachenko, A.A. Leontiev, E.V. Kazaku, S.A. Ershova, T.N. Orlovskaya, M.N. Yudenko, Theory and Practice of Risk Management, St. Petersburg, (2020)
3. G.D. Antonov, O.P. Ivanova, V.M. Tumin, Organization Risk Management, textbook, Moscow, (2020)
4. E.N. Stanislavchik. Risk Management in Small and Medium Business, Moscow, (2020)
5. D.S. Demidenko, E.D. Malevskaya-Malevich, Y.A. Dubolazova, Effectiveness of Risk Management Systems Application at Enterprises, St. Petersburg (2019)
6. N.A. Rikhtikova, Risk Analysis and Management of an Organization, Moscow (2018)
7. A.G. Badalova, A.V. Panteleev, Managing the Risks of an Enterprise, Moscow (2017)
8. D.L. Olson, D. Wu, Enterprise risk management models. University of Nebraska (2017)
9. Advanced methods for decision making and risk management in sustainability science, New York, (2007)
10. A.A. Rudryavtsev, A.V. Radionov, Introduction to quantitative risk management, textbook, Un-ta, Publishing House of St. Petersburg (2016)
11. P.N. Sharonin, Risk management, textbook, Moscow, (2021)
12. D.E. Ivakhnik, V.Z. Grigorieva, Marketing in Russia and abroad, Optimization of the enterprise production program in the conditions of market relations, 1, 9-12 (1999)
13. D. Ivakhnik, A. Tverdokhleb, Finansoviy Direktor, Choosing the optimal budget , 6, 19-24, (2005)