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Optimization of the enterprise marketing strategy using the operations research

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Abstract

It is examined an approach to the analytical tools construction of marketing of the enterprise designed to select the optimal assortment, sales volume, market segments and product prices and based on the use of the operations research methods and optimal software systems. Is proposed a model of nonlinear integer programming with variables of continuous and boolean type, which allows to plan production of existing and new products. To analyse the optimization model is proposed using of heuristic algorithm based on iterative increase in products prices and solution of the linear integer programming task by method of Land and Doig at each step of changing prices.

Keywords – production system, modeling, optimization, operations research, marketing, target segment, sales volume, price of the product

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Introduction

Background research is due to the need to develop an effective marketing strategy of enterprise in the conditions of high dynamics of changes in market parameters of printed products, high intensity of competition and the limited production resources [1], 22]. The practice of russian and foreign companies shows that due to the best use of limited resources, the optimization of management and marketing solutions allows to increase the profit of the enterprise by 3-8% [3].

The aim is to develop analytical tools of optimal planning of commodity, marketing and pricing strategies of the enterprise based on heuristic methods and mathematical programming models.

The proposed approach is based on the mathematical model of choosing the optimal assortment, sales volumes, market segments and product prices over the planning period. The proposed optimization model gives possibility to plan production and sales of previously produced and new products.

2. Problem statatement

The study business situation is as follows. Suppose that the enterprise is working with its products in certain markets (or market segments). The product portfolio of the enterprise also includes products, which still doesn't go to the market and it is necessary to decide whether to manufacture and market them. Marketing research allowed us to estimate the volume of market segments where the enterprise is already working or going to release their products. Marketers are also defined for each segment of the market limits the prices at which the consumer agrees to purchase products. The company's management aims to achieve in the planning period of certain values such targets as profits from the sale of products and the market share controlled by the enterprise. Expected levels of available production resources (materials, equipment and labor) in the planning period are defined and used in the planning as limiting factors. The application rates of inputs per unit of each type of product, the cost of implementing unit price for each market segment (transport and trading costs, advertising costs), the unit price of each kind of resources assumed to be defined.

Is necessary to define, what segments of the market, what products and what volumes of offers and prices the enterprise should go to market. The purposes of the enterprise and marketing have to be realised, also constraints on the demand and production resources, and thus the expected profit from the production and sales will reach its maximum value.

3. The building mathematical model of the problem

We describe the task of market segments selection, also product volumes and prices in terms of mathematical programming. When building a mathematical model the random parameters of the model (for example, the demand for products in different market segments) are replaced by their expectations. To build the mathematical model we set a fixed time interval, i.e. the planning process is studied in a static regime. For a dynamic model we should suggest a temporary characteristics of all the variables and parameters of a mathematical model.

Let us consider the components of the proposed optimization model [4], [5].
Control variables in the model are:
x_{jf} – sales of product j in the segment f; where $j \in J_1$ – a set of products, which the company is already operating in the market; or $j \in J_2$ – a variety of products, which the company must make a decision to enter the market; $f \in F$ – a set of segments, on which the company can work with its products;
w_{jf} – boolean variables that govern inclusion in the production plan and the implementation of "new", previously developed products (indicators feasibility of entering the market with a particular product); variables $w_{jf} = 1$ if product j will be sold on the market segment and $w_{jf} = 0$ – otherwise;
q_{jf} – price per unit of product j in the segment f;
k_{jf} – boolean variables showing the fact of exceeding the estimated price q_{jf} the maximal prices q_f for the segment f;
variables $k_{jf} = 1$, if $q_{jf} \le q_f$ and $k_{jf} = 0$, if $q_{jf} > q_f$.

Consider the restrictions on the values of the control variables, which describes the conditions for the functioning of the production system.

Restriction, which guarantees the achievement of required level of profit of the production and sales, for the enterprise in the planned period has the form:

$$P_{(x,g,k)} = \sum_{j \in J} \sum_{f \in F} \left\{ \left(k_{jf} q_{jf} - s_{jf} - \sum_{l \in L} \tilde{q}_l m_{jl} \right) x_{jf} \right\} \ge P_0, \qquad (1)$$

where
s_{jf} – implementation costs per unit product j in the segment f;
$\tilde{q}_l$ – the unit price of a resource l;
m_{jl} – the rate of consumption resource l per unit of product j;
L – the set of names of production resources l;
P_o – the expected value of the enterprise profit from sales during the planning period;

$$k_{jf} = \begin{cases} 1, & if \quad q_{jf} \le q_f; \\ 0, & if \quad q_{jf} > q_f. \end{cases}$$

Restrictions to ensure the achievement of the set value to the enterprise market share for each test segment, are reduced to a system of inequalities has the form:

$$\sum_{j\in J_1} x_{jf} + \sum_{j\in J_2} x_{jf} \geq b_f E_f, \quad f \in F, \tag{2}$$

where

b_f – desired market share of the segment f;

E_f – market volume of the segment f.

Restrictions on the values in the supply of products in different segments of the market has the form:

$$\underline{a}_{jf} \leq x_{jf} \leq \bar{a}_{jf}, \quad j \in J_1, \quad f \in F, \tag{3}$$

$$\underline{a}_{jf} w_{jf} \leq x_{jf} \leq \bar{a}_{jf} w_{jf}, \quad j \in J_2, \quad f \in F, \tag{4}$$

$$\begin{gathered} 0 \leq w_{jf} \leq 1; \\ w_{jf} - \text{integers}, \end{gathered} \tag{5}$$

where

$\underline{a}_{jf}$, $\bar{a}_{jf}$ – respectively lower and upper limits of the scope of product j offerings in the segment f ($\underline{a}_{jf}$, – mandatory part of the production volume of the product j to implement it on a segment f; $\bar{a}_{jf}$ – level of effective demand for the product j on the segment f).

Restrictions on productive resources, guaranteeing not exceed the estimated resource requirements of levels of available resources, are reduced to the following inequalities:

$$\sum_{j\in J} m_{jl} x_{jf} \leq M_l, \quad l \in L, \tag{6}$$

Where M_l – the level of available resources of the form l in the planning period.

Restrictions on values of product prices written as follows:

$$\underline{q}_{jf} \leq q_{jf} \leq q_f, \quad j \in J_1, \quad f \in F, \tag{7}$$

$$\underline{q}_{jf} w_{jf} \leq q_{jf} \leq q_f w_{jf}, \quad j \in J_2, \quad f \in F, \tag{8}$$

where

$\underline{q}_{jf}$ – the lower boundary of the unit price of the product j on the segment f (for example, the cost of the product);

q_f – the marginal price of the product j on the segment f.

Optimality criterion (objective function) of the problem is to maximize the expected profit from sales during the planning period:

$$\max_{x,q,k} P(x,q,k). \tag{9}$$

As a result, we obtain the following formulation of the problem: it is necessary to find such values of control variables $x^*=||x^*_{jf}||$, $w^*=||w^*_{jf}||$, $q^*=||q^*_{jf}||$ and $k^*=||k^*_{jf}||$, which satisfy the system of constraints and provide the maximum of the objective function $P(x, q, k)$.

Optimization model belongs to the class of non-linear programming models with control variables of a boolean and continuous type [6], [7], [8].

To analyze the model we use a heuristic algorithm [4] based on the gradual increase in the values of the products prices and following solutions the tasks of partially-integer programming by the branch and bound method (the method of Land and Doig) at every stage of problem [8]. When iterative price increase (since the cost of product) the expected profit in the beginning grows due to growth in revenue. Later certain types of products for which the current price values will exceed the price limits for the segments will "drop out" of the segments. As a result, the profit growth should slow down, and from a certain iteration the profits will decrease. At a certain step of the iterative process the values of the supply volume and the products prices will meet the optimal solution, as well as a set of the remaining segments. Solution of the problem will help to optimize the choice of target segments, the range and volume of supply of products and rational food prices in each market segment; more fully into account consumer demand; maximize expected profits from sales of products and efficiency of resource use.

In addition to the basic solution of the problem may also be acquired dual assessment of products and resources that enable the management company to carry out a deep technical and economic analysis prepared variant behavior of the enterprise in the market. Dual assessment of products indicate the degree of profitability of each type of product for the enterprise. Analysis of the dual assessment of products allows the company management to select the most effective directions of investment funds on advertising, i.e. to determine what segments of the market need to work to increase effective demand for them. Dual resource assessment allow you to select the most profitable areas of investment for the enterprise funds for the purchase of additional resources in order to increase profits.

Implementation on a PC optimization model requires a preliminary decision of a number of auxiliary tasks. These problems include: the formation of the company and marketing purposes (profit, sales volume, market share of the enterprise), segmentation of the market – partitioning the entire set of consumer segments; demand forecasting; definition limits the prices at which the buyer agrees to pay for each product; the formation of norms of material consumption per unit of each type of product; forecasting level of available resources in the planning period. An analysis of the list of supporting tasks that form the baseline for the main optimization problem,

shows that for the "pleasure of optimization" to pay dearly. But, on the other hand, domestic and foreign practice of optimization calculations in management and marketing companies shows that business profits may rise by 3-8% is due to the optimization of management and marketing decisions [3].

4. The results of computational experiments solution of the problem using the system "Lindo"

4.1 Description conditional business situation

The implementation of the optimization model on the PC is part of a conditional business situation at a fixed time interval and replaced the random parameters of the system on their expectations. Let Publishing Company assumes publish and distribute printed materials on the five segments of the market, the capacity of which are given in Table 1.

Table 1. Capacity of the market segment

Name of the market segment (segment code)	Capacity of the market segment (thous. ind.)
Preschools (S1)	50
Schools (S2)	250
Colleges and Universities (S3)	160
Universal bookstores (S4)	90
Specialized bookstores (S5)	100

The desired value of profit P_0, obtained from the production and sales in the planned period, should be 30 000 rub. Here the firm suggests to control the shares on market segments, represented in Table 2.

Table 2. Planned share of the market segments

Name of the market segment	Planned share of the market segment (%)
Preschools	10
Schools	15
Colleges and Universities	20
Universal bookstores	15
Specialized bookstores	30

The distribution of alternative ("new") products by market segments is presented in Table 3. The * in the table. 3 is a potential handling this product to market.

The boundaries of the proposed demand by types of printed products in selected market segments are shown in Table 4. For each of the market segments are defined price caps on publications (see. Table 5).

Table 3. Distribution of alternative types

Product (product code)	Market segments				
	S1	S2	S3	S4	S5
ABC-book (P1)	-	-	-	-	-
Textbook (P2)	-	*	*	*	-
Collection of problems (P3)	-	-	-	-	-
Turbo C (P4)	-	*	*	*	*
The explanatory dictionary (P5)	-	-	-	-	-
Computer for Beginners (P6)	-	-	*	*	*

Table 4. Demand for publication

Product code	Lower and upper limits of demand for publication (thous. ind.)									
	Market segments									
	S1		S2		S3		S4		S5	
P1	5	15	10	25	-	-	1	5	-	-
P2	-	-	20	40	1	5	5	15	-	-
P3	-	-	10	20	5	10	1	5	-	-
P4	-	-	1	5	20	40	5	10	10	20
P5	-	-	5	10	15	30	5	10	5	15
P6	-	-	-	-	5	15	1	5	20	40

Table 5. The limit price of publication on market segments

Segment code	Price limit of publication (rubles / thous. ind.)
S1	200
S2	300
S3	300
S4	400
S5	300

The initial value of the price of publications in each of the market segments are shown in Table 6, and their stepwise increment in Table 7.

Table 6. Initial values of publication prices

Product code	The initial values of publication prices (thous. rubles / thous. ind.)				
	Market segments				
	S1	**S2**	**S3**	**S4**	**S5**
P1	100	100	-	150	-
P2	-	150	150	150	-
P3	-	200	200	250	-
P4	-	200	200	250	250
P5	-	150	150	250	250
P6	-	-	200	200	250

Table 7. The increment prices for publication on market segment

Product code	Increment prices for publication (thous. rubles / thous. ind.)				
	Market segments				
	S1	**S2**	**S3**	**S4**	**S5**
P1	5	5	-	15	-
P2	-	5	15	10	-
P3	-	10	10	10	-
P4	-	15	10	5	10
P5	-	10	15	10	5
P6	-	-	10	5	5

We are given the expected production levels of cash resources in the planning period. Rates of production resources per unit of each type of product, the cost of implementing unit price for each segment of the market, the price of each type of resource are assumed to be defined. It is necessary to determine the assortment, sales volumes and prices of publications for the market segments in which profit publishing company will be maximum.

4.2 The results of solving the problem

To solve the problem is suggested to use a heuristic algorithm based on the removal of restrictions on the prices of the publication in the optimization model and application procedures iterative increase at a constant pitch on the publication of prices. At each step of the iterative process for each product j is checked not exceed the estimated price q_{jf} its limit value q_f for a particular market segment and assigning corresponding values to factor k_{jf}. The solution obtained at each iteration (step) the problem of mixed integer programming was conducted by the branch and bound method (Land and Doig), implemented in the optimization package LINDO [9]. The dimension of the problem for the first iteration of price changes: the number of variables of continuous type – 20; boolean variable number –

10; number of restrictions – 67. Using the results of the tasks received during the iterative increase in the price of publications, we can construct a graph of profits, depending on the number of iterations (fig. 1).

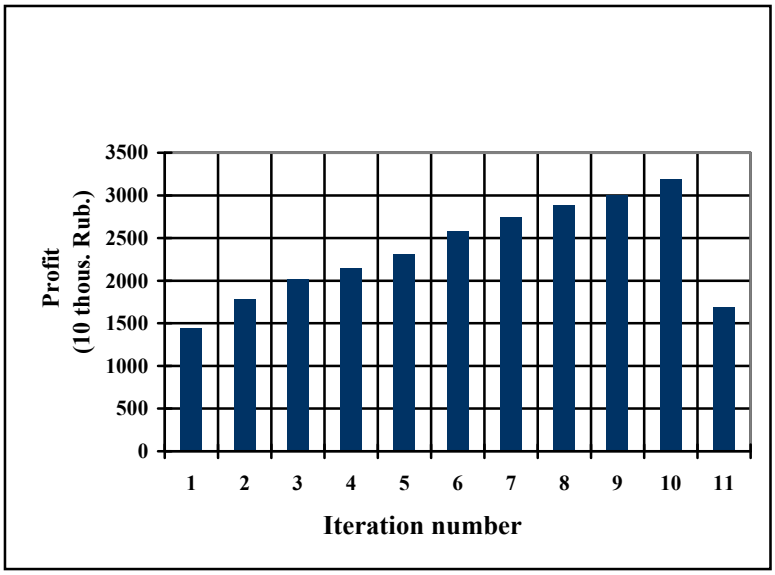

Figure 1. Graph of dependence the profit of the iteration number of price changes

When iterative price of publication increases is observed the growth of profit as long as the products begin to drop out of the market segments. When exceeding the price of the goods its limit value for the coefficient of the corresponding segment of a variable in the model objective function becomes negative, which leads to a decrease in the objective function. Values in supply and prices of publication, as well as many of the remaining segments of the tenth step of the iterative process in which the maximum profit of the company will meet the optimal solution. Values of supply volumes and prices of publications, and also set of the remaining segments of the tenth step of the iterative process in which the maximum profit of the company will meet the optimal solution.

The optimal values of print runs and the price of publications are presented in Table 8, 9.

Table 8. The optimal value of publications sales

Product code	The optimal value of sales of publications (thous. ind.)				
	Market segments				
	S1	S2	S3	S4	S5
P1	5	10	-	5	-
P2	-	40	5	0	-
P3	-	10	5	1	-
P4	-	0	40	10	0
P5	-	5	15	10	5
P6	-	-	0	1.599	40
Total	5	65	75	27.599	45

Table 9. The optimal value of publication prices

Product code	The optimal value of publication prices (thous.rubles / thous. ind)				
	Market segments				
	S1	S2	S3	S4	S5
P1	150	150	-	300	-
P2	-	200	300	-	-
P3	-	300	300	350	-
P4	-	-	300	300	-
P5	-	250	300	350	300
P6	-	-	-	250	300

Analysis of the solution obtained shows the inadvisability of work with the following alternative products – with the publication P2 on the segment S4, and the publication P4 on the segments S2 and S5.

5. Conclusions

Analysis of the results of computational experiment leads to the conclusion about the correctness of the assumptions and restrictions of examined mathematical model of the firm behavior in the market and the performance of the proposed method of solving the problem**.**

Application of operations research in the formation of marketing strategy can significantly accelerate the process of development and implementation of marketing information - analytical systems and make better marketing decisions. Proposed in the paper computing algorithms can be the basis of computer decision support systems for strategic planning marketing business.

In the future, to improve the accuracy of the solution is necessary to study the problem of determining the best price increments for products using the method of random search with training.

In addition, to improve the adequacy of the model is expected to use a stochastic approach based on the of Charns Cooper method and to build a single-stage stochastic programming model with probabilistic constraints, and the subsequent transition with a given level of risk to its deterministic equivalent.

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