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MODELING OF A CREDIT DECISION MAKING WITH TAKING INTO ACCOUNT THE CAPACITY OF THE COMPANY'S MARKET

МОДЕЛЮВАННЯ ПРИЙНЯТТЯ КРЕДИТНОГО РІШЕННЯ ПІДПРИЄМСТВОМ З УРАХУВАННЯМ ЄМНОСТІ РИНКУ

A mathematical model of the analysis of the company's activity is built in the article, taking into account the market capacity, the company's market share, the main indicators of the company's activity and the need to attract credit funds. The urgency of the research enforces the importance in the conditions of high competition in the spheres of economy and the deficit of own funds of enterprises. The mathematical dependence is established and solved the equation of the dynamics of the value of the main productive assets from the change in the time of the share of the company's market, the chosen volume of the selected loan and the corresponding interest rate. The article shows how the offered model allows to take into account the dynamics of the share of the company's market and provides the opportunity to choose a loan program for prompt response to the deterioration of enterprise performance. The work of the real enterprise on the market of household chemistry is considered, the sales volume decrease has been fixed and the target market share indicators set which the company has to achieve by applying the described model of the credit decision. To achieve the selected indicators, three different loan programs were used. In accordance with the considered credit programs, the results of the application of the chosen model were analyzed and the dynamics of the key indicators of the enterprise was compared: market shares of the company, sales volumes, net profit and fixed assets. As a result, a loan program has been identified that satisfies the selected targets of the share of the company's market most. Consequently, the proposed model for making a credit decision allows us to establish the most appropriate amount of credit and interest rate. Also, the model takes into account important indicators for the company, such as the market capacity, the company's market share and the characteristics of the main productive assets. The chosen volume of the loan, with the help of the described model, allows to achieve the established targets on the market, operating on the main financial and marketing characteristics of the company. The peculiarity of the research is in usage in the model the indicator of the company's market share, ensuring the relationship between the company's position on the market and the possibility of

attracting credit funds to the activities of the company, as well as the application of the model on the real data of household chemicals market in Ukraine.

Keywords: market capacity, market share, mathematical modeling, economic activity, main productive funds, effective activity, profit of the enterprise.

У статті побудовано математичну модель аналізу діяльності компанії з урахуванням ємності ринку, частки підприємства на ринку, основних показників діяльності підприємства та необхідності залучення кредитних коштів. Актуальність дослідження набуває особливого значення в умовах високої конкуренції в сферах економіки та дефіциту власних коштів підприємств. Встановлено математичну залежність та вирішено рівняння динаміки вартості основних виробничих фондів від зміни в часі частки ринку компанії, обраного об'єму залученого кредиту та відповідної відсоткової ставки. У статті показано як запропонована модель дозволяє врахувати динаміку частки ринку компанії та надає можливість вибору кредитної програми для оперативного реагування на погіршення показників діяльності підприємства. В роботі розглянуто діяльність реального підприємства на ринку побутової хімії, виявлено зниження обсягів його продажів та встановлено цільові показники частки ринку, які підприємство має досягти, застосувавши описану модель прийняття кредитного рішення. Для досягнення обраних показників використано три різні кредитні програми. Відповідно із розглянутими кредитними програмами проаналізовано результати застосування обраної моделі та проведено порівняння динаміки ключових показників підприємства: частки ринку досліджуваної компанії, об'ємів продажів, чистого прибутку та основних виробничих фондів. В результаті визначена кредитна програма, що задовольняє обрані цільові показники частки ринку підприємства найбільше. Отже, запропонована модель прийняття кредитного рішення дозволяє встановити найбільш доцільний об'єм кредиту та відсоткової ставки. Також модель враховує важливі для підприємства показники, такі як ємність ринку, частка компанії на ринку і характеристику основних виробничих фондів. Обраний за допомогою описаної моделі об'єм кредиту дозволяє досягти встановлених цільових показників на ринку, оперуючи основними фінансовими і маркетинговими характеристиками діяльності компанії. Особливість дослідження полягає у використанні в моделі показника частки компанії на ринку, забезпеченні взаємозв'язку між позицією компанії на ринку та можливістю залучення кредитних коштів у діяльність підприємства, а також у застосуванні моделі на реальних даних підприємств ринку побутової хімії України.

Ключові слова: ємність ринку, частка ринку, математичне моделювання, економічна діяльність, основні виробничі фонди, ефективна діяльність, прибуток підприємства.

Introduction. In the long-term period of the company operation the usual phenomenon is a gradual decrease in profits due to the moral aging of the goods. In order to keep the positions on the market, it is necessary to upgrade production from time to time, which requires additional funds. At the same time, we need to keep in mind the future demand for improved products, the market share, the behavior of

competitors, and plan for the modernization of production, and accordingly, to calculate the amount of credit funds, depending on these circumstances.

At present, there are many models for analyzing the dynamics of enterprises with the use of credit and investment resources [1, 3], organization of optimal scales of production, mutually agreed with the process of its implementation [2]. In [6], a formal model for making a credit decision for a small business, based on market volatility under the conditions of price volatility, was constructed. Obviously, in order to achieve the desired economic effect, an enterprise must also take into account its present position in the market as regards competitors. However, these models do not allow us to investigate the dynamics of enterprise development, depending on the real state of the market and the share taken into account, taking into account the functions of the utility of competitors. Taking into account this fact, [4, 5] we consider the dynamics of the company's development through reinvestment and foreign investment. However, it is not always possible to carry out modernization of production, counting only on own funds. Also, since the company is not always able to attract public investment, special attention is paid to studying banking institutions' credit programs and choosing the most appropriate for a particular enterprise.

Setting objectives. The purpose of the article is to construct a model for making a credit decision by the enterprise depending on the market share occupied, taking into account the functions of the utility of competitors and the study of the dynamics of profit depending on the size of the loan.

Methodology: methods for determining the market share, market capacity, dynamic model of enterprise development.

Research results.

The model of dynamics of enterprise development using credit resources is described by the system below of the equations:

$$C(t) = \varphi A(t),\ A_0 = A(0), \tag{1}$$

$$M^r(t) = (1 - p - c)A(t) - s(t), \tag{2}$$

$$M(t) = M^r(t) - N(t), \tag{3}$$

$$N(t) = \tau M^r(t), \tag{4}$$

$$K(t) = A(t) - \lambda M(t), \tag{5}$$

$$\frac{A(t)}{dt} = \xi(M(t) - S(t)) + (1 + \lambda)K(t) - \mu P\nu(t), \tag{6}$$

where

$A(t)$ – the average annual cost of fixed assets (FA) at the period t;
φ – indicator of return on assets;
A_0 – FA cost at the beginning of period $t = 0$;
$C(t)$ – volume of production;
p – share of unrealized output, $0 \le p \le 1$;
$M^r(t)$ – the value of the company's total profit before tax at the period t;
c – marginal cost of production;
$s(t)$ – interest rate index;
$M(t)$ – amount of net profit of the enterprise at the time t;
$N(t)$ – value of tax deductions of the enterprise at the time t;
τ – the rate of taxation of the profit of a small enterprise, for Ukraine, $\tau = 18\%$;
$K(t)$ – the size of the enterprise's credit resources at the time t;
λ – own funding factor;
ξ – the share of net profit deducted for reinvestment $0 \le \xi \le 1$;
$S(t)$ – principal repayment amount;
μ – FA exit rate, $0 \le \mu \le 1$.

The volume of production *C(t)* in terms of value should be less than or equal to the market's ability to absorb production. Therefore, we will accept such equality:

$$C(t) = P\nu(t), \tag{7}$$

where P – capacity of the investigated market, $\nu(t)$ – occupied market share of the company, which depends on the competitive interaction between firms [6]:

$$\nu_i(t) = \frac{\exp f_i(t)}{1 + \sum_{j=1}^{N} \exp f_j(t)}, \quad i = 1,...,N-1. \tag{8}$$

The equation (8) is based on the Lotka-Volterra model, which describes the competition among *N* firms in the market, $f_i(t)$ – utility functions that characterize the products of the *i*-th firm.

The general solution of the differential equation (7) taking into account the equations (2) - (8) will be:

$$A(t) = e^{-\mu t} \int_1^t e^{\mu x} [\xi(kP\nu(x) - (1-\tau)s(x) - \xi S(x)) + (1-\lambda)K(x)]dx + A_0, \quad (9)$$

where $k = (1-\tau)(1-p-c)$.

The solution of the linear differential equation (8) expresses the dependence of the value of the annual average of the FA $A(t)$ on the indicator of the share of the company in the market $\nu(t)$, which is determined on the basis of statistical studies, and the credit program $K(t)$. The required loan amount is determined on the basis of equations (1), (5), (7), (8):

$$K(t) = \frac{P}{\varphi} \frac{\exp f_i(t)}{1 + \sum_{j=1}^{N} \exp f_j(t)} - \lambda M(t). \quad (10)$$

Note that formula (10) defines the maximum amount of loan that has collateral.

On the basis of the proposed model (2) - (8), the activity of the company - one of the leaders on the market of household chemistry - was analyzed. Recently, the company's revenue has become a downtrend. A 12-month sales survey of each segment's products showed a negative dynamics in the "Softeners" segment (Fig. 1). Based on the analysis of the reasons for the decrease in demand, the decision on the need to improve this type of product. This improvement requires modernization of production. As a result, the question arose about such a level of modernization, and accordingly, the size of the loan, so that the output of the product was completely absorbed by the market.

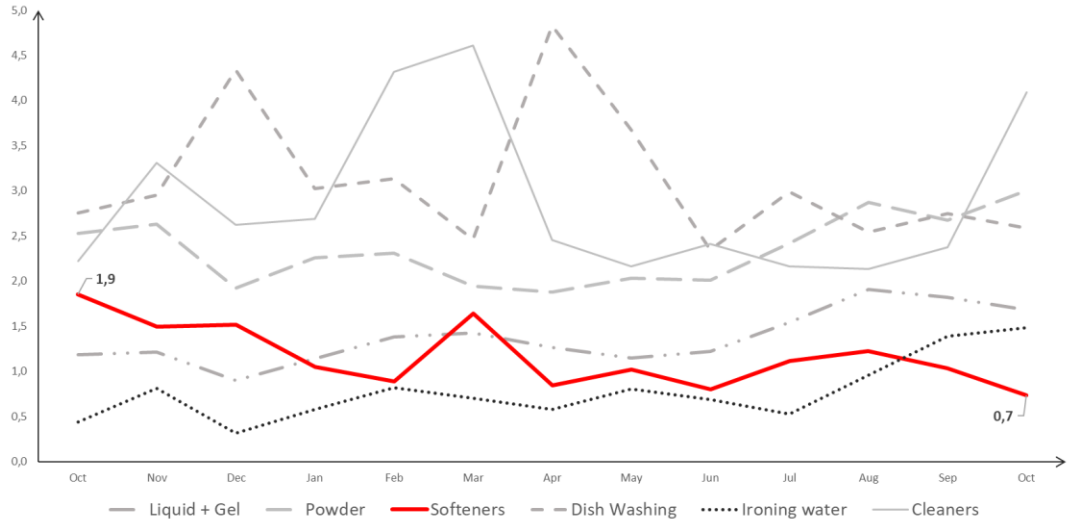


Fig. 1 – Company sales statistics for each of the market segments

Three credit programs $K_1(t)$, $K_2(t)$, $K_3(t)$ are offered for the modernization of the company's production.

The calculation of the amount of principal repayment was carried out according to the scheme

The calculation of the amount of principal repayment $S(t)$ was carried out according to the scheme

$$S(t) = \begin{cases} 0, & t \neq T, \\ K(t), & t = T. \end{cases}$$

Monthly interest payments with the interest rate r set by the bank are calculated as follows

$$s(t) = r\sum_{i=1}^{T} K(i-1) = \frac{K(T)tr(2T+1)}{T(T+1)} - kt^2 r,\ t \in [1,T].$$

It is clear that the growth of the size of fixed assets is increasing when choosing a larger loan. Figure 2 shows the graphs of the dependence of FA on time with the size of the loan selected on the terms of own financing (expressed in coefficient λ) in the amount of 18%, 15% and 10%, respectively.

However, given the main goal of the company - the coverage of new volumes of the market without detriment to the volumes of sales of other enterprises, not all of the selected credit programs will satisfy it.

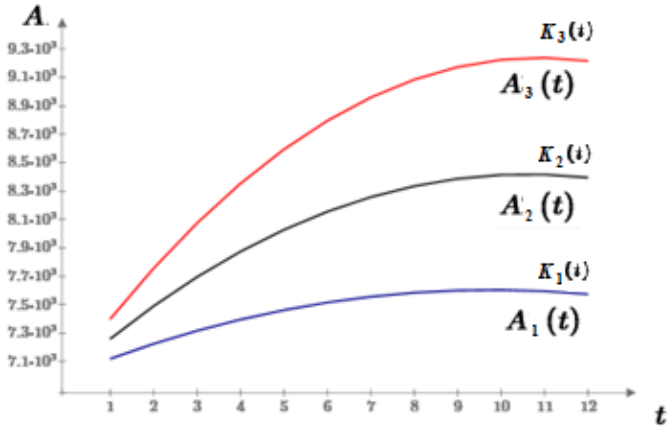


Fig.2 – Results of calculations of volume of basic fixed assets $A(t)$ *depending on credit programs* $K_1(t)$, $K_2(t)$, $K_3(t)$

In the graph (fig. 3), the dotted line indicates the lower and upper limits of the market share that can be achieved by attracting credit funds. Given this fact, from fig. 3, we see that the volume of production $C_2(t)$ supported by a loan program K_2 meets the necessary requirements.

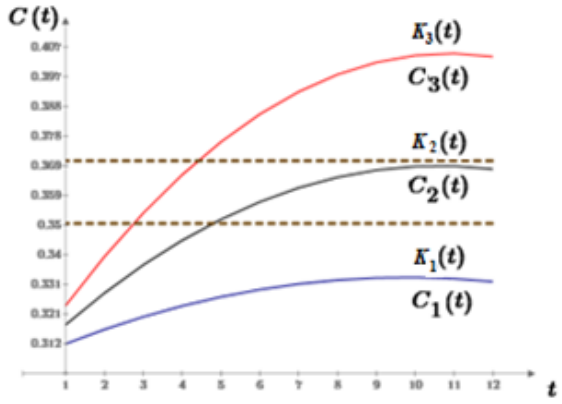


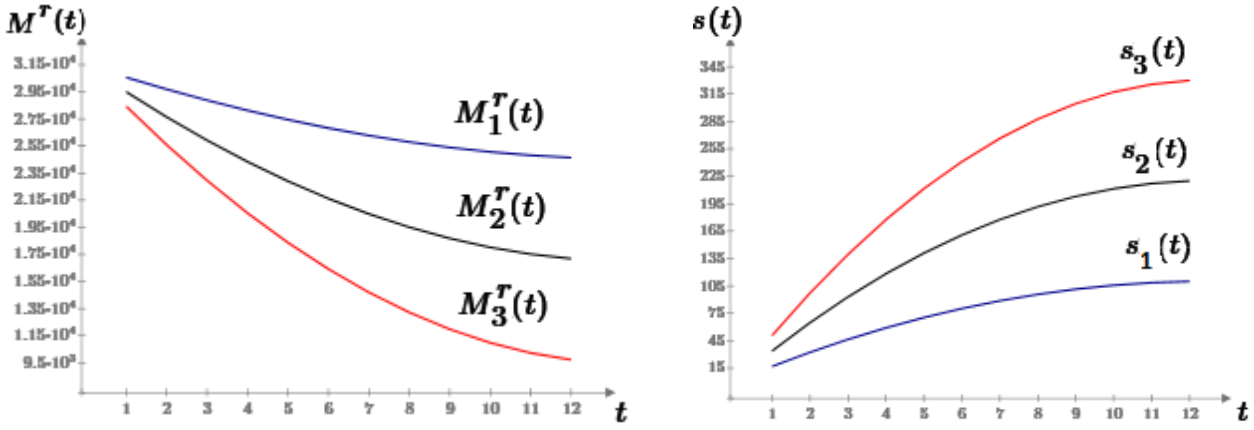
Fig.3 – Dynamics of volumes of production $C_1(t)$, $C_2(t)$, $C_3(t)$ *depending on loan programs*

The results of the comparison of the three credit programs are given in Table 1.

Table 1 – Comparative table of key indicators of an enterprise with attraction of various credit programs

	K_1	K_2	K_3
Loan size K_Σ, cur. un., $r = 11\%$	1346	2122	3681
FA size $A(0)$ at the beginning, cur. un.	7000	7000	7000
FA size $A(12)$ at the end of lending, cur. un.	7574	8395	9216
Net profit after the first month of lending $M^r(1)$, cur. un.	30573	29533	28431
Net profit at the end of the crediting period $M^r(12)$, cur. un.	24651	17192	9724

The decline in the net profit dynamics (fig. 4a) during the modernization of production is due to the fact that according to (2), net profit depends on the size of the company's market and is reduced by the size of monthly interest payments. Since, according to (6), over time, the amount of interest payments increases (fig. 4b), then the amount of net profit decreases accordingly.



a) *б)*

Fig.4 – a) dynamics of net profit, cur. un.;
b) interest rate dynamics, cur. un.

Therefore, when choosing a loan from the three options described above, it is advisable for the management of the company to choose a loan program 2, which will allow to achieve an increase in sales volumes and not violate the limitations in the permissible share of the company's market.

Conclusions: In today's Ukrainian market, the choice of an optimal strategy for their development in a market economy is of great importance for the successful and efficient functioning of the various production and distribution facilities of the country, including small enterprises. One of the most important factors in the operation and development of these objects is the efficient use of credit or borrowed funds.

Within the framework of solving the problems described above, in this model, the model was investigated and built on the basis of known approaches to the construction of models for making credit decisions and models of a small enterprise, a dynamic model for making a credit decision by an entrepreneur when changing the market of goods, taking into account existing banking systems for debt repayment and key characteristics enterprises.

The model provides the opportunity for an entrepreneur-client to determine the optimum terms and size of the required loan by the method of estimating the volume of fixed assets that will be acquired as a result of obtaining a loan.

The scientific novelty of the study is to combine the study of the market share and the model of enterprise activity, allowing to adjust the actions of the entrepreneur to achieve a specific goal in market share; as well as in the study of the obtained model on the market of household chemistry in Ukraine

References:

1. Egorova N. E. Primenenie differentsialnyih uravneniy dlya analiza dinamiki razvitiya malyih predpriyatiy, ispolzuyuschih kreditno-investitsionnyiy resurs / N. E. Egorova, S. R. Hachatryan. // Ekonomika i matematicheskie metodyi.– 2006. – №1. – C. 50–67.
2. Sherstennikov Y. V. Model Optimisation of Production, Storage and Sales of Goods/ Sherstennikov Y. V. // Business Inform. – 2013. – № 8. – C. 128-134. – Access mode: http://nbuv.gov.ua/UJRN/binf_2013_8_23
3. Sherstennikov Y. V. Model vliyaniya tempov vnedreniya innovatsionnyih resheniy na dinamiku razvitiya malogo predpriyatiya / Y. V. Sherstennikov, L. V. Romaschuk. // EkonomIka: problemi teoriyi ta praktiki: ZbIrnik naukovih prats.– 2007. – T.5 №222 – C. 468–480.
4. Zhukovska O.A. Economic and mathematical modelling of company business on the market /O. A. Zhukovska, P.A. Nikitina// Economic Bulletin..– 2017. – № 14– P. 544–552.
5. Zhukovska O.A. Model economic decisions on the optimal credit strategies under incomplete information / O. A. Zhukovska, K. O. Odintsova. // Economic Bulletin. – 2013. – №9. – P. 543–551.

6. Zhukovska O. A. Formalna model priynyattya kreditnogo rishennya malim pidpriemstvom / O. A. Zhukovska, V. V. Kovalova. // Ekonomika: problemi teoriyi ta praktiki.– ZbIrnik naukovih prats.– 2010. – T.2 №260. – P. 421–427.

7. Marasco A. Market share dynamics using Lotka–Volterra models / A. Marasco, A. Picucci, A. Romano. // Technological Forecasting & Social Change. – 2016. – №105. – P. 49–62.