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ANALYSIS OF A BASIC MODEL OF INVENTORY MANAGEMENT, BUILT USING THEORY OF COMPLEX NUMBERS AND DEVELOPMENT SOFTWARE

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The economy is widely used mathematical methods and models that can accelerate economic analysis. For ensure continuous and efficient operation of the business it is important to choose the right strategy for inventory management. Therefore the construction of economic – mathematical models needed for the success of the enterprise; develop models of inventory management using the theory of complex numbers is a promising direction for the expansion and improvement of existing models. In the article analyzed the basic inventory management model, built using the theory of complex numbers, and developed software for this model.
Keywords: theory of functions complex numbers, economic – mathematical model, inventory management, order, volume, costs, software.

Formulation of the problem. In the economic systems are widely used mathematical methods and models. They can accelerate economic analysis, increase the accuracy of calculations that best take into account the influence of factors on the performance of the company. Therefore the construction of economic – mathematical models is an important component for success of the company. The inventory management is an important part of management. Their using enables the company to maximize its revenue by optimizing inventory levels and effective using of them. Many models of inventory management developed with using various mathematical methods, but theory of complex numbers they have not been applied.

Analysis of recent research and publications. Many scholars in their writings paid their attention to the problem of inventory management, they are Lomkova E.N., Epov A.A., Efimov A.V., Sterligova A.M., Alesynska T.V., Novikov N.V., Fedoseev V.V., Plotkin B.K., Delyukin L.A., Bakanov M.I., Miller N.V., Sheremet A.D., Havruk V.A. and others.

Bold unsolved aspects of the problem. Nowadays, the question, which remains unresolved, is construction of models of inventory management with using the theory of complex variables.

The purpose of the article. The article aims are review of the basic model of inventory management, which built with using the theory of complex numbers and analysis of its results; development of software for this model.

The main material of the research. The models of inventory management is an important component of successful existence of any enterprise that work faces the availability of stocks. Their using enables the company to maximize its revenue by optimizing inventory levels and effective using of stocks.

A basic model of inventory management is the model of optimal economic size of the order, which provides the minimum value of the total costs and makes it possible to minimize storage costs on stock and helps identify the effective area warehouse. The whole number of units in the order comes at one time [3, p. 312].

Here is the formulas of the basic model of inventory management, which built with using the theory of complex numbers [4, p. 164-166].

Usually, the theory of inventory control variables are: total cost of inventory management L, costs of order K, the intensity (speed) stock consumption v, Q order size and storage costs stock s, as the most important factors. Costs for the purchase and storage costs are presented as a complex variable b_0+ib_1. The function of the total cost of inventory management looks like [4, p. 164-166]:

$$L = f(b_0+ib_1), \qquad (1)$$

where $b_0 = K\frac{v}{Q}$ – the costs of purchase; (2)

$b_1 = s\frac{Q}{2}$ – the storage costs. (3)

In the simplest case, the costs related to the purchase and storage of the following:

$$L = (a_0+ia_1)(b_0+ib_1) \qquad (4)$$

Through multiplying the factors on the right side of (4) and grouping the real and imaginary parts, we've got:

$$L = (a_0b_0+a_1b_1)+i(a_0b_1-a_1b_0) \qquad (5)$$

The result is a complex number, the real part $(a_0b_0+a_1b_1)$ is equal to L, and the imaginary part $(a_0b_1-a_1b_0)$ must be zero; due to the fact that the left side of the imaginary part not equal, that is represented by the product i_0. Thus, the function (4) is an additive model form:

$$L = a_0b_0+a_1b_1, \qquad (6)$$

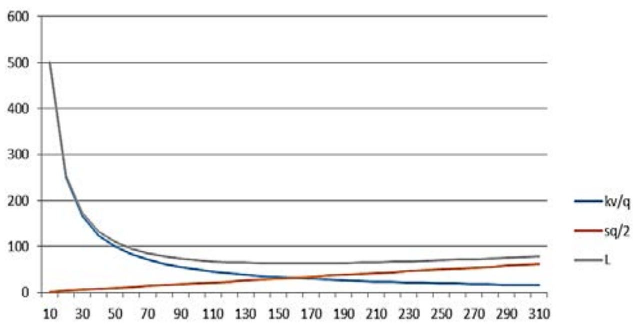

Figure 1. The graph for the task of inventory management costs

where the coefficients a_0 and a_1 are parts of a complex number.

The last fact causes characteristic properties of the proposed model. We can not use the model (6) in this case, because of the condition:

$$a_0b_1-a_1b_0 = 0 \qquad (7)$$

Solving equations (6) – (7) allows to determine the coefficients a_0 and a_1. These values also can be obtained using a direct model (4). To define this complex number coefficients of the cost, making a few basic changes:

$$a_0-ia_1 = \frac{L}{b_0+ib_1} = \frac{L(b_0+ib_1)}{b_0^2+b_1^2} \qquad (8)$$

Equality (1) is performed only if level pairs real and imaginary parts of complex numbers in its left and right sides. Expanding the brackets and grouping separate real and imaginary parts, you can get the formula for calculating each of the factors [4, p. 164-166]:

$$a_0 = \frac{Lb_0}{b_0^2+b_1^2} \qquad (9)$$

$$a_1 = \frac{Lb_1}{b_0^2+b_1^2} \qquad (10)$$

These formulas can not only find the numerical values of coefficients for known values of costs, but also to the economic interpretation of the values of each of the coefficients a_0 and a_1 [4, p. 164-166].

$$a_0 = \frac{LK\frac{v}{Q}}{K^2\frac{V^2}{Q^2}+s^2\frac{Q^2}{4}} = \frac{LK\frac{v}{Q}}{\frac{4K^2v^2+s^2Q^2}{4Q^2}} = \frac{LKv}{Q} \times \frac{4Q^2}{4K^2v^2+s^2Q^2} = \frac{4LKvQ}{4K^2v^2+s^2Q^2} \qquad (11)$$

$$a_1 = \frac{Ls\frac{Q}{2}}{\frac{4K^2v^2s^2Q^4}{4Q^2}} = \frac{LsQ}{2} \times \frac{4Q^2}{4K^2v^2+s^2Q^2} = \frac{2LSQ^3}{4K^2Q^2+s^2Q^2} = \frac{2LsQ}{4K^2+s^2} \qquad (12)$$

It follows from (9-10) ratio a_1 reflects the change in costs for the purchase of stocks, and the coefficient a_0 reflects the change in the cost of storage inventory. Therefore, we can name these

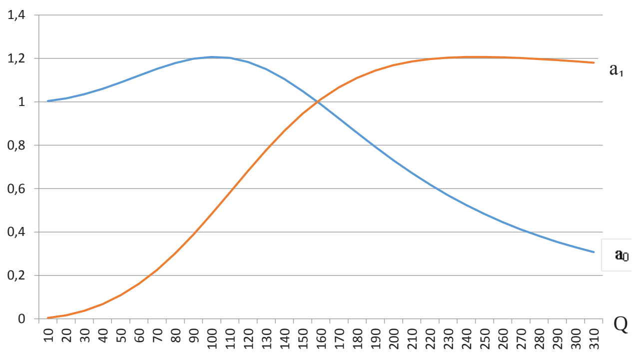

Figure 2. The graphs of changes coefficients a_0 and a_1

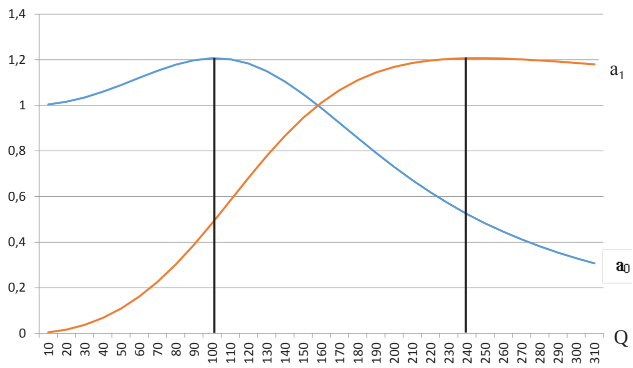

Figure 3. The domain of the function a_0 and a_1

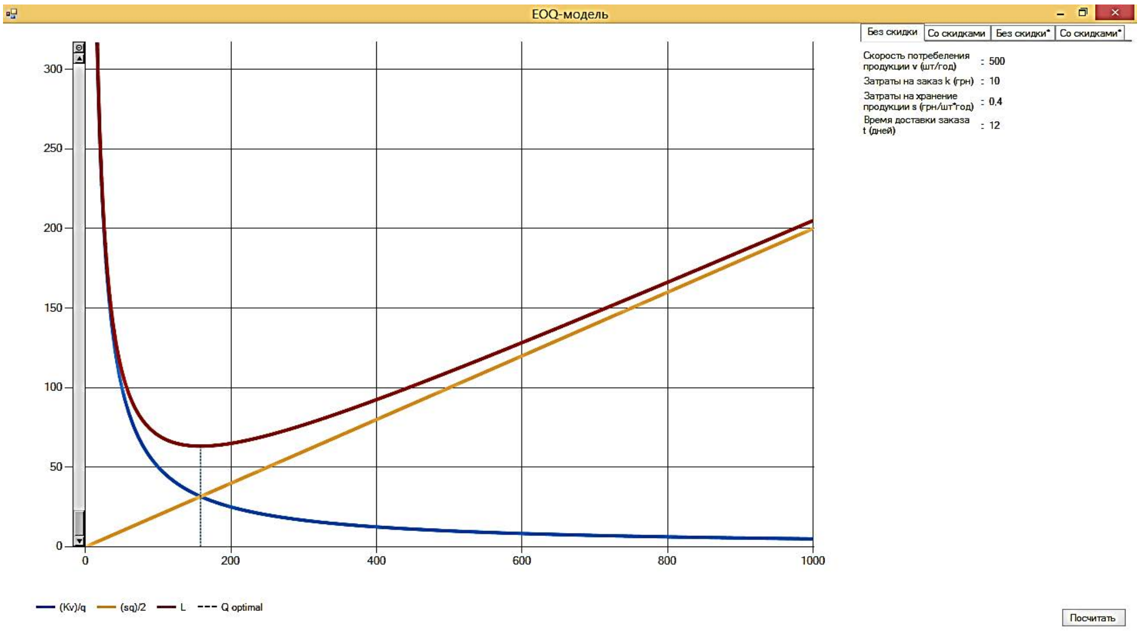

Figure 4. The program's interface

factors cost ratios for the purchase and storage respectively.

Consider the verge of change of these factors depending on changes in the cost or the supply or on storage, scilicet:

$$a_0 = f(\frac{Kv}{Q}), \quad (13)$$

$$a_1 = f(\frac{sQ}{2}). \quad (14)$$

The coefficients a_0 and a_1 behave differently. The limits of these coefficients will be equal:

$$\lim_{Q \to 0} a_0 = 0, \quad (15)$$

$$\lim_{Q \to \infty} a_1 = 1. \quad (16)$$

Therefore, taking into account the asymmetry behavior of factors, they should be consider separately.

For illustrative analysis coefficients storage costs and the purchase, we will consider a specific example of solving the problem of inventory management and build graphics for it. Background tasks are taken from the source [1, c. 137]. They are: the demand supply of stock ν = 500 pc. per year, the costs of order K = 10 UAH., the costs of storage reserve s = 0,4 UAH. / pcs. * year.

Construct a graph for the task of inventory management costs (Figure 1) and a graph of the coefficients a_0 and a_1 (Figure 2) [4, p. 164-166].

Analyzing the graph of coefficients a_0 and a_1, we can conclude that the curves coefficients a_0 and a_1 behave in different directions.

The curve for factor of costs for the purchase a_0, with increasing order size Q, has such behavior: curve initially increases, reaches its maximum and begins to decrease rapidly, then intersects with the a_1 and the curve continues to decrease, tending to zero. With the required Q factor a_0 approximately equal to 1. When the purchase costs are maximum, coefficient a_0 will reach its maximum.

With the increasing size of the order Q curve for factor storage costs a_1 starts to grow, intersects the curve a_0 and rising to its peak, then gradually reduced, striving for unity. With the required Q factor a_1 is approximately equal to 0. The maximum storage costs reaches the maximum coefficient a_1.

The values of coefficients a_0 and a_1 at their maximum points approximately equal to each other [4, p. 164-166].

Limit allowable area for coefficients a_0 and a_1 (Figure 3).

Thus, the domain of the function a_0 and a_1 can be limited only by the values of the party supply volumes corresponding to a maximum value ratios. The coefficient a_1 is steadily growing, and the coefficient a_0 – subside. This is because the volume of deliveries of parties that has the same values that are not included in this segment, is absolutely not acceptable, because these costs are very high.

For a visual presentation solutions, automation of the study parameters and analysis of the results for tasks of inventory management was designed software. The software was created by the software environment Microsoft Visual Studio 2013 programming language C#. This product is a desktop-application and operates on any computers running the Windows 98 operating system (NT) and above.

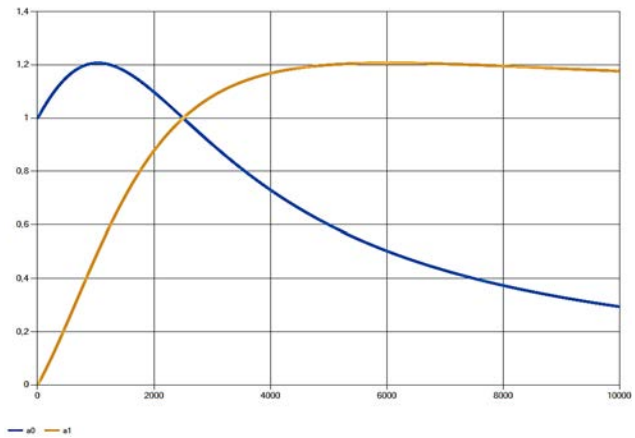

Figure 5. The graphs of changes coefficients a0 and a1

The main window and the main interface of software you can see in Figure 4.

On a separate tab shows graphs for curves of costs for the purchase and storage of stocks (Figure 5).

The developed software is a tool that provides an accessible form numerical solution for problems of inventory management with flexible customizable for all basic parameters of the problem.

Conclusions and suggestions. In the article reviewed a basic model of inventory management, which built with using the theory of complex variables, obtained and analyzed the results of the model. Also for this model, developed software that represents a clear and convenient graphical visualization of the results of the algorithms and allows to investigate the behavior of the coefficients a_0 and a_1. This software can be used for the practical solution of problems of inventory management.

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АНАЛІЗ БАЗОВОЇ МОДЕЛІ УПРАВЛІННЯ ЗАПАСАМИ, ПОБУДОВАНОЇ З ВИКОРИСТАННЯМ ТЕОРІЇ КОМПЛЕКСНИХ ЧИСЕЛ ТА РОЗРОБКА ПРОГРАМНОГО ЗАБЕЗПЕЧЕННЯ

Анотація
В економіці широко використовуються математичні методи і моделі, що дозволяють прискорити проведення економічного аналізу. Для забезпечення безперервного та ефективного функціонування підприємства важливим є вибір правильної стратегії управління запасами. Тому побудова економіко-математичних моделей необхідна для успішної діяльності підприємства, а розробка моделей управління запасами з використанням теорії комплексних чисел є перспективним напрямком для розширення та вдосконалення існуючих моделей. У статті проаналізована базова модель управління запасами, побудована із застосуванням теорії комплексних чисел, а також для цієї моделі розроблено програмне забезпечення.

Ключові слова: теорія комплексних чисел, економіко-математична модель, управління запасами, замовлення, обсяг, витрати, програмний продукт.

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АНАЛИЗ БАЗОВОЙ МОДЕЛИ УПРАВЛЕНИЯ ЗАПАСАМИ, ПОСТРОЕННОЙ С ИСПОЛЬЗОВАНИЕМ ТЕОРИИ КОМПЛЕКСНЫХ ЧИСЕЛ И РАЗРАБОТКА ПРОГРАММНОГО ОБЕСПЕЧЕНИЯ

Аннотация
В экономике широко используются математические методы и модели, позволяющие ускорить проведение экономического анализа. Для обеспечения непрерывного и эффективного функционирования предприятия важен выбор правильной стратегии управления запасами. Поэтому построение экономико-математических моделей необходимо для успешной деятельности предприятия, а разработка моделей управления запасами с использованием теории комплексных чисел является перспективным направлением для расширения и совершенствования существующих моделей. В статье проанализирована базовая модель управления запасами, построеная с применением теории комплексных чисел, а также для этой модели разработано программное обеспечение.

Ключевые слова: теория комплексных чисел, экономико-математическая модель, управление запасами, заказ, объем, затраты, программное обеспечение.