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Complex System Of Optimization And Decision Support For Logistics System With Reverse.

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ABSTRACT

The system of optimization and support of decision-making for a logistic system with a reverse which allows to build reasonable, most expedient administrative decisions for participants of the market of delivery of water to houses and offices (HOD – Home & Office Delivery), taking into account reversive character inherent in it is presented.
Keywords: decision support system, stockpile management, reverse, joint costs, optimization, minimization of expenses, insurance stocks, service level.

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INTRODUCTION

The key feature of HOD marketis several times excess of container cost over product cost, therefore it is necessary to develop such economic-mathematical model decision-making supportthat would consider a container recycling, dimensional characteristics of goods and will solve the following problems:

− preservation and enhancement of client base,
− reduction of various costs,
− improvement of customer service's quality,
− effective stocks' management.

In this regard authors have developed the complex system of optimization of expenses and decision-making support on stockpile management covering all cycle of storage and movement of goods and a container between warehouses and consumers [2].

MATERIAL AND METHODS

Optimization of a logistics system

The reverse is a broad concept that covers logistics management and activities to reduce and eliminate dangerous and non-hazardous losses of tare and products in their reverse movement. Recycling of tare from mineral drinking water for the supplier firm is a functionally dependent factor in the expansion of the sales market. To optimize the logistic system, it is necessary to determine the criteria that the company puts at each stage of its development, while the most important from the point of view of the strategic management of the company we consider, the indicators of total costs for managing the stocks of expensive containers.

The task of minimizing the total logistic costs is set in cases when the company plans to enter a new sales market.

Adaptation of classical model of stockpile management under real logistic process with a reverse

Authors' interpretation of the adapted classical model of inventory management under the real logistical process with a reverse is described in detail below.

The structure of total costs for inventory management is:

$$C_i = C_{iPg} + C_{iO} + C_{iSt} + C_{iD} + C_{iL} + C_{iRp}, i = \overline{1,m};$$

$$C_{SC} = \sum_{i=1}^{m} C_i = \sum_{i=1}^{m} \left(C_{iPg} + C_{iO} + C_{iSt} + C_{iD} + C_{iL} + C_{iRp}\right),$$

where C_{SC}- the sum of total logistic costs for all warehouses of the company; C_i- the sum of the total logistic costs of the i-th warehouse; C_{iPg}- the cost of purchasing goods; C_{iO}- the cost of ordering; C_{iSt}- storage costs;C_{iD}- losses from deficiency; C_{iL}- latent costs; C_{iRp}- the cost of return and storage of the reverse packaging; m– number of warehouses.

Let's consider consistently the components of total costs. Since there is no sales activity between the central and regional warehouses, the goods enter the regional warehouse without changing the price. Thus, the cost of purchasing C_{iPg} products from the central warehouse is reduced to zero, they are included in the cost of the goods at the stage of purchase at the distribution center. In this regard, all regional sales divisions trade at uniform prices set by the central warehouse. Latent costs will not be taken into account, since their influence is unimportant. Losses from the deficit are not available in this study, as the central warehouse maintains a full range, sufficient for the company.

Minimization of expenses of the main articles of costs

To minimize the costs of the main items of costs, it is necessary to search for a minimum relative to the volume of shipments of products to the i-th warehouse, that is of the quantity q_i. Thus, for a company with a network structure, the objective function of minimizing costs is set as:

$$C_{SC} = \sum_{i=1}^{m}(C_{iO} + C_{iSt} + C_{iRp}) = \sum_{i=1}^{m} C_{iO} + \sum_{i=1}^{m} C_{iSt}(q_i) + \sum_{i=1}^{m} C_{iRp}(q_i) \to \min,$$

$$C_{SC} = \sum_{i=1}^{m} C_{iTC}(q_i) \to \min,$$

where C_{iTC}- the total cost of storage of goods and return packaging.

Limitations of the linear programming model for the calculation of costs in a warehouse have the following form:

$$C_{iO} \leq C_{iTC}(q_i), i = \overline{1, m},$$

$$q_i \times C_U \geq C_{iO}/k, \overline{1, m},$$

where C_U is the cost per unit of output, rub; q_i- the volume of the delivery schedule for the i-th warehouse, pcs.; k- coefficient of profitability of delivery of a consignment of goods (usually in practice values from 1% to 5% are taken).

Consider the summands separately and define the minimization function for one regional warehouse. The total cost of storing products in a warehouse consists of two types of costs: storage costs C_{USt} and lost profit C_P: $C_U = C_{USt} + C_P$.

For their calculation, the introduction of additional parameters is required: r- the annual rate of growth in the market, r> 1, l- the monthly realization from the warehouse of the goods, pcs., A- the cost of storing of unit of production, taking into account the occupied warehouse area, t- the time period, month. It should be noted that the quarterly sale of products from the warehouse is uniform, since the fluctuation in demand is 0.1%. Also the fixed storage area S_i in the product warehouse is a constraint on the volume of delivery and the amount that allows to optimize costs. In this case, the area occupied by the packaging of the goods, and the area occupied by the empty bottle, will be designated respectively s and s_{Rp}, and the total demand for the goods at the i-th warehouse for the year is Y_i.

Then the optimization function of total storage costs for the i-th warehouse will look in accordance with the formula:

$$C_{iTC}(q_i) = \sum_{f=1}^{t}\left(q_i^f - l_i^f\right) \times (rC_U + A) \to \min$$

under the following restrictions:

$$\textstyle\sum_{f=1}^{t}\left(q_i^{f-1} - l_i^f + q_i^f\right)s + s_{Rp}^{f-1} \leq S_i, \sum_{f=1}^{t} q_i^f \geq Y_i.$$

$$q_i \geq q_{\min}, q_{\min} > 0, i = \overline{1, m}, t = \overline{1,12},$$

where $q_{\min}$ is the minimum batch of delivery of products, pcs.

The calculation of real costs for the delivery of products and the return of containers requires a study of the method of delivery. There are several ways of delivery: by private transport and by rented. The definition of the service provider should be the result of calculating the cost optimization model for the delivery of products and the return packaging to the regional warehouse [3].

Enterprises that provide transport have two systems for calculating the cost of delivery: by kilometers and by hours. Let's define the cost of delivering goods by private and by rented vehicles.

The choice of the method of product delivery is based on the minimum value of the cost indicator for ordering from the warehouse, determined from the expression:

$$\begin{cases} C_{iot} = L/100 \times p \times e + C_{ce,} \\ C_{ilm} = L \times v, \\ C_{ilh} = H \times z, \end{cases}$$

where C_{iot}- costs for own transport; C_{ilm}- costs for leased vehicles, based on payment for mileage; C_{ilh}- costs for leased vehicles, based on hourly charges; L- distance from the distribution center to the regional warehouse, km; p-cost per liter of gasoline, rub/l; e- average fuel consumption per 100 km, l; $C_{ce,}$- constant expenses for transport service, rubles, v- cost of kilometer of mileage of the leased truck, rubles/km; H- time from distribution center to regional warehouse, hour (at an average speed of 60 km/h); z- the cost of an hour of a rented lorry, rubles/hour.

The reordering interval (T_i) of the batch of products for the planned period (year) for the i-th warehouse is calculated according to the formula:

$$T_i = \min\left\{\frac{q_i}{Y_i}\right\}, i = \overline{1, m},$$

where Y_i is the annual consumption of products at the i-th warehouse, pcs.

The result of application of the proposed model is the data that is the input to the decision-making system that optimizes the costs of inventory management in the company at the stage of moving and storing the products and the return container between the central warehouse and the warehouse of the regional office [1].

RESULTS AND DISCUSSION

Decision supportfor two types of levels of service

At the next stage of building an integrated system of optimization and decision-making for a logistic system with a reverse, we will consider one of the top priorities of HOD market companies: duly and high-quality delivery of water to existing and new customers. It is always necessary for a company to have in addition to already ordered products a certain insurance stock for potential customers.

The starting point in modeling the calculation of insurance stocks is the choice of the criterion as the upper limit for the calculated indicator. This can be the probability of working without a deficit, otherwise called the level of service of the first kind (cyclical), or the indicator of missed demand; it is also an indicator of the saturation of demand, called the level of service of the second kind. It is obvious that there is a connection between the first and second indicators. In addition, it is worth mentioning that given level of service is most often chosen; it is based on market expectations or from the calculation of costs for storage of insurance stocks. As a result, the level of service is usually based on some popular figure from 90 to 99 percent and rarely carries an economic justification.

It should be noted that if the demand forecast is not shifted in one direction or another from the real and the distribution of demand is normal, then to ensure high levels of service (95% or more), the level of insurance stocks should be slightly larger than the largest deviation of the forecast from sales in recent history.

Safety stock

The analytical expression of insurance stocks has the following form:

$$SS = z\sigma, \tag{1}$$

where z is calculated for each service level value.

For the service level of the first kind, the formula for calculating z is the inverse standard deviation formula.

With the level of service of the second kind, it is necessary to know the inverse standard loss function for calculating z, which shows how much of the demand (in physical units) at a given level of service of the second kind is lost in the form of missed demand (unsatisfied customers).

For the standard loss function, there is no explicit expression, so there are two ways out of this situation:

- use the tables to find z by the inverse standard loss function,
- numerically solve the equation for the selection of z roots (for example, by the secant method, to which the emphasis is made).

Since replenishment of stocks does not happen instantly, it takes time to plan and produce the order, deliver the products. Accordingly, insurance stocks should be increased in proportion to the time interval from the registration of the order and before it arrives at the warehouse. This time interval in itself is a probabilistic value, depending on the stability of production, carriers, etc.

The model mentioned above (1) is extended to a system in which the delivery period to the warehouse is provided. This time interval is determined by the average transportation time L and the planning horizon R, then the size of the insurance stocks can be estimated using the formula:

$$SS = z\sigma\sqrt{L+R}. \tag{2}$$

Planning horizon role in system

A significant role in the system is played by the planning horizon R. When switching from a fixed planning horizon to a sliding volume of insurance stocks decreases by more than 60%. Naturally, not every production can simply go from a fixed horizon to a sliding horizon, especially if the planning system MRP and MRP-II is used. But this is usually a giant company, which is not considered in this study.

At the time of R will be influenced by another significant factor: the minimum batch size specified by the supplier or the economically justified order size calculated by the company's specialist. At the same time, it is obvious that with large purchases, most of the time in the warehouse will be a significant number of products and the probability of a deficit will arise only at the very end of the period. This means that with an increase in the volume of purchases and an increase in R, the level of service will also increase, but not free of charge, but at the expense of the working capital cost.

Delivery shoulder role in system

The second important indicator involved in the calculations is the shoulder of the supply L. It contains a significant part of the insurance stocks. Naturally, the shorter the supply arm is, the lower the insurance reserves are. Obviously, insurance stocks will also be affected by the stability of suppliers, which is much more difficult to influence from the point of view of management than the choice of suppliers by geographic preferences.

The indicator of the standard deviation of demand is a measure that reflects the degree of awareness about demand. The standard deviation depends both on the quality of the work of the forecasting department and on the uncertainty of demand. It should be noted that the formula for calculating insurance stocks is extremely sensitive to the adequacy of forecasts and suggests that before optimizing insurance stocks, work is needed to be done in order to improve the quality of forecasting. In addition, the formula (2) for the calculation of insurance stocks assumes that the time L is distributed normally, because taking into account the peculiarities of the HOD market, it is not expedient to work with the supplier using the "deferred orders" system initially. To calculate the standard deviation, we need to estimate the average demand and its standard deviation from the forecast.

There are several methods for calculating the root-mean-square deviation depending on the analytical support in the literature, that is, if there are data on sales, but information about the forecast is not available, then we use the standard deviation of the sales data; if there is information about future demand, then - the standard deviation of demand from the forecast. The developed program provides both options, including the calculation of the forecast itself based on adaptive methods for the multiplicative model with the possibility of updating the data.

For the level of service of the first kind, it is sufficient to analyze the frequency of falling to zero the level of stocks in the stock of products for the past periods ($R + L$ should be chosen as the window for analysis). For example, we use weekly rolling scheduling and provide direct deliveries within a few hours to the closest customers. If for any warehouse for a year we observe 7 weeks, when there was a deficit, then the current level of service will be equal to $1 - (7/52) = 87\%$.

It should be noted that the level of service is a value specified for the two sides of the interaction. In this case, we average for all customers in the warehouse, using the average delivery time of L.

CONCLUSIONS

The considered models have existed for half a century, however, the practice of their application shows that there is no revolutionary way to introduce modern models of stock optimization, bypassing the basic components of effective organization of supply chain management, especially for HOD market companies, whose main interest is timeliness and quality of service delivery to deliver water to homes and offices.

Thus, the authors developed a comprehensive universal reserve management strategy with reverse logistics, which can be used by any distributor operating in the HOD market.

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