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MODEL OF STOCK CONTROL AT SCRAP PROCESSING ENTERPRISES

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Abstract: For the effective functioning of scrap processing enterprises and optimization of the production capacities it is necessary to predict the optimal level of production stock based on logistical approaches and studying the demand for products. The paper proposes the model of stock control at scrap processing enterprises. It is considered that scrap processing enterprises are often functioning at the oligopsony market. It has been determined that the scrap market is a typical example of the oligopsony market. In the oligopsony market, enterprises are usually in a state that can be considered a state of equilibrium, when none of the market players is profitable to break this balance. Changes in market prices or price policies should be deliberate and justified. The relation of pricing models and stock control models at enterprises are considered. By regulating its price, the company can significantly and quickly change the number of scrap stocks. It is stated that an enterprise having its pricing system should track the number of scrap stocks. The method of stock controlling at the enterprise by changing its pricing policy is proposed. The model considers the expected value of demand, the price elasticity of supply and demand, storage costs, the stock volume at the warehouse and the specific loss due to unsatisfied demand. The inventory management model is based on modern models of scrap price forecasting, is an optimization model and is based on it proposed the algorithm for the functioning of the computer-aided system of stock control.

1 Introduction

One of the problems of improving the enterprise is related to the efficiency of its stock control. An unreasonable largeness of stocks can lead to freezing the assets of the enterprise [1]. Moreover, it is associated with high storage costs and the risk of moral and physical depreciation [2]. On the contrary, the low level of stock can lead to the situation when the enterprise will not be ready to meet the current demand and it will lose a part of its clients [3] which will have a significant impact on the financial state.

Processes of stock control are the component part of the enterprise control system; that is why, their efficiency is characterized by such an important criterion as the value of costs appearing within the stock control. Independently applied traditional parameters – volume of stocks, resource turnover, continuity of supply – cannot unambiguously determine the level of increasing the effectiveness of the system of stock control, since they are the part of the common criterion – costs.

Models of stock control are differently specified depending on their application area. Evidently, it is determined by the specific feature of the market itself. For instance, “Ferrous and nonferrous scrap markets, when regional rather than global in scope, may have many sellers but only a few buyers, and so provide examples of oligopsony” [4].

The specifics of the oligopsony market are that the number of buyers in the market is limited and the market is usually already divided. If one of the oligopsony companies starts to change its price policy, it can cause a reaction of competitors, so often in such market changes are rare. It is usually not advantageous for any of the players to upset the balance.

We are considering a stock management model for scrap processing enterprises based on price policy. The purpose of this paper is to develop a model of stock control at scrap processing enterprises, in particular, and for the players of the oligopsonic market as a whole.

2 Methodology

Nowadays it is impossible to increase the efficiency of the enterprise control in general without application of the advanced computer-aided systems and software products [2]. Experience shows that computer-aided systems of the enterprise control are expensive; and not every enterprise can afford to implement them in practice.

Let us apply the model of stock control with the continuous control of the level of stock; this system means that every time when the stock level is reduced to the level r, the order for the quantity Q is applied. In our case the essence of the order of the quantity Q is to provide such terms of the contract which would allow for replenishing the raw stock by the quantity Q.

Problems related to the issues of stock control have been studied by many scientists and experts [2,5-8]. These authors developed a number of methods and models of stock control to be used by enterprises and various resources. Let us consider some of them.

The main systems of stock control are the system with continuous control and the system with periodic check-ups [8].

Within the periodic check-up system, the stock estimation is made periodically (once a day, week, month); and depending on the level of the available stock the order of a definite batch of products is submitted.

If a computer-aided system of accounting is available, the system of stock control can be based on the model of stock control with the continuous control of the level of stock; this system means that every time when the stock level is reduced to the level *r*, the order for the quantity *Q* is applied. To develop a computer-aided system of stock control, the model with the continuous control was chosen which was proposed by Hadley and Whitin [8] and corrected by the excess demand. Moreover, this model is modified by the value of transport expenses and differential discounts depending on the order volume.

The latter condition is extremely important for any enterprise since the possibility of buying a greater volume of products at a lower price helps to reduce the costs. In certain cases, the reduction turns to be essential.

Advanced models differ significantly by complexity from those existing two decades ago. Liang-Tu Chen and Chun-Chin Wei (2009) state in [9] that “The objective of the model is to jointly determine the optimal selling price, base-stock level, and inventory cycle over an infinite planning horizon so that the net profit per time unit in the channel is maximized. The profit-maximizing problem is formulated as a multivariate optimization model, solved by an iterative search process combined with an enumeration scheme. In addition, the saving-sharing mechanisms, through return, target sales rebate, and feature price discount, will also be developed so that win-win can be achieved between vendor and buyer. Special emphasis is placed on the comparative study between the proposed optimization models that are based on the coordinated and decentralized policies between vendor and buyer in the channel”.

The proposed model is based on the possibilities of modern economic, mathematical and econometric devices. The inventory management model is based on a model of the relationship between global metal prices and scrap prices of this metal [10-18]. Because metal scrap prices change more slowly than metal prices on the world market, we can predict prices. Knowing about the upcoming price change, we have the opportunity to manage stocks. The article has developed a stock management model that optimizes the potential benefits.

2 3 Result and discussion

To build a model of stock control at oligopsony, the scrap metal market uses the approaches of authors studying macroeconomic systemic changes. [2,7,10,15,19].

Similarly, let us consider the model taking into account the necessity of simultaneous tracking the change of volume and prices in time, but let us introduce certain allowances without loss of generality: unsatisfied demand is accumulated, distribution of demand-supply values within the considered time unit is stationary (unchangeable) in time.

In order to determine the function reflecting the total costs referred to the time unit, the following designations are introduced.

$f(Q_D)$ is the density for distribution of demand D within the delivery time,

$M[Q_{Dt+1}]$ is the expected value of demand between time instants *t* and *t*+1,

$h(\varphi_i)$ are storage costs (per unit of product within the time unit),

p is the specific loss due to unsatisfied demand (per unit of the product within the time unit),

$M[Q_{St+1}]$ is the expected supply,

$Q_S = E(x)$ is the function of supply variation from the price x,

φ_i is the stock volume at the warehouse at the instant *i*.

The optimization criterion is the cost function within the time unit which is combined of:

1. Expected storage costs. The average level of stock between time instants *t* and *t*+1 is $M[\varphi_i]$, where $i = [t, t+1]$.

Therefore, the expected storage costs per time unit are $h(\varphi_i) \cdot M[\varphi_i]$.

2. The cost of necessary stock volume for meeting the consumer demand. The initial proposition should be the tendency to the equality $M[Q_{Dt+1}] = \varphi_t + M[Q_{St+1}]$; however, both Q_{Dt+1} and Q_{St+1} are random values with the corresponding distribution functions. Without loss of generality, let us consider only the period for which the demand for raw material is known ($\hat{Q}_{Dt+1}$). Under specific functioning of scrap processing enterprises, it does not impose any restrictions for the stated task as a whole, since consumers of the scrap processing products make contracts with the limited time of obligation discharge. Then the cost of the necessary stock volume for meeting the consumer demand is equal to the cost of the stock volume $\hat{Q}_{Dt+1} - \varphi_t$. It should be noted, that within solving the task of stock control it is required to support the insured stock level at the warehouse. Therefore, introduction of the system of stock control will lead to the following situation: after production meets the demand for raw materials, there should be the insured reserve φ_{cmp} at the warehouse. Therefore, the cost of the necessary stock volume for meeting the consumer demand should be equal to $x(\hat{Q}_{Dt+1} - \varphi_t + \varphi_{cmp})$; and in case when $\varphi_t < \varphi_{cmp}$, the stock level should be supplemented up to the insured level.

3. Expected losses related to the unsatisfied demand. The deficiency appears at $Q_{Dt+1} > \varphi_t + Q_{St+1}$. If a scrap processing enterprise sets the price by following a certain enterprise policy that provides the long-term demand-supply equilibrium, then a random value Q_{Dt+1} - Q_{St+1} should be considered. The enterprise is interested in diffusing all random impacts on the result of its activity. Formation of the price policy is one of its stimulating tools. As a result, many authors note the dependence of scrap prices at the local market (in particular, in Russia, on world prices of metal [10-20].

With account of the stated above, the expected losses per time unit will be equal to (1):

$$S = \int_{\varphi_t+\varphi_{cmp}}^{\infty} (Q_{Dt+1} - Q_{St+1} - (\varphi_t + \varphi_{cmp})) f(Q_{Dt+1} - Q_{St+1}) d(Q_{Dt+1} - Q_{St+1}) \quad (1)$$

Since the model implies that p is proportional to the deficiency volume, the expected losses related to the unsatisfied demand are equal to pS.

The resultant function of total losses per time unit TC is the following (2)

$$TC = h(\varphi_i) \cdot \mathrm{M}[\varphi_i] + x_i \cdot (\hat{Q}_{Dt+1} - \varphi_i + \varphi_{cmp}) + pS \quad (2).$$

The first component in this equation for scrap processing enterprises is mainly the constant value equal to the cost of warehouse keeping; the second component is the function of the price for raw material (scrap), the third component is characterized by the random value Q_{Dt+1} - Q_{St+1} which changes its parameters within variation of the scrap price x.

Therefore, the problem of stock control at the scrap processing enterprise is reduced to solving the following task (3):

$$\hat{Q}_{Dt+1} \cdot y - TC \rightarrow \max \quad (3).$$

In order to make the probability of losses related to the unsatisfied demand not exceeding 0.1% the value φ_{cmp} should be chosen so that $P(Q_{Dt+1} - Q_{St+1} \geq \varphi_{cmp}) \leq 0.1\%$; that is, to choose x so that the distribution function for the random value Q_{Dt+1} - Q_{St+1} could meet the condition $F_{Q_{Dt+1}-Q_{St+1}}(\varphi_{cmp}) \leq 0.1\%$. In this case, the main expenses will be related to keeping the insured stock volume that in turn is reduced as the uncertainty related to Q_{Dt+1} - Q_{St+1} is decreased, which can be achieved by the effective choice of x.

One should also take into account the specific features of enterprises for which the system is developed. Since the demand and supply for scrap are seasonal, it should be in some way considered.

Basing on statistic data, one should assess the influence of the season pattern and choose such a system of pricing for contracts that will allow for minimizing the dispersion Q_{Dt+1} - Q_{St+1} which will in turn decrease the costs of formation and keeping the necessary stock level.

The algorithm for functioning of the computer-aided system of stock control is as follows:

1. In accordance with the pre-assigned sampling, the dependence of Q_{Dt+1} - Q_{St+1} on x (scrap price) and y (price of metal at the world market) is determined, or, to be exact, it is the character of the random value Q_{Dt+1} - Q_{St+1} depending on the deviation of x from the long-term equilibrium.
2. The deviation of the observed stock level from the insured level is assessed within the enterprise functioning; if it is thought that this error has distribution different from the expected one, one should return to p.1.

The long-term equilibrium implies a certain model of pricing at the enterprise. In fact, the scrap price at the market is often changed due to variations of metal prices in the world with some delay (time lag) [12-15]. If certain rules are laid into the pricing policy, such a model should generate a long-term equilibrium of demand and supply. However, another price can be formed at the market and the enterprise itself can set the price different from the model one, for instance, in the lack of scrap at the enterprise it can raise the price. The enterprise stock value turns to be the observable value and the criterion of the state of the stock control system at the enterprise, while the price is the parameter which can be changed to correct the stock value.

4 Conclusion

Therefore, the model of stock control at scrap processing enterprises is proposed. It is taken into account that scrap processing enterprises are often functioning at the oligopsony market. The proposed model accounts the advanced models of pricing at scrap processing enterprises and considers the situation that metal prices in the world influence the scrap prices but with a certain delay (time lag). It turns out that the enterprise having its own pricing system should track the quantity of scrap stocks. The enterprise stock value is both the observable value and the criterion of the state of the stock control system at the enterprise, while the price is the parameter which can be changed to correct the stock value. The model can be applied by enterprises in other oligopsony markets (especially raw materials) and markets where the company's pricing policy affects the level of inventory in the enterprise.

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