DECISION MAKING METHOD RELATING TO OUTSOURCING OF FINISHED GOODS STORAGE ACTIVITIES

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Abstract: In this study we elaborated variations for warehouse enlargement possibilities. Logistics indicators were determined which have effect on evaluation of warehousing activities. The calculated values were normalized and transformed for easier handling. The most effective variation can be defined by the application of multi objective optimization. The elaborated procedure can be also suitable for selection of best alternative of main variations.

Keywords: Outsourcing, decision making method, warehouse

1. Introduction

Number of product types required by customers is increasing which has influence on the capacity demand of finished good storage at manufacturers. Due to the variety of product structure minimum stock level of lot of components should be provided to fulfil the customers' demands. The shorter ordering lead times as a very important competitive factor can generate the high number of consumer orders. Because of the increasing of the finished goods storage stock level in most of cases the existing storage capacity is not enough. We can determine some solution alternatives for the solution of this problem.
Main variations can be the followings:

- **main variation I. :** increasing of storage capacity of the central warehouse (by reorganization of the existing storage system, or increase of the warehouse capacity),
- **main variation II. :** renting of an new distribution warehouse beside the existing central warehouse,
- **main variation III. :** renting of a higher capacity distribution warehouse (which storage capacity is higher than the existing warehouse), instead of the existing central warehouse.

2. Main variations for finished goods storage capacity enlargement

We defined three possible main variations – introduced in chapter 1. – for elimination of storage capacity lack of finished products. One central warehouse and one central warehouse with more distribution warehouses are taken into consideration in case of main alternatives.

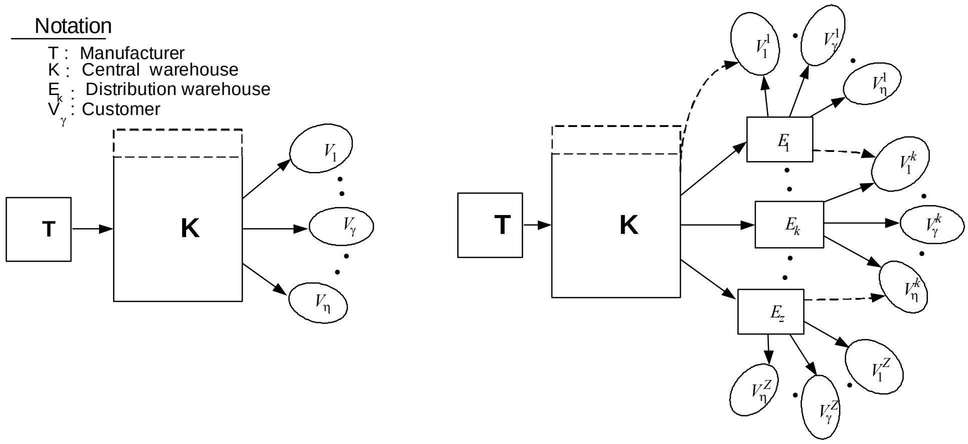
In case of a given distribution system we suppose that:

- the distribution warehouses – if these exist – have optimal formation, so the capacity can not be improved and the customer supply is not possible to complete from better place,
- there are full and released loading units (LU) stored in the locations of the analyzed warehouse system,
- loading units should be homogenous in the storage locations.

Alternative I.: Increasing of storage capacity of the central warehouse

In this case the elimination of the storage capacity lack can be realized by capacity growing of the central warehouse:

- at the alternative 1/a. the customer can be supplied from the enlarged central warehouse,
- at the alternative 1/b. the customer supply is completed generally from distribution warehouses, but in some cases (e.g. lack of product volume):
    - from central warehouse,
    - from other rented distribution warehouse.



a) Enlarged central warehouse

b) Enlarged central warehouse with more distribution warehouses

Figure 1.

Alternative II.: Renting of a new distribution warehouse beside the existing central warehouse

In the case of main variation II. the elimination of the storage capacity lack is realized by the application of a new distribution warehouse.

- At the alternative 1/a. the customer supply is generally completed from central warehouse and one of distribution warehouses, but in some cases (e.g. lack of product volume):
    - the customer is supplied from the distribution warehouse, who originally supplied from the central warehouse,

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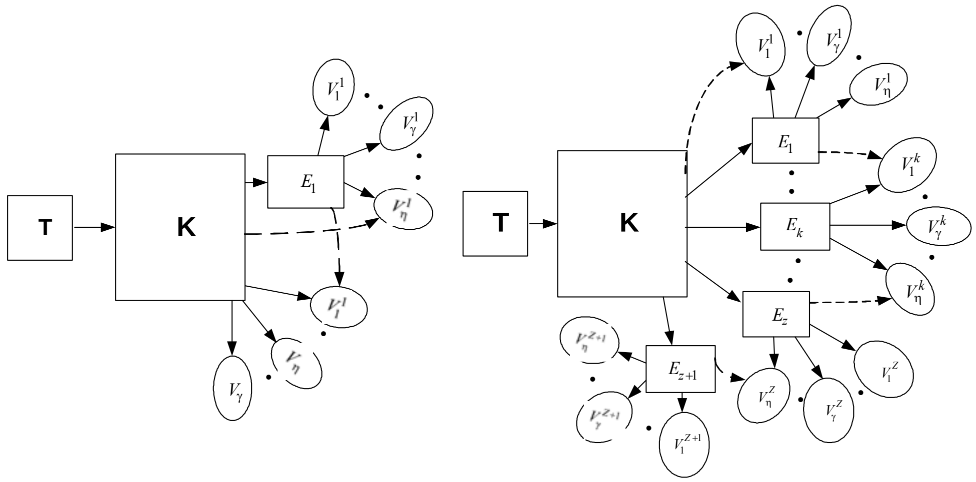
- at the alternative 1/b. the customer supply is completed generally from distribution warehouses, but in some cases (e.g. lack of product volume):
  - from central warehouse,
  - from other rented distribution warehouse.



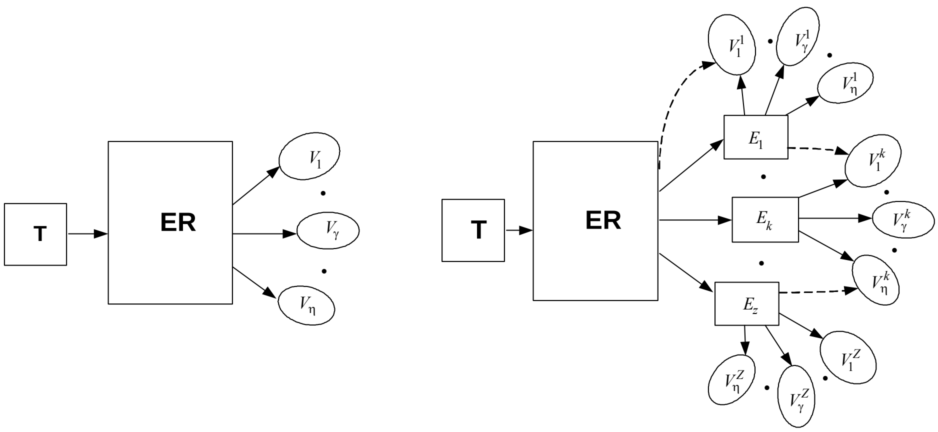
a) Application of a new distribution warehouse

b) Application of more distribution warehouses

Figure 2.

Alternative III.: Renting of a higher capacity distribution warehouse instead of the existing central warehouse

In this case the central warehouse should be eliminated, renting of a higher capacity distribution warehouse will complete the fulfilment of a higher storage capacity demand.
In extreme cases it can be occurred that the nearby distribution warehouse(s) also will be eliminated.



a) Renting of a new higher distribution warehouse instead of the central warehouse

b) Renting of a new higher distribution warehouse and more distribution warehouses

Figure 3.

The supply of customers will be completed similarly than in the main alternative I., but the different is only that a higher distribution warehouse will receive the tasks of the central warehouse.

3. Determination of volume of finished goods storage capacity enlargement in case of the main variations

Margin of storage capacity of the existing warehouse system and the forecasts relating to the future stock levels should be known for the determination of volume of capacity enlargement.

In case of main variations I.-II.

The volume of capacity enlargement can be defined based on the following equation:

$$C_v^{bőv} = \underset{i}{Max}\left\{\sum_{j=1}^{n}\left\lceil q_{ij} / C_j \right\rceil\right\} + Q_{növ} - C_{kr} \qquad \text{[LU]} \tag{1}$$

where

- q_{ij} : quantity of j^{th} product stored at the i^{th} day [piece],
- C_j : quantity of the j^{th} products located on a loading unit [piece/LU],
- $Q_{növ}$: forecasted capacity enlargement [LU],
- C_{kr} : actual storage capacity of the central warehouse [LU],
- i: days of analyzed term [day],
- j: number of stored products [piece],
- v: identification of main variation I. or II.

In case of main variation III.

Enlargement of the central warehouse can be avoided by the application of this variation, which is very advantageous because of decrease of the investment cost and we can use arising area for other tasks. The required capacity can be defined by equation 2.. In extreme cases it can be occurred that the nearby distribution warehouse(es) also will be eliminated. Lower stock level and lower specific warehousing cost can be realised.

$$C_v^{bőv} = \underset{i}{Max}\left\{\sum_{c\in\Theta_v}\sum_{j=1}^{n}\left\lceil q_{ij} / C_j \right\rceil\right\} + Q_{növ} \tag{2}$$

where

- c: storages to be merged,
- Θ_v : storages to be merged in case of v^{th} main variation,
- v: refers to main variation III..

4. Logistics indicators for evaluation of warehouse enlargement alternatives

Authors followed the systematic approach during the determination of logistics indicators. In other words we had to examine such indicators which have influence on the total costs of the distribution system, e.g. storage and transportation costs directly or indirectly. In addition the efficiency and the service level (subjective factor) were also important part of the evaluation that represents the efficient operation of the system.

4.1. Material flow work

Supply of costumer can be completed from different warehouses in case of individual main variations. Thus on purpose to compare the alternatives we have to take into consideration – where it is possible – the material flow work of the partial distribution system (for example in case of central warehouse, rented warehouse, newly rented warehouse, etc.). We suppose that the material flow work is proportional to the cost of transportation.

$$W_v = Spur Q_v L_v^T \quad [\text{t·km}] \tag{3}$$

where:

- Q_v : the matrix which describes the quantity of products to be transported from the given warehouses in case of v^{th} main variation [LU],
- L_v^T : length of material flow routes of the products to be transported in case of v^{th} main variation [km].

4.2. Specific storage cost (cost per loading unit)

In case of every single main variation f_v refers to the specific storage cost per unit loads.

$$f_v = (K_v + B_v - P_v) / q_{vki} \quad [\text{EUR\LU}] \tag{4}$$

where:

- K_v : operation cost of warehouses in case of v^{th} main variation [EUR],
- B_v : annual amortization of the investment in case of v^{th} main variation [EUR],
- P_v : annual surplus returns comes from the utilization of arising free area [EUR],
- q_{vki} : the product volume transported in the examined time period [LU].

4.3. Efficiency of order picking, loading in and loading out activities

Efficiency parameters are important indicators of warehousing processes, because a higher efficiency can result better ability of delivery or lower stock level. Efficiency of order picking activity can be defined by the following equation:

$$Q_v^K = \psi_v^K \frac{60}{\overline{T_v^K}} d_v^K \qquad [\text{LU /Hour}] \tag{5}$$

where:

- ψ_v^K : factor for loss of time caused by disturbance of parallel order picking processes in case of v^{th} main variation,
- $\overline{T_v^K}$: average cycle time of order picking process in case of v^{th} main variation,
- d_v^K : number of parallel order picking processes in case of v^{th} main variation,

- K: related to order picking activity.

Efficiency of loading in and loading out activities can be described similar to the before mentioned equation.

4.4. Standard of service

Standard of service is a subjective indicator, it is a general impression about the examined variation (e.g.: development level of the applied information system, conditions of equipments, etc.). Volume of scoring of it is from 1 to 10 points.

5. Description of decision making method

The aim is to achieve the highest value of one of logistics indicators introduced in chapter 4. (e.g. standard of service). On the other hand there are some indicators which lowest values are more favourable (specific storage cost; material flow work; efficiency of order picking, loading in and loading out). By application of multi objective programming we can take components must be maximized or minimized into consideration at the same time.
The objective function components should be normalized and transformed to use the method.

Normalization of objective function components to be minimized:

- 1. step: we determine the average value of logistics indicators to be minimized;
- 2. step: differences between the minimum value and the average value as well as the maximum value and average value will be divided up to 5-5 intervals;
- 3. step: we have to score the values of examined variations from 1 to 10 by the help of earlier defined scale; if the value of examined component is lower the value of objective function will be more advantageous.

Normalization of objective function components to be maximized:

- 1. step: we determine the average of logistics indicators to be maximized;
- 2. step: differences between the minimum value and the average value as well as the maximum value and average value will be divided up to 5-5 intervals;
- 3. step: we have to score the values of examined variations from 1 to 10 points by the help of earlier defined scale,
- 4. step: transformation of objective functions to be maximized should be completed on behalf of easier handling (the given points should be subtracted from 10, so the objective function components to be maximized will be transformed to objective function components to be minimized);
  After this conversion the aim is to achieve the minimal value of the components to be originally maximized.

Objective function used to obtain the optimal value

The objective function is described by the equation 6..

$$X = \underset{v}{Min}\left\{ \sum_{l=1}^{p} \delta_l * Y_{vl} \right\} \qquad 0 \le \delta_j \le 1 \qquad \sum_{j=1}^{p} \delta_j = 1 \tag{6}$$

where

- δ_l : weight of a given objective function component,
- Y_{vl} : value of the l^{th} objective function component in case of v^{th} main variation,
- l: analyzed objective function component.

The most effective variation can be defined by the application of above mentioned multi objective optimization method.

6. Summary

In this study we elaborated variations for warehouse enlargement possibilities. Logistics indicators were determined which have effect on evaluation of warehousing activities. The calculated values were normalized and transformed for easier handling. The most effective variation can be defined by the application of multi objective optimization. The elaborated procedure can be also suitable for selection of best alternative of main variations.

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