DECISION MAKING MODEL AND METHOD FOR THE TOTAL OR PARTIAL RELOCATION OF ACTIVITIES OF MAINTENANCE DE-CENTRES

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Abstract: Presentation of the possibilities of efficiency improvement in maintenance networks. Presentation of the elements of the examined maintenance networks and description of its operation. Determination of the activities and the features of the maintenance de-centre. Demonstration of the recording method and the set of logistic indices to be evaluated. Demonstration of the method used for the total or partial relocation of the activities of the examined maintenance de-centres.

Keywords: maintenace, relocation, decision making method

1. Introduction

Nowadays pooling of the maintenance activities forms an important part of the reengineering of the maintenance networks, so the operation of the network is made more efficient by rearrangement in the existing maintenance network. First of all it is advisable to examine the possibility of the relocation of the maintenance de-centres where there is significant under-utilisation of human and machine resources due to the decrease in maintenance work of the region. When examining the maintenance de-centres not only are economic aspects to take into consideration but also quality features to pay attention to, as they indirectly influence the operation cost of the system. The under-utilisation of human and machine resources can be reduced to a great extent with the relocation of the activities, as well as the technological standard of the completion of tasks can also be improved , as a result, the decrease of maintenance costs can be achieved directly and indirectly. At the same time during maintenance activities not only maintenance costs but also extra material handling costs related to this have to be taken into account as well. (transporting the vehicle to the de-centre, or handling of maintenance staff and equipments to the right location)

2. The objective of the paper

The objective of this essay is to revise the activities connected to the transporter's maintenance de-centres which have become uneconomical maintenance de-centres of the personal and goods transport companies which have become uneconomical due to the decrease in the number of tasks to be performed. With the help of the method we can determine whether it is reasonable to relocate the operation of the examined maintenance de-centre into another de-centre, moreover, a decision can be made to determine the optimal new location of the total maintenance system. In our model the new locations can only be the de-centres operating already in our maintenance network.

3. Presentation of the maintenance network

In the maintenance network demonstrated on figure 1. the suppliers provide the maintenance units (central maintenance and decentralized network maintenance shops) with the basic and auxiliary materials and parts. In certain cases it may occur that the decentralized maintenance units receive parts also from the central maintenance units (if larger partial units need to be repaired, as well). The maintenance tasks with greater technology demands will naturally be made by the central maintenance shop, the tasks required more frequently and having less technology demand (lubrication, cleaning, diagnostic examinations, tanking) will be provided by the decentralized network maintenance shop.

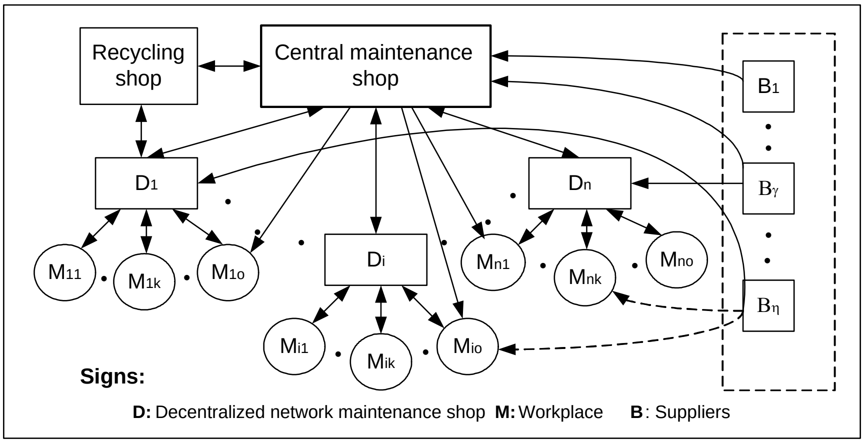

Figure 1. Material flow relations of maintenance network

There may be both-way material flow relations among the workplaces and the maintenance units depending on the fact where the transport vehicle can be repaired and/or is more economical to be repaired. In the cases the parts or partial units cannot be repaired they are delivered into the recycling shop, where they are disassembled, assorted, then the reusable parts are returned to the maintenance units on demand.

4. Presentation of the selection method

For the sake of the adaptation of the decision making model it is necessary to determine the logistic indices as the basis of the comparison. The interval of the determination of the logistic indexes is the year before the examination.

4. 1. Presentation of the logistic indexes

The logistic indices presented from (1) to (8) show the values received with the relocation of the activity no. "i" of the maintenance de-centre 1 into the de-centre no. "j".

– **Transport costs matrix,** which shows the transport costs - in connection with the maintenance - received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$K^S = \left[k_{ij}^S\right] \begin{matrix}(i=1\ldots n)\\(j=1\ldots m)\end{matrix} \quad [\text{EUR}]. \tag{1}$$

- **Supply costs matrix of materials required for maintenance,** which describes the supply costs of material received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$K^A = \left[k_{ij}^A\right] \begin{matrix}(i=1\ldots n)\\(j=1\ldots m)\end{matrix} \quad [\text{EUR}]. \tag{2}$$

  In this case it is possible to benefit from the discount of the larger amount of supply.
- **Storage costs matrix of materials required for maintenance,** which shows the storage costs of materials received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$K^R = \left[k_{ij}^R\right] \begin{matrix}(i=1\ldots n)\\(j=1\ldots m)\end{matrix} \quad [\text{EUR}]. \tag{3}$$

  Human and machine resources required for storage, as well as depreciation costs create this factor.
- **Maintenance costs matrix**, which shows the maintenance costs received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$K^K = \left[k_{ij}^K\right] \begin{matrix}(i=1\ldots n)\\(j=1\ldots m)\end{matrix} \quad [\text{EUR}]. \tag{4}$$

  Costs linked to the maintenance activity (wages, costs of the actuation of machines, depreciation costs), where like the storage costs lower specific costs can occur due to the increase in the utilisation of human and machine resources.
- **Matrix including the depreciation costs after the investment's capitalization**, which includes the annual depreciation after the investment's capitalization received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$K^B = \left[k_{ij}^B\right] \begin{matrix}(i=1\ldots n)\\(j=1\ldots m)\end{matrix} \quad [\text{EUR}]. \tag{5}$$

  On the basis of figure 2. it can be determined what investment costs the relocations will cause in the cases when the shipping and/or maintenance capacities required to perform the tasks are not available.
- **Income matrix of the shop's closing down**, which describes the income growth received with the relocation of the activity no. "i" into the maintenance unit no. "j" (from sales of the free area, or use for another purpose).

$$K^M = \left[k_{ij}^M\right] \begin{matrix}(i=1\ldots n)\\(j=1\ldots m)\end{matrix} \quad [\text{EUR}]. \tag{6}$$

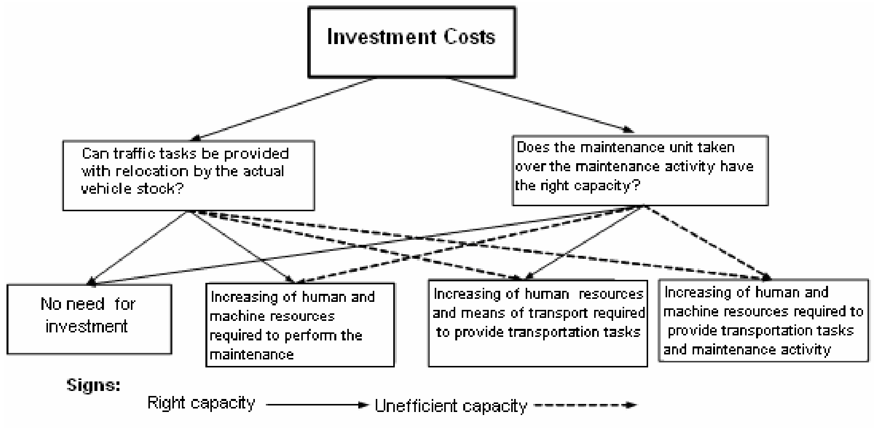

Figure 2. The structure of investment costs

– **The maintenance's duration matrix**, which shows the run of the average maintenance's duration time received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$T_{ij}=\left[t_{ij}\right]\begin{pmatrix}i=1\ldots n\\ j=1\ldots m\end{pmatrix} \quad [\text{EUR}]. \tag{7}$$

– **The maintenance's quality standard matrix**, which shows the maintenance's quality standard received with the relocation of the activity no. "i" into the maintenance unit no. "j".

$$M=\left[m_{ij}\right]\begin{pmatrix}i=1\ldots n\\ j=1\ldots m\end{pmatrix} \tag{8}$$

The quality standard is a subjective factor, it shows what kind of technological equipment and extra service the maintenance unit has. (1-5 points can be given in each cases).

4. 2. The normalization of the logistic indices

In order to act the above mentioned features as the components of a single objective function it is necessary to simplify and normalize the formerly examined features. During simplification the features which can be reduced to a common denominator (costs) are enough to take into account as a single factor, deviation from the subjective weighting can be decreased with this. So the total cost, the duration time and the quality standard will create the components of the objective function.

– Total cost matrix, which shows the total cost received with the completion of the activity no. "i" into the maintenance unit no. "j".

$$K^{T}=\left[k_{ij}^{T}\right]\begin{pmatrix}i=1\ldots n\\ j=1\ldots m\end{pmatrix} \quad [\text{EUR}]. \tag{9}$$

The way of the determination of the total cost:

$$k_{ij}^{T}=k_{ij}^{S}+k_{ij}^{A}+k_{ij}^{R}+k_{ij}^{K}+k_{ij}^{B}-k_{ij}^{M} \qquad \text{[EUR]}. \tag{10}$$

The total cost - with relocation – in the maintenance units no. 2..m has to be decreased by the cost without relocation, as the maintenance units can only be compared with each other from the aspect of cost.

$$\begin{aligned} k_{i1}^{T1} &= k_{i1}^{T} && i \to 1..n \\ k_{ij}^{T1} &= k_{ij}^{T} - k_{ij}^{T(prev)} && i \to 1..n;\ j \to 2..m \end{aligned} \qquad \text{[EUR]}. \tag{11}$$

The determination of the components of the objective function:

– Total cost:

$$k_{i}^{T1(max)} = \max_{j}\left\{k_{ij}^{T1}\right\} \qquad \text{[EUR]}, \tag{12}$$

$$\gamma_{ij}^{1} = k_{ij}^{T1} / k_{i}^{T1(max)}. \tag{13}$$

– Lead time:

$$t_{i}^{max} = \max_{j}\left\{t_{ij}\right\} \qquad \text{[EUR]}, \tag{14}$$

$$\gamma_{ij}^{2} = t_{ij} / t_{i}^{max}. \tag{15}$$

– Quality standard:

$$m_{i}^{max} = \max_{j}\left\{m_{ij}\right\}, \tag{16}$$

$$m_{ij}^{ö1} = m_{ij} / m_{i}^{max}, \tag{17}$$

$$\gamma_{ij}^{3} = 1 - m_{ij}^{ö1}. \tag{18}$$

4. 3. Presentation of the selection method

The selection method of the optimal relocation space is demonstrated in (4.19)..to (4.26) points in case of the total or partial relocation of the actitvities of maintenance de-centres. It is reasonable to take two kind of weighting factors into consideration:

– $\varepsilon_1 \ldots \varepsilon_i \ldots \varepsilon_n$ the importance of certain maintenance activities:

$$0 \le \varepsilon_i \le 1 \tag{19}$$

and

$$\sum_{i=1}^{n} \varepsilon_i = 1, \tag{20}$$

– $\eta_1 \ldots \eta_k \ldots \eta_3$ the importance of the components of the objective function:

$$0 \le \eta_k \le 1 \tag{21}$$

and

$$\sum_{k=1}^{3} \eta_k = 1, \tag{22}$$

The value of the objective function in case of the maintenance space no. “j”:

$$\omega_j = \sum_{k=1}^{3} \eta_k \sum_{i=1}^{n} \varepsilon_i \gamma_{ij}^k \ , \tag{23}$$

i.e.

$$\omega = \underset{j}{\mathrm{Min}} \left\{ \omega_j \right\} \ . \tag{24}$$

It can be determined that ω includes the objective function’s value of the optimum maintenance space j. In the case when j=1 there is no need for relocation, otherwise the relocation into de-centre no. “j” is proved to be more favourable.

The value of the objective function in case of the maintenance space no. “j” of the maintenance activity no. “i”:

$$\kappa_{ij} = \sum_{k=1}^{3} \eta_k \gamma_{ij}^k \ , \tag{25}$$

i.e.

$$\kappa_i = \underset{j}{\mathrm{Min}} \left\{ \kappa_{ij} \right\} , \tag{26}$$

where the maintenance activity no. “i” is to be relocated into de-centre j, if $j \neq 1$.

5. Summary

The paper has presented a decision method based on the optimising of several objective functional Pareto. We have outlined the possible cases of the method’s utilization which is limited mainly to the partial or total relocation of the chosen decentralized maintenance unit’s activities. The relocation’s possible places are the maintenance units of the presently operating maintenance network. Furthermore, we have revealed the set of the logistic indices to be examined and the way they can be recorded and used.

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