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# OPTIMISING THE SUPPLIER SYSTEM OF NETWORK-LIKE OPERATING ASSEMBLY PLANTS

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**Abstract.** This paper is analysing how the different factors influence the suppliers of each component parts and the optimum number of yearly transports, using a simplified cost function as objective function, based on a general model used for designing and running network-like operating supplier-assembly logistics systems, which has been detailed in former publications. The authors introduce the data structure required for the calculation in the following chapter, then they analyse the influence of each characteristics of the objective function parameters and their relative ratios of one to another in relation to several suppliers and customers, using the method of total discount with limited number of transports as well as using a heuristic algorithm (former analyses referred to one customer i.e. one production company). In the end part, evaluation and comparison of results of the two methods (limited total discount and heuristic algorithm) related to the introduced model and drafting further tasks required for optimum operation of the supplier system will take place, such as taking the capacity limits of the suppliers and combined supplies of several component parts from some suppliers into consideration.

*Keywords*: optimisation, logistics

## 1. Introduction

The aim of this paper is to solve a partial optimisation problem not known so far, during which the optimum supplier is to be selected for each component and for each production company and to determine the optimum number of transports of components into the production companies in a network-like operating supplier-assembly logistics system. There are several approaches to the matter of this paper, i.e. the optimisation of supplier logistics tasks, e.g. purchasing and production model for one product – Hill (1998). Several optimisation methods are known: linear programming – Pan (1989), game theory – Tallury (2002), neural networks – Siying (1997). Novelty of this paper appears in its network-like nature, in its methods of optimising as well as in its approach to the objective functions, especially to the cost functions. The specified system is considered as network-like operating, because analyses are carried out assuming several suppliers, several production companies and several customers. Optimisation is made with several parameters of objective functions and with several limitations. Among the objective functions, the cost function is of great importance, in whose context, it means new ways that realistic costs are used; our philosophy is based on displaying specific costs and natural characteristics when assuming these costs. [6, 7, 8, 9]

## 2. Objective functions and conditions of optimising the supplier system

In the operation of assembly networks, the optimisation of the supplier logistics system is a highly important task, where different objective functions and conditions must and can be taken into consideration.

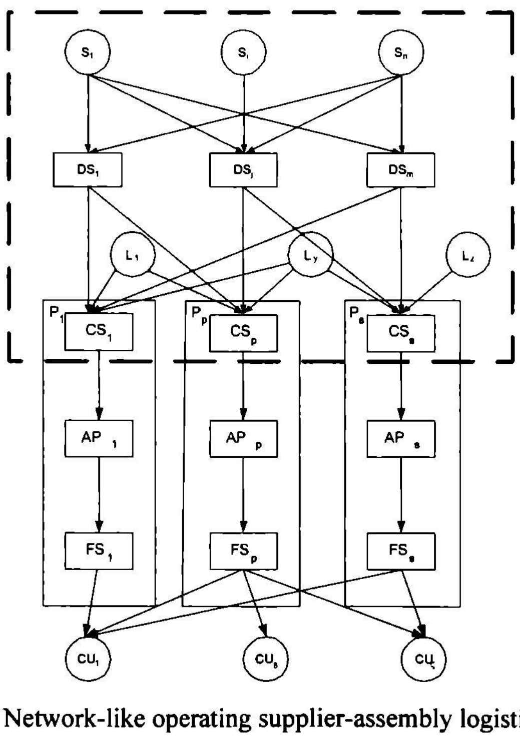


**Figure 1.** Network-like operating supplier-assembly logistics system

In the first step of the present optimisation, a cost function is chosen as objective function. Besides the method of total discount, the drafted multi-parameter optimisation task requires a heuristic method, which is to be solved in several steps, with a feedback after each step. First, the present network-like logistics system, its objective functions, the influence of ordered quantity on the specific costs, the optimum selection of appointed suppliers and a simplified objective function and its parameters for optimising the number of yearly transports are blocked in.

This system consists of the following units: production companies ($P_p$), in which component stores ($CS_p$), assembly plants ($AP_p$), finished goods stores ($FS_p$) (finished goods are transported from here to the customers ($CU_\delta$)) are indicated. Transports of component parts can take place into the above mentioned component stores: indirectly from the group of preferential suppliers ($S_i$), i.e. through distribution stores ($DS_j$), or by direct transports in case of bypassing the distribution stores. The preferential suppliers provide the so called brand featured component parts, which guarantee the quality connecting to a brand name for the customers. Suppliers within the right proximity to the assembly plants make up the group of local suppliers ($L_y$), from where only direct transports can take place into the production companies. [3]

The following cost function is the objective function when analysing the preferential suppliers:

$$C_{gpi}^{S} = C_{gpi}^{SP} + C_{gpi}^{ST_1} + C_{gpi}^{DS} + C_{gpi}^{ST_2} + C_{gp}^{CS} \rightarrow \min \tag{2.1}$$

Where $C_{gpi}^{S}$ is the total cost of component $g$ manufactured by preferential supplier $i$, which has been ordered by assembly plant $p$ within the present partial system, which consists of the following cost components: $C_{gpi}^{SP}$ is the total purchasing cost of component $g$ in case of purchasing from the preferential supplier, $C_{gpi}^{ST_1}$ is the total transport cost of component $g$ from the preferential supplier to the distribution store, $C_{gpi}^{DS}$ is the total storage cost of component $g$ in the distribution store, $C_{gpi}^{ST_2}$ is the total transport cost of component $g$ from the distribution store to the assembly plant and $C_{gpi}^{CS}$ is the total storage cost of component $g$ in the component store of assembly plant $p$.

The following objective function refers to the local suppliers:

$$C_{gpy}^{L} = C_{gpy}^{LP} + C_{gpy}^{LT} + C_{gp}^{CS} \rightarrow \min. \tag{2.2}$$

Superior (index) letter L refers to the local suppliers. In this case, supplies take place without distribution stores. In the former studies [1, 2], function connections of each cost component were unfolded generally. At present, a typical version is being introduced, using those cost function components, which are required for selecting the suppliers and scheduling the transports.

## 2.1. Simplified cost function

In the first step, a simplified formula of the cost function of the preferential suppliers is used as objective function, which of course, applies to direct transports only.

$$C_{gpi}^{S} = C_{gpi}^{SP} + C_{gpi}^{ST} + C_{gpi}^{CS} \rightarrow \min, \tag{2.3}$$

where $C_{gpi}^{S}$ is the total yearly cost of component $g$ in the present partial system, which consists of the following cost components: $C_{gpi}^{SP}$ is the yearly total purchasing cost, $C_{gpi}^{ST}$ is the yearly total transport cost, $C_{gpi}^{CS}$ is the yearly total storage cost at the production company's component store. (Similar to 2.1.) Formulas for calculating total costs and the cost function components of each total costs are described hereinafter.

## 2.2. Cost function components

### *2.2.1. Purchasing cost*

$$C_{gpi}^{SP} = s_{gpi}^{SP}(q_{gpi}^{S}) * Q_{gpi}^{S} \tag{2.4}$$

Specific purchasing cost: $s_{gpi}^{SP} = s_{gpi}^{SP}(q_{gpi}^{S})$, where $q_{gpi}^{S}$ means the quantity of component $g$ shipped at the same time by supplier $i$ to production company $p$. Yearly total purchasing cost can be calculated according to the above mentioned, where $Q_{gpi}^{S}$ means the total quantity ordered yearly. Formula (2.4) assumes that every supply of any component part consists of the same quantity during the year and the component part consumption at the production company is uniform during the examined period of one year.

### *2.2.2. Transport cost*

The following formula is to calculate the total yearly transport cost, assuming that component parts purchased at the same time will also be transported at the same time:

$$C_{gpi}^{ST} = n_{gpi}^{S}\left(Entier\frac{q_{gpi}^{S}}{c_{\phi g}} + \Phi\right) * l_{ip}^{ST} * s_{Gpi}^{ST*}, \tag{2.5}$$

where $n_{gpi}^{S}$ means the number of shipments in one year, i.e. how many shipments of component part $g$ by supplier $i$ to production company $p$ takes place during the examined period. Parameter $c_{\varphi g}$ defines the capacity of the vehicle, i.e. what quantity of component $g$ can be shipped by vehicle $\varphi$ at the same time. Parameter $s_{ip}^{ST}$ indicates the transport distance between the suppliers and the production company. Parameter $s_{gpi}^{ST}$ is the specific transport cost referring to the average shipped quantity and parameter $s_{gpi}^{ST*}$ is the specific transport cost referring to one shipment. If $\frac{q_{gpi}^{S}}{c_{\varphi g}} = Integer$, then $\Phi = 0$, else $\Phi = 1$, i.e. if the quantity to be shipped is integral multiple of the vehicle capacity, then obviously, the number of required transport vehicles is the quotient result of the above formula. Otherwise, an additional transport vehicle must be put in the shipping progress, even with empty tonnage.

### 2.2.3. Storage cost

The total storage cost can be calculated as follows, where $\vartheta = 1$ year means the examined period:

$$C_{gp}^{CS} = n_{gpi}^{S} * q_{gpi}^{S} * \frac{1}{2} \frac{\vartheta}{n_{gpi}^{S}} * s_{gp}^{CS*} \tag{2.6}$$

Parameter $s_{gp}^{CS*}$ is the specific storage cost, which means the storage cost of one piece of component $g$ at production company $p$. The cost calculation according to formula (4) assumes that shipped components are consumed uniformly.

## 2.3. Specific costs as functions of $q_{gpi}^{S}$

*Specific purchasing cost:* $s_{gpi}^{SP} = s_{gpi}^{SP}(q_{gpi}^{S})$, where $q_{gpi}^{S}$ means the quantity of component $g$ transported at the same time from supplier $i$ to production company $p$.

The figure above shows the step function of specific purchasing cost of component $g$ ordered by production company $p$ and supplied by supplier $i$. A similar specific cost function can be made for each component part from each supplier. This nature of the function arises from the assumption that higher ordered quantity is accompanied with lower specific purchasing costs. The total yearly purchasing cost can be calculated as follows, where $Q_{gpi}^{S}$ means the yearly ordered quantity:

$$s_{gpi}^{SP}(q_{gpi}^{S}) = \frac{C_{gpi}^{SP}}{Q_{gpi}^{S}} \tag{2.7}$$

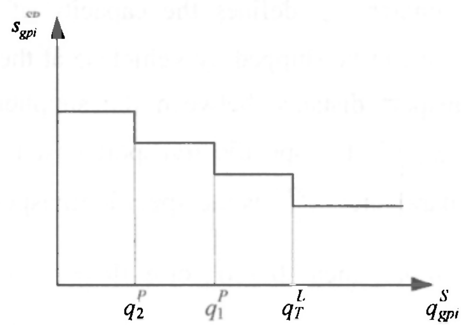


**Figure 2.** Change of specific purchasing cost as a function of ordered quantity

*Specific transport cost:* $s_{gpi}^{ST} = s_{gpi}^{ST}(q_{gpi}^{S})$. The specific transport cost can be calculated as follows (2.8). Parameter $s_{gpi}^{ST}$ is the specific transport cost referring to the average quantity and parameter $s_{gpi}^{ST*}$ is the specific transport cost referring to one piece.

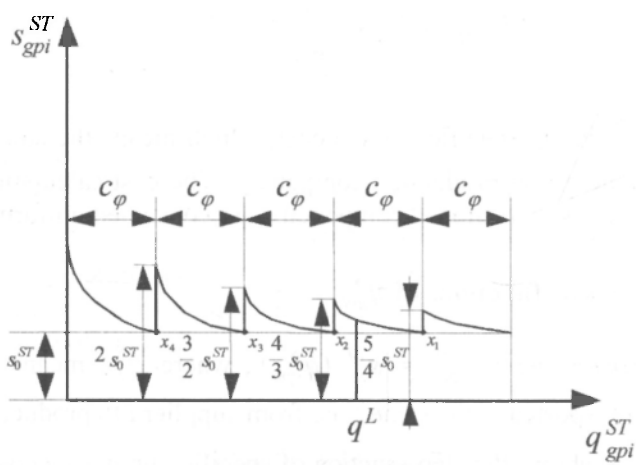


**Figure 3.** Change of specific transport cost as a function of ordered quantity

Specific transport costs decrease hyperbolically as well as the maximum values of each range also decrease hyperbolically (ranges refer to the transport capacities).

$$s_{gpi}^{ST} = \frac{C_{gpi}^{ST}}{Q_{gpi}^{S}} = \frac{1}{q_{gpi}^{S}} \left( Entier \frac{q_{gpi}^{S}}{c_{\phi}} + \Phi \right) * l_{ip}^{ST} * s_{gpi}^{ST*} \qquad (2.8)$$

*Specific storage cost:* $s_{gp}^{CS} = s_{gp}^{CS}(n_{gpi}^{S})$

$$s_{gp}^{CS} = \frac{C_{gp}^{CS}}{Q_{gpi}^{S}} = \frac{\vartheta}{2n_{gpi}^{S}} f_{gp}^{CS*} \qquad (2.9)$$

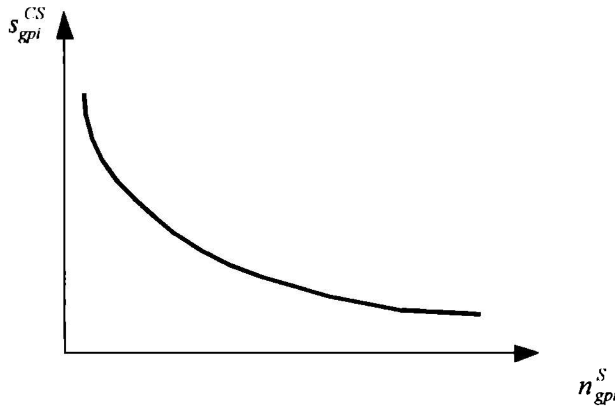


**Figure 4.** Specific storage cost as a function of yearly transport number

On the one part, the specific storage cost changes as a function of number of transports (hyperbolically); on the other part, it changes as a function of the transported quantity linearly.

A short evaluation of specific cost functions: the specific purchasing cost is constant above the $q_T^L$ limit quantity; the specific transport costs are the lowest at the X points; the specific cost of storage makes up a hyperbolic function as a function of yearly transport number.

The main principle of the heuristic algorithm arises from examining the specific costs: quantity transported at one time may be decreased until transport and purchasing costs do not increase.

The specified simplified cost function can be calculated by two methods. One is the method of total discount, limited regarding the number of transports, which means that the cost function is calculated for numbers of transports discussed in the further parts of this paper (this time only for them) regarding each supplier, component part and production company. The other method is to go through a heuristic algorithm, whose principle is detailed later. The goal is to compare the results of these two methods within the confines of this paper.

## 3. Methods of optimisation

### 3.1. Limited total discount (I.)

On the grounds of the assumed base data, using formula (2.3), the optimum cost is calculated for different numbers of transports regarding component *g*, supplier *i* and production company *p* and the optimum supplier is determined. Because of the large extent of the example, calculations are made only with $n_{gpi} = 1, 2, 3, 12$ and 48 yearly transports. (Therefore is limited the total discount.) In the first step, calculations are made regarding one production company, then regarding several companies (three companies within the confines of this paper).

### 3.2. Heuristic algorithm (II.)

When compiling the algorithm, specific purchasing, transport and storage costs have been taken as bases. The essential part of the algorithm examines the given specific cost functions (purchasing and transport costs), determines where the breakpoints are, it calculates step-by-step the costs at these breakpoints and then it calculates the total cost. All these calculations are made while the total costs decrease. At the resulted optimum point, it is also resulted that which component parts should be supplied by which suppliers how many times a year, i.e. the optimum supplier is selected for each component and for each production company and also the yearly transport number is determined regarding a given component and a given production company by this.

### 3.3. Principle of heuristic algorithm for optimising transports for each component part

#### *3.3.1. Optimising the transports for each component part*

1. Determine $q^L$ value (limit quantity) for that supplier of the given component part, where $s_{gpi}^{SP}$ is minimum at $q^L$, i.e. the specific purchasing cost. It is called limit quantity, because in case of ordering higher quantity than this, the specific purchasing cost of the given component does not decrease further from the given supplier for the given production company, therefore it is not economical to transport higher quantity than this at one time from the point of view of the total cost.

2. Take the point, where $q_T > q^L$ and $q_T \equiv q_{x_1}$ i.e. $q_T$ point at $x_1$ point after $q^L$

At $x_1$ point, there is one of the breakpoints of the specific transport cost, which means that aiming at the maximum utilisation of transport capacity, shipments can be started with $x_1$ quantity.

3. At $q_{X_1}$ point, determine $C^S_{gpi1} = C^{SP}_{gpi1} + C^{SP}_{gpi1} + C^{CS}_{gp1}$, thus total cost for the given component is resulted at $x_1$ point.

4. Examine the point, where $q_T < q^L$ and $q_T = q_{x_2}$, i.e. $q_T$ point at $x_2$ point before $q^L$, because there is another breakpoint of the specific transport cost.

5. At $q_{T_2}$ point, determine a total cost, i.e. $C^S_{gpi2} = C^{SP}_{gpi2} + C^{ST}_{gpi2} + C^{CS}_{gp2}$.

6. If $C^S_{gpi1} < C^S_{gpi2}$, i.e. total cost at $x_2$ point is higher than at $x_1$ point, then it should be examined, if there is a $q_{x_2} > q_1^P > q^L$ range of $s^{SP}_{gpi} = s^{SP}_{gpi}(q^S_{gpi})$ function, i.e. find a breakpoint in the given range of the specific transport cost function, since there is a purchasing cost decrease at this breakpoint. If yes, then take $q_T \equiv q^*_{x_2}$ and calculate the total cost at this point ($C^{S*}_{gpi2} = C^{SP*}_{gpi2} + C^{ST*}_{gpi2} + C^{CS*}_{gp2}$).

If the resulted total cost is less than total cost at $x_1$ point ($C^{S*}_{gpi2} < C^S_{gpi1}$), then $q_T = q^*_{x_2}$ If it is higher ($C^{S*}_{gpi2} > C^S_{gpi1}$), then using formula $q_T \le \dfrac{q^*_{x_2} + q_{x_1}}{2} = q^{**}_{x_2}$, find the next point, an ordered quantity, which is between the limit quantity and $q^*_{x_2}$ Determine $C^{S**}_{gpi2} = C^{SP**}_{gpi2} + C^{ST**}_{gpi2} + C^{CS**}_{gp2}$, i.e. the total cost at this point, too. If $C^{S**}_{gpi2} < C^{S*}_{gpi2}$ and $C^{S**}_{gpi2} < C^S_{gpi1}$, then $q_T = q^{**}_{x_2}$ If $C^{S**}_{gpi2} < C^{S*}_{gpi2}$ and $C^{S**}_{gpi2} > C^S_{gpi1}$, $\Delta q_{x_2} = q_{x_1} - q^{**}_{x_2} < \Delta q_0$, then $q_T = q_{x_1}$ If $\Delta q_{x_2} > \Delta q_2$, then $q_T = \dfrac{q^{**}_{x_2} + q_{x_1}}{2} = q^{***}_{x_2}$ Value of $q_{x_1}$ is to be converged step-by-step, until it is closer than $\Delta q_0$, i.e. $\Delta q^*_{x_2} < \Delta q_0$.

7. If $C^S_{gpi1} > C^S_{gpi2}$, i.e. the total cost is less at $x_2$ point than at $x_1$ point, then sort the common set of $\{(q_{V_2}; q_{V_3}; \ldots)\ és\ (q_{x_3}; q_{x_4}; \ldots)\}$ in decreasing order.

Calculate the cost functions ($C^S_{gpi3};C^S_{gpi4};...$), until $q_{T\min} \geq 0{,}1 * q^S_{gpi}$ or $n^S_{gpi} \leq 52$, respectively.

Determine the minimum values of the above calculated costs: $C^S_{gpi0} = Min\{C^S_{gpi3};C^S_{gpi4};...\}$ It results $C^S_{gpi0} \rightarrow q^S_{gpiT0}$, i.e. the optimum quantity to order, which also results the optimum number of transports.

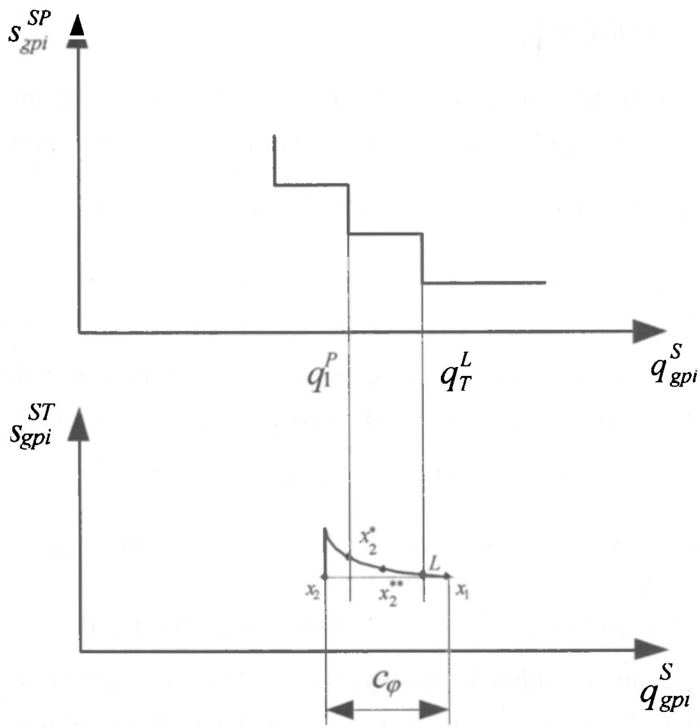


**Figure 5.** Specific purchasing and transport costs

8. It must be examined for the optimum of $q^B_{gpiT0}$, if there is any other supplier (ν), where $C^{SP*}_{gp\nu0} + C^{ST*}_{gp\nu0} < C^{SP}_{gpi0} + C^{ST}_{gpi0}$ i.e. the sum of purchasing and transport cost is more favourable. If $C^{SP*}_{gp\nu0} + C^{ST*}_{gp\nu0} < C^{SP}_{gpi0} + C^{ST}_{gpi0}$, then supplier $i$ will be selected. If several $i$ suppliers can be found, then that supplier will be selected, where $\{C^{SP}_{gpi0} + C^{ST}_{gpi0}\} \rightarrow \min$.

The above optimisation must be carried out for each component part and each supplier.

## 4. Data structure required for examining optimisation methods

To analyse the present system, several base data must be assumed so that the mentioned two methods can be used on this system. Base data in this example can be divided into constant and variable data.

### 4.1. Constant data of the examinations

$g=4$, examinations cover four types of component parts,

$p=3$, costs are calculated for three production companies (in the first example, examinations covered one production company)

$\varphi_i=1$, calculations concern one transport vehicle,

$C_{1g} = [700,700,800,1000]$ vehicle capacity matrix, which is defined as follows: transport vehicle no. 1 can carry the given quantity of the component part no. 1, i.e. the vehicle can carry 700 pcs of component part no. 1 at the same time. Similar definitions apply to the other components, too.

$$Q^B_{gpi} = \begin{bmatrix} 120 & 100 & 150 \\ 90 & 130 & 120 \\ 150 & 80 & 200 \\ 30 & 50 & 100 \end{bmatrix}$$ [kpcs/year] yearly ordered quantity, e.g. production company no. 2 orders yearly 100,000 pcs. of component part no. 1,

$s^{SP}_{gpi}$ specific purchasing cost can be read out of the graphs (see e.g. Figure 2.) as a function of the purchased and at the same time transported quantity.

$s^{ST*}_{gpi} = 0{,}8k_0\ [EUR/travel\_km]$ specific transport cost for each supplier,

$$s^{CS*}_{gp} = \begin{bmatrix} 0.004 & 0.004 & 0.004 \\ 0.005 & 0.005 & 0.005 \\ 0.005 & 0.005 & 0.005 \\ 0.005 & 0.005 & 0.005 \end{bmatrix} k_0\ [EURO/(pieces * day)]$$ specific storage cost.

### 4.2. Variable data of the examinations

During the examinations

$i=7$, optimum supplier is selected out of 7 suppliers,

in the examinations, all cases of yearly transport numbers $n_{11i} = 1, 2, 3, 12$ and 48 are to be considered,

distance matrix, its elements mean the transport distances from each supplier in km (transposed matrix is shown here):

$$L_{ip}^{ST''} = \begin{bmatrix} 40 & 50 & 70 & 75 & 80 & 100 & 125 \\ 50 & 60 & 80 & 60 & 85 & 60 & 110 \\ 120 & 90 & 70 & 95 & 100 & 90 & 70 \end{bmatrix} km \cdot$$

## 5. Analysing optimum selection of suppliers

Among the examination results, characteristics of suppliers summarised in Figure 6 to 8 are analysed as follows.

Sum of purchasing and transport costs are shown in case of each suppliers: $C_{gpi}^{SP} + C_{gpi}^{ST} = C_{gpi}^{'}(i,n)$, five values of yearly transport numbers can be seen as well as four types of component parts (regarding one production company).

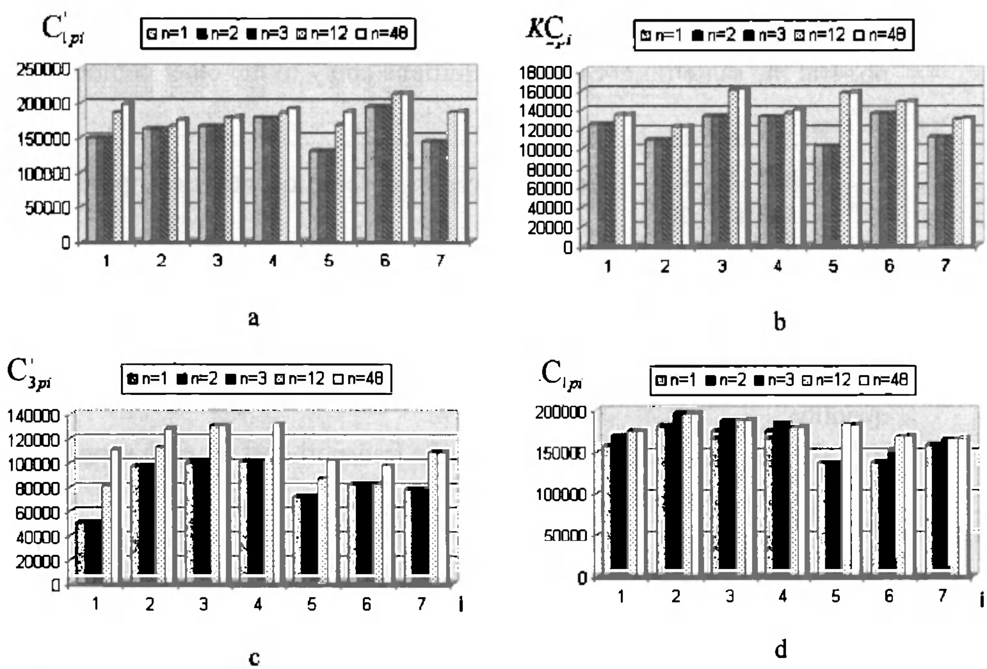


**Figure 6.** Sum of purchasing and transport costs as a function of yearly transport number

The following can be set out of Figure 6:

the sum of the two costs:

- at components nos. 1, 2 and 4, at n=1, 2 and 3 yearly transports and at supplier no. 5, there are the minimum values; at component no 3, at n=1, 2, 3 and 12 yearly transports and at supplier no. 1, there are the minimum values,

- at components nos. 1 and 2, at n=12 and 48 yearly transports and at supplier no. 2, there are the minimum values; at component no 3, n=48 yearly transports and at supplier no. 6, there is the minimum value; at component no 4, n=12 and 48 yearly transports and at supplier no. 7, there are the minimum values,
- in case of component no 1, at n=1, 2, 3, 12 and 48 yearly transports and at supplier no. 6, there are the maximum values, while at component no. 4, and at supplier no. 2, there are the maximum values,
- at n=1, 2 and 3 yearly transports, in case of component no. 2 and at supplier no. 6, there are the maximum values, while in cases of n=12 and 48 yearly transports, at supplier no. 3 show the highest costs; highest values of component no. 3 in cases of n=1, 2, 3 and 12 yearly transports and at supplier no 3, there are the maximum values; while in case of n=48 yearly transports and at supplier no. 4, there is the highest cost.

In Figure 7, the total yearly cost is shown for different yearly transport numbers and for different component parts in case of the optimum supplier $C^{SP}_{gpi} + C^{ST}_{gpi} + C^{CS}_{gp} = C^{S}_{gpi}(n)$. Values in the graph are accompanied with a $k_0$ factor, which makes the resulted values relative.

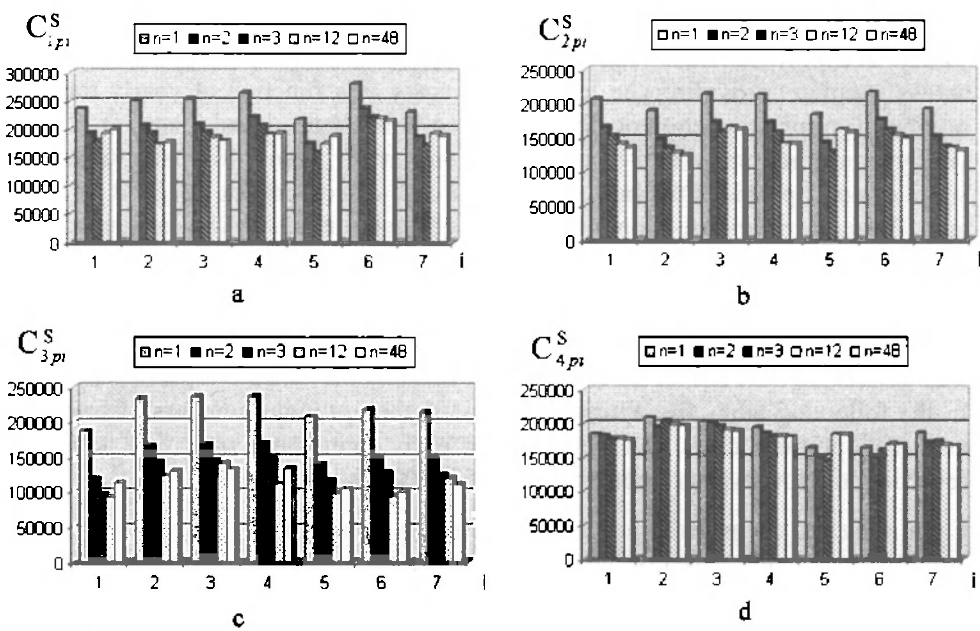


**Figure 7.** Change of total cost in cases of different yearly transport numbers

Differences between the sums of each total cost regarding each component part and considering each yearly transport numbers and each suppliers are the follows: at component no. 1, difference between the highest and lowest costs is: 105584 $k_0$; at component no. 2, it is: 90878.1 $k_0$; at component no. 3, it is: 145604.8 $k_0$; while at component no. 4, it is: 62010 $k_0$. Analysing Figure 7, it can be set out that if the optimum supplier is selected, then at n=2, 3, 12 and 48 yearly transport numbers, the total costs hardly change.

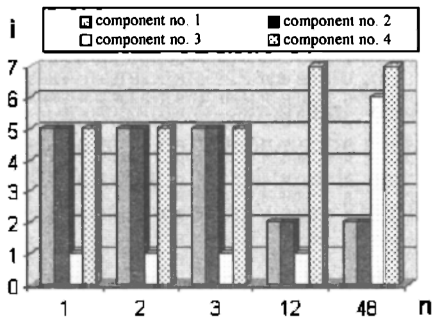


**Figure 8.** Selecting optimum supplier as a function of yearly transport number regarding each component part

In Figure 8, the optimum suppliers $i_0 = i_0(n)$ are delineated in cases of different yearly transport numbers regarding four types of component parts. This figure shows suppliers providing the lowest total costs as a function of yearly transport number. It turns up unequivocally, that at components no. 1 and 2, at n=1, 2 and 3 yearly transports, supplier i=5 is the best and at n=12 and 48 yearly transports, supplier no. 2 provides the best solution. In case of component no. 3, at n=1, 2, 3 and 12 yearly transports, supplier i=1 is the optimum and at n=48 yearly transports, supplier no. 6 is the optimum supplier. Regarding component no. 4, at n=1, 2 and 3 yearly transports, supplier no. 5 is the optimum, while in cases of n=12 and 48 yearly transports, it is practical to order from supplier no. 7. All these are consonant with the results of Figures 3 to 8.

In the following table, the optimum suppliers, the optimum numbers of transports and the optimum costs can be seen for each component part. The total cost regarding the four types of components is 523402.2 $k_0$.

Examining the optimum solutions for each components and the results of supply combinations made based on these solutions (e.g.: in case of n=1 transport a year, components nos. 1, 2 and 4 are supplied by supplier no. 5 at the same time), it can be set out that the cost function is reduced only by 0.008 to 1.382 percent. It can be established from all these, that transport cost is not as dominant as purchasing and storage costs in case of the present example. Although the total cost is not reduced considerably based on the above results, however taking other points of view into account (only two suppliers are to be in communication with, contingent price reductions because of purchasing three types of component parts, fixed and constant number of yearly supplies for each components, etc.) it is worth to purchase the appointed three types of components from supplier no. 5 as well as component no. 3 from supplier no. 1 three times a year.

**Table 1.** Optimum suppliers, the optimum numbers of transports and the optimum costs

| Component no. (g) | Optimum supplier no. (i) | No. of optimum yearly transports (n) | Optimum cost ($C_{gpi}^{S} * k_0$) |
|---|---|---|---|
| 1 | 5 | 3 | 160336 |
| 2 | 2 | 48 | 124470.9 |
| 3 | 1 | 12 | 92550.3 |
| 4 | 5 | 3 | 146045 |

In cases of different yearly transport numbers, the following table shows, which component parts to be supplied by which suppliers.

**Table 2.** Connection of the component parts and the suppliers

| No. of transports | Component no. $\rightarrow$ Optimum supplier |
|---|---|
| 1 | 1,2,4 $\rightarrow$ 5; 3 $\rightarrow$ 1 |
| 2 | 1,2,4 $\rightarrow$ 5; 3 $\rightarrow$ 1 |
| 3 | 1,2,4 $\rightarrow$ 5; 3 $\rightarrow$ 1 |
| 12 | 1,2 $\rightarrow$ 2; 3 $\rightarrow$ 1; 4 $\rightarrow$ 7 |
| 48 | 1,2 $\rightarrow$ 2; 3 $\rightarrow$ 6; 4 $\rightarrow$ 7 |

It has been displayed that in case 1 production company, 4 types of component parts and 7 suppliers, how to select the optimum supplier using limited total discount, and which is the most favourable among the given yearly transport numbers regarding the costs.

## 6. Comparing the methods for optimising supplier logistics systems

In the following, results of the introduced two methods are given for three production companies. In the following table, optimum suppliers, yearly transport numbers and costs as results of total discount and heuristic algorithm can be seen for each component parts. In case of four components and regarding different numbers of yearly transports, the total cost is 523402.2 $k_0$ by total discount and it is 495341 $k_0$ by heuristic algorithm. It can be seen that result of heuristic algorithm is better regarding the total cost. It is because the above mentioned cause, i.e. by total discount, optimum case is determined for the given yearly transport numbers only, because of the large extent of the example.

**Table 3.** Results of total discount and heuristic algorithm

| Component no. into Production co. no. (g-p) | Optimum supplier no. (i) | | Optimum no. of yearly transports (n) | | Optimum cost ($C^S_{gpi} * k_0$ $[EUR]$) | |
|---|---|---|---|---|---|---|
| | I. | II. | I. | II. | I. | II. |
| 1 into 1 | 5 | 5 | 3 | 4 | 160336 | 152908 |
| 2 into 1 | 2 | 5 | 48 | 3 | 124470.9 | 130131 |
| 3 into 1 | 1 | 1 | 12 | 9 | 92550.3 | 66257 |
| 4 into 1 | 5 | 5 | 3 | 3 | 146045 | 146045 |
| **Total** | | | | | **523402.2** | **495341** |
| 1 into 2 | 5 | 5 | 3 | 3 | 134125.82 | 134125.82 |
| 2 into 2 | 2 | 5 | 48 | 5 | 180687.96 | 173145 |
| 3 into 2 | 6 | 1 | 12 | 5 | 51267.64 | 42600 |
| 4 into 2 | 6 | 5 | 3 | 5 | 242656.64 | 237525 |
| **Total** | | | | | **608738.06** | **587395.82** |
| 1 into 3 | 5 | 5 | 3 | 7 | 203780 | 205503.17 |
| 2 into 3 | 7 | 5 | 48 | 4 | 169033.25 | 167135 |
| 3 into 3 | 1 | 1 | 12 | 12 | 99400.64 | 99400.64 |
| 4 into 3 | 6 | 5 | 3 | 10 | 515380.78 | 467125 |
| **Total** | | | | | **987594.67** | **939163.81** |
| **Grand total** | | | | | **2119734.93** | **2021900.63** |

If each component is compared in case of production company no. 1, then practically, very little difference turns up regarding components nos. 1 and 2. At component no. 4, the two methods give the same results, considerable difference is resulted at component no. 3 only, which is 26293.3 $k_0$, but the algorithm is better. This can be because of the before mentioned, i.e. total discount has been done for the given numbers of transports, because of the large extent of the example. It can be seen well that also in this case, both methods give supplier no. 1 as optimum, difference only occurs between the yearly transport numbers, which results in the already mentioned difference. Regarding production company no. 2, there is also a component part (component no. 1), for which both methods give the same results. Considerable differences occur for the optimum suppliers and optimum transport numbers of methods I and II. However, if the results of both methods are approached from the cost side, then it can be noticed that the difference is not so much examining components nos. 2 and 4. For component no. 3, the difference is 16.9 percent in favour of the heuristic algorithm. For production company no. 3, in case of component no. 3, both methods give the same results. In case of component no. 1, it results the same supplier, but with different transport numbers. However, this is the only case, where total discount gives better result regarding the costs. In relation to the other three production companies, total discount gives worse results by 4.615 percent than heuristic algorithm.

Data in the above table are shown is the following graph.

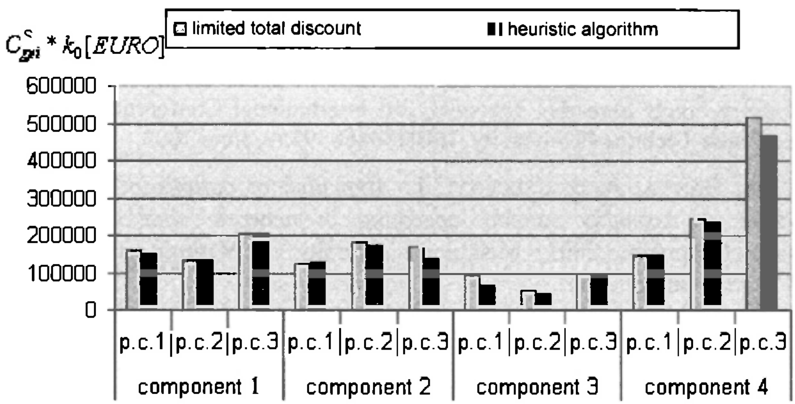


**Figure 9.** Comparing results of total discount and heuristic algorithm

## 7. Summary

In this paper, a network-like operating logistics system, objective functions as well as an optimisation algorithm for the simplified objective function is being presented. This paper shows the optimum numbers of suppliers and yearly transports for each component parts in cases of three production companies, seven suppliers and four types of component parts; it displays the results of the two methods used for cost optimisation and their comparison. Efficiency of heuristic method is proven unequivocally, besides that it results lower costs and it needs considerably less calculation mainly in tasks of great extent. (It must be noticed, that only limited total discount has been made, because of the large extent of the example, therefore heuristic method resulted better solutions.) The heuristic algorithm results better solution unequivocally, if there is no need to decide on fixed numbers of transports and it requires less calculations. If the number of transports are fixed, then the two methods are of the same accuracy, but in this case, calculation method is much simpler and it demands less time. Henceforth, a correction method will be introduced, which takes the capacity limits of the suppliers and the possibility of transporting several types of component parts at the same time into account. One of the authors' intentions is to examine it referring to four types of comonent parts, that using contractions in case of each component, to what extent lesser costs can be achieved compared to the optimum solutions resulted herein.

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