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1. Introduction

Free market and the development of Polish economy connected with it, forces the use of modern tools and methods in company management, leading to the improvement of effectiveness in company functioning. One of the methods of improving this effectiveness is logistics.

Logistic system functioning in a company is organised purposely and integrated within a given economic structure or a single company - material and goods flows and information corresponding with them - which enables optimisation in managing logistic chains of supplies (among others by automatic goods identification, computer simulation, controlling, electronic data exchange and a complex calculation of costs) [1, 2].

Logistic strategies are characterised by the predominance of organisational activities which do not demand considerable costs, so which can be used in building companies whose financial condition is usually weak.

Building production has some specific features (individuality, changeability of production places, seasonability, long production cycles, great absorption of capital) and because of that logistic systems of building companies have their own peculiarities. There is no possibility of adopting logistic systems of companies from other branches of national economy. These reasons constitute the basis for separating logistic systems in building sector [3].

The analysis of building companies in a logistic aspect shows the predominance of logistic processes in the sphere of supply with material and building products. It is characteristic of these companies to use up great amount of materials while the production (technological) process itself is not too complicated. Materials constitute about 50 - 70% cost of a building structure, which causes the delivery sphere to influence considerably the final results of a building company.

Subject to the realisation level of logistic concepts (logistic processes, company, market channels - logistic chains, macroeconomic level - market) various scientific methods are used to build, examine and analyse logistic systems models - starting with the methods of operations research [4, 5], systems dynamics [6, 7], etc.

The company logistic system is of low-level generalisation, and that is why the simulation of discreet processes is the most suitable research method [2].

The paper presents methodology of building logistic system which is to assist the decision-taking in the logistic management of a building company, on the basis of simulation models. Using a simulation model for examining and evaluating the results of the planned strategy of managing the company (in this case in the supply sphere) presents taking up risky decisions. The evaluation of supply strategy in the company is made on the basis of logistic costs.

2. The essence of logistic management

Logistic management consists in achieving logistic concepts included in the general strategy of a company. This strategy can be regarded as the system of its partial strategies. It can be assumed that partial strategies in the field of logistics constitute the contents of logistic management.

Logistic management is made up of formulating strategies, planning, controlling and checking the flow of streams of: raw material, production-in-progress stocks, ready products and adequate information throughout all the links of logistic chain, ie from the point of obtaining it to the point of receipt. The methods and techniques of logistic management used should provide effective and smooth flows - they should minimise global costs, and contribute to accomplishing such a product or service as to meet clients' requirements[1].

The essence of logistic management in the aspect of using computerisation and simulation technique is shown in Fig 1.

At the age of common computerisation, logistic management should be aided with informatic systems. Informatic systems enable introducing decision algorithms selecting automatically, as it were, the best variants of solutions.

Examining logistic systems of a company aim at giving knowledge for rational management of logistic processes and achieving logistic strategies.

The work out methodology of building informatic system requires carrying out studies, identification and analysis of logistic processes in a company [8].

3. Methodology of creating DSS within the sphere of logistic management

Creating informatic system meeting the needs of logistics in a company is preceded by working out a simulation model imitating company logistic system. Modelling logistic system requires a lot of work at a preparatory stage (identifying, analysing, logical modelling) and evaluating simulation results.

Examining logistic processes and creating a model of logistic system which would serve to anticipate the effects of different variants of the future system, can be done in accordance with different methodologies. The methodology suggested by the paper consists of the following stages [2]:

1. Identifying company organisational structure from the point of view of running logistic processes and connections of company to various elements of setting which in great degree influence these processes inside the company.

2. Identifying raw material, material, building products, equipment and machines which are used in production processes. Because of the possibility of having a large number of materials, it is necessary to aggregate them at that stage. The goal of such an action is to get homogeneous materials as regards logistic processes.

3. Identifying models of goods and information flows on the basis of investigation conducted in a company. This information refers in particular to:
- determining points and procedures of decision-taking about generating material flow,
- determining points of transmitting, collecting and receiving goods and information, and points of collecting and processing information,
- external flows is in the structures whose source of setting.

4. Creating a simulation model including:
- defining the structure of a logistic system, ie isolating a logistic system from the setting through stating boundaries of the system and through identifying connections of the system with the setting and pointing out the processes taking place in it,
- the description of the logistic system with the help of graphic and tabular models which imitate material and information flows showing connections between them.

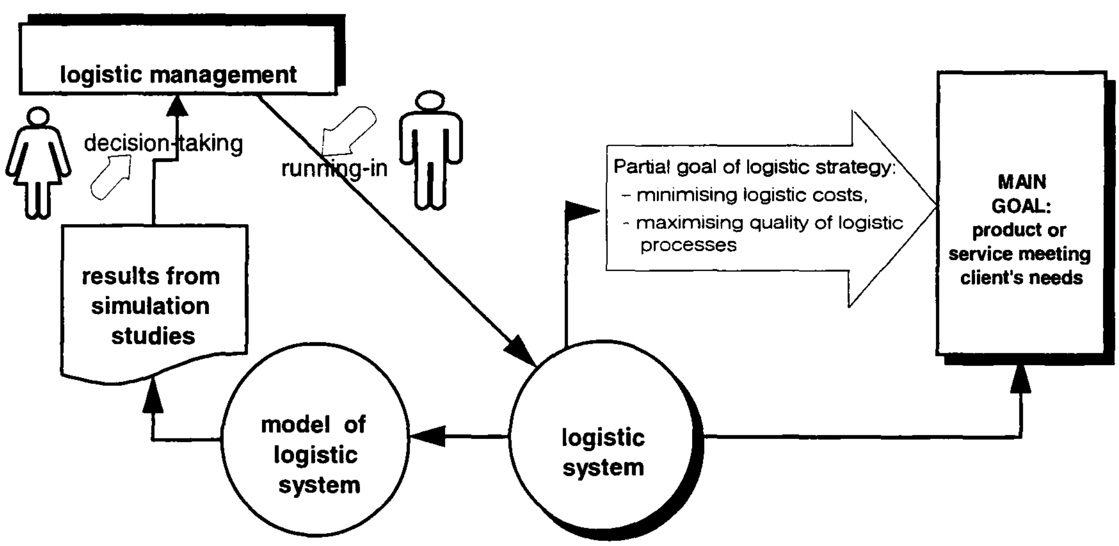

Fig 1. The essence of logistic management

5. Formalization of the model by means of a net description with the use of queueing networks. The result of research at this stage is to define a set of parameters and analytical and logical relationships which will be the basis for the simulation.

6. The selection of a simulation technique; logistic system of a company can be rated as of low-level generalisation, the processes taking place in it have the nature of discrete processes. In connection with this, it seems that a better technique is a discrete simulation of stochastic processes.

7. Making up a simulator. This stage, also called the computerisation of the model, in practice boils down to making up schemes of processing and collecting data which describe media flows in a company, and to the selection of programming language in which the simulator will be constructed.

8. Verification and validation of a simulation model should be carried on day after day (at each stage of creating a model) employing, as far as possible, reconstructing methods, predictions, structural and typical statistical tests. In case of a logistic system in a building company which can be regarded as so-called poorly described system, special validation techniques should mainly be used [2, 9].

9. Optimisation of a logistic system in a building company from the point of view of accepted optimisation criteria which are usually: quality, costs and the time of carrying out logistic processes.

Examining logistic processes with the aid of the worked-out model of the logistic system which is the worked-out informatic system only serves the purpose of predicting the results of different variants of the future system. In case of economic system, the methods of examining without interference are extremely desirable.

4. The description of the selected logistic system

As a result of examining logistic processes in Polish building companies, various models of logistic systems have been isolated taking into account distribution of materials from the point of view of their kind, worth, using up, etc., and the factors influencing the character of logistic flows, i.e. the way of ordering and supplying goods [8].

In the paper, the model of logistic system DSSL_3 is presented, as an instance, in which supplies are directed to a building site, and the surplus to the central warehouse. In its structure it has many elements in common with and is typical of the majority of other models (ordering mode, complaint of supplies, acceptance of purchases, supplies checking, return of material surplus and the existence of the central warehouse and on-the site warehouses). The model comprises flows of basic materials used in the building process, both at the stage of raw and finishing stages.

The size of order is defined by the Supplies Department on the basis of demands from various building sites in the period of taking orders, and it is corrected against the amount of stock in the central warehouse. The final size of the order takes into account financial abilities of the company, terms of payment, storage and transport.

Supplies are distributed to building sites in accordance with the size of demand, the remaining part is stored in the central warehouse. The material is not collected as stock on purpose, but it results from the sensible use of transport and negotiated terms of payment.

The remaining factors (a type of supplier, a way of using up material, a position of materials on delivery market with regard to their position in building processes, value of delivery and its size, freight distances, time of delivery, a kind of transport, costs) are the parameters of logistic processes. They do not influence the structure of logistic systems models, and are taken into account only while describing in detail the dynamics of processes in the system (eg time of delivery) or while analysing costs of functioning the system (eg logistic costs).

A fragment of the graphic model including the structure of the system, ie elements of the system and material and information flows are shown in Fig 2.

Logistic costs are the basic criterion for evaluating the functioning of logistic system, assumed in the present study. A simplified form of costs function has been worked out on the basis of isolating logistic costs of a building company, which results from the necessity of adapting to rules of record, costs calculation and financial outcome of companies [2].

Objective function has the following form:

$$K = k_{tz} \cdot L_s + k_{ul} \cdot L_{dm} + k_{tw} \cdot L_{db} + s_o \cdot M_{zm} \cdot c_j + \\ + k_{kz} \cdot L_{ub} + s_o \cdot M_{zb} \cdot c_j + k_b \qquad [\text{zl/T}], \quad (1)$$

at the same time

$$k_b = c_j \cdot D \cdot L_{dm} - (D \cdot L_{dm} - D_{bu} \cdot L_{dbu}) \cdot c_j \cdot u \quad [\text{zl/T}],(2)$$

where:

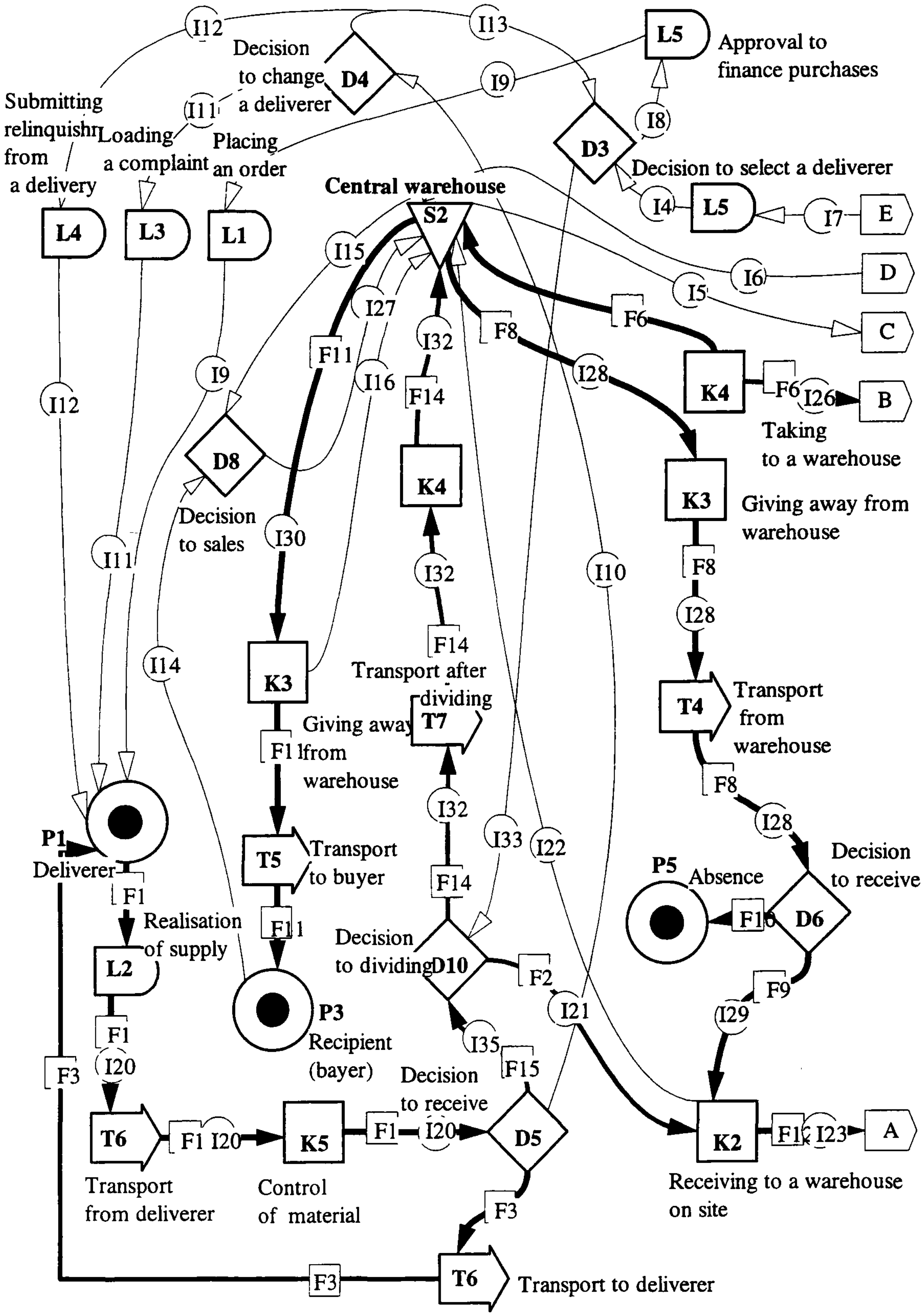

Fig 2. A fragment of the graphic model of logistic system

a) variables received from the simulator make controllable parameters:

L_s - average number of car courses (means of transport of identical load capacity, which means that supplies bigger than load capacity of a single car, will be brought by two or more cars), at time T,

L_{db} - average number of supplies from a supplier to a company, (pcs/T),

L_{dm} - average number of supplies to building sites from the central warehouse, (pcs/T),

L_{uz} - average number of days without stock at building sites (breaks in building processes), days/T),

L_{dbu} - average number of supplies without discounts, (pcs/T),

M_{zc} - average stock in the central warehouse, (zl/day),

M_{zb} - average stock at building sites, (zl/day),

D^* - average delivery to a company, (material units),

D_{bu} - average delivery to a company without discounts in unit price.

b) factors making uncontrollable parameters in the model and having the character of stable coefficients of objective function:

k_{tz} - unit cost of delivery to a company, including costs of transport only, [zl/delivery],

k_{id} - unit cost of carrying out supplies (from the point of view of information-decision processes, ie costs: depreciation of informatic equipment, materials and energy, salaries for supplies staff, extraneous service - telephones, faxes, others), [zl/delivery],

k_{tw} - unit cost of delivery from the warehouse to building sites, including costs of transport only, [zl/delivery],

s_o - average interest rate of the credit frozen in stocks (expressed as decimal number),

k_{uz} - unit cost of penalties for the delay in building processes, assumed as cost of losses because of the lack of stock, [zl/day],

c_j - average unit price of delivered goods, [zl/material unit] (omitted if D is expressed in zlotys),

u - proportional indicator of discount from unit price.

Attention: Logistic costs refer to a definite lot of goods (means of transport capacity - 5000 pieces). In the example shown unit costs values were estimated on the basis of data from one company [2].

Table 1 contains a set of input data for the research presented in paragraph 4 which are made up on the basis of Supplies Department documentation in one of building company under examination [2].

5. Simulation studies and the analysis of the results

The simulation model programmed in GPSS World language is a tool which enables conducting manifold studies of the logistic system [10]. The paper presents the results of one of the possible strategies of supply. The strategy consists in defining the size of delivery which is equal to the difference between the demand planned and the amount of material in stock at a building site at the moment of sending an order to the Supplies Department by the manager. It is sent when the stock level falls below the level which is equal to the demand planned.

This strategy minimises stock level at a site. There is a danger, though, that some materials will be lacking in case of badly-chosen controlling parameters.

Controlling parameters in this strategy are:

1) t_w - period of planning the use up, at building sites,
2) t_z - time of collecting orders by the Supplies Department.

In the assumed methodology, logistic costs are modelled starting from the base point which is defined by values of controlling parameters in the company under examination. Next step is looking for successive better solutions, from the point of view of minimising criterion function. While taking decision as to the choice of the direction of changes, limiting factors that result both from the setting (eg crediting growth of stock) and from the company itself (changes in employment, changes in infrastructure of logistic processes) are taken into account. The final decision about the choice of a solution is taken by the experimenter on account of costs issuing from a possible modification of elements in the structure of the model. It is necessary because coefficients occurring in cost function and representing logistic unit costs were defined for the base point.

To find the optimum solution, successive iterations were done according to the assumed optimising procedure by changing the values of the parameters t_w and t_z accordingly.

The tendency of changes in logistic costs according to changes in controlling parameters within assumed variation range at the base point (t_w = 14, t_z =3) for the assumed strategy is shown in Fig 3.

6. Interpretation of the research results

The analysis of simulation results for different values of t_w and t_z (Fig 3a) allows to reach the following conclusions:

- the lowest logistic costs in this series occur in the 5th experiment when t_z = 3 days and t_w = 21 days;
- this result is caused by the fact that while lengthening the planning period t_w, the demand grows, supplies ordered by the Supplies Department grow because of growing lots of order, discounts in price grow too, stock level becomes higher and so is money freeze, but a number of days with lack of stock and penalties for the down-time diminish. As penalties diminish quicker than circulating resources freeze grow, total logistic costs diminish with comparison to the base point (t_w = 14 days, t_z = 3 days);
- the above conclusion prompts to lengthen the planning period of using up material at building sites;
- changes connected with the planning cycle lengthening are of organisational nature and do not require additional costs, and 21-day planning cycle approximates one month's cycle used in building companies;
- profit on the combination t_w =21 and t_z = 3 is 180 zl in logistic costs connected with the flow of 5000 pieces of brick with reference to the year;
- next series of experiments is suggested for the constant value of t_w =21 and t_z {1,7}.

Table 1. A set of input data for the simulation study

No	Name of parameter	Symbol	Numerical value
	Building sites		
1.	Number of building sites	n	5
2.	Daily use up of material	z_{ij} [pieces]	1 - N(400,100); 2 - N(1200,240); 3 - N(2000,600);4 - N(1600,800); 5 - 800
3.	Time of demand shift in relation to the beginning of work of the model	t_{oj} [days]	1 -30; 2 - N(30,10); 3 - 150; 4 - 600; 5 - N(60,20)
4.	Periods of using up material at a building site	t_{1j} [days]	1- N(90,9);2 - 100; 3 - N(180,18); 4 - N(30,3);5 - 100
5.	Periods of not using up material at a building site	t_{2j} [days]	1- 90; 2 - 0; 3 - 0; 4 - N(30,3);5 - 0
6.	Period for planning the using up materials at a building site called set-up time	t_w [days]	{7,30}
7.	Time limit for sending orders for materials by a building site	t_{bij} [days]	according to pattern depending on the accepted strategy [2]
8.	Delivery size for a building site	Z_{bij} [pieces]	according to pattern depending on the accepted strategy [2]
9.	Delivery size sent by the Supplies Department	D_{bij} [pieces]	according to pattern depending on the accepted strategy [2
10.	Transport time of the delivery from the central warehouse to building sites	t_{ti} [days]	N(1,0.5)
11.	Time of collecting orders in the Supplies Department	t_z [days]	{1,7}
12.	Time of lodging complaints	t_{1i} [days]	M(1)
13.	Number of the claimed supplies	l_{ri}	according to a distribution list
14.	Size of the claimed lot	D_{ri} [%]	defined proportionally[1]
15.	Time of executing the claim	t_{pi} [days]	M(1)
16.	Time of financial acceptance	t_{ai} [days]	M(1)
17.	Time for placing an order	t_{mi} [days]	N(1,0.2)
18.	Time of fulfilling the order by the supplier	t_{ri} [days]	M(1)
19.	Transport time from the supplier	t_{di} [days]	N(1, 0.5)
20.	Material in stock at building sites in days	b	{1,30}

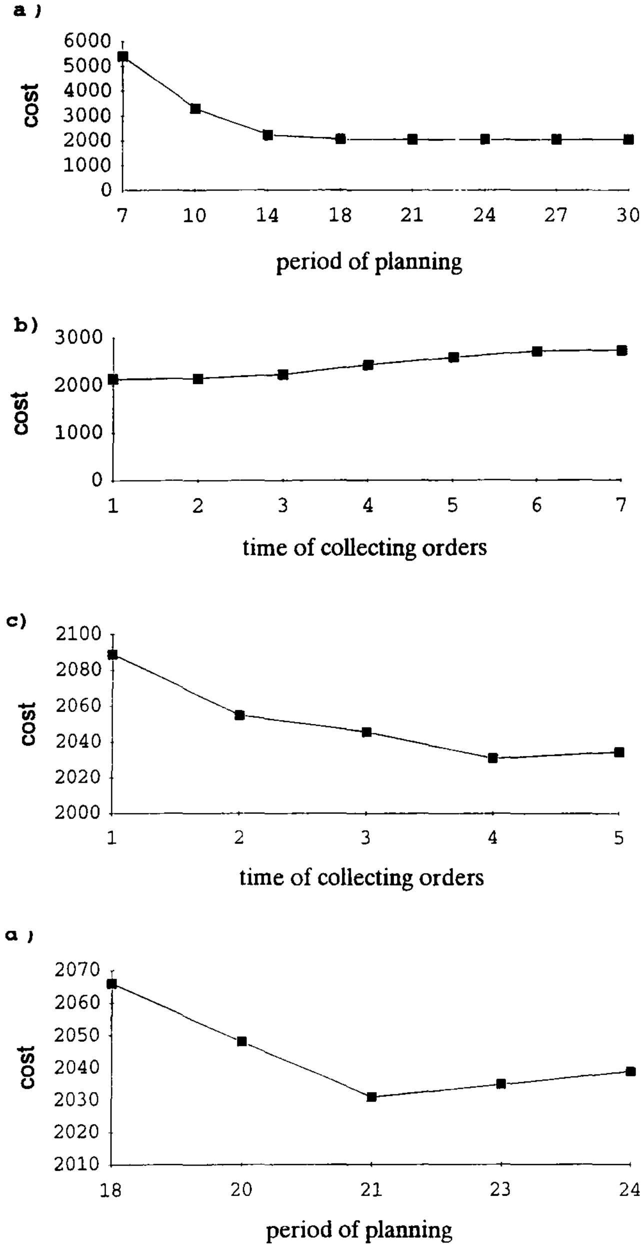

Fig 3. Changeability of costs according to the changes in controlling parameters,in a successive iteration study (cost [zl/500C pieces], period of planning [days], time of collecting orders [days])

Fig 3b shows the behaviour of costs for the base point t_w =14 days, t_z {1,7}.

They are analysed from the point of view of changes from the 3rd base point where t_w =14 days in the direction of t_z =1 day, for this series of minimum logistic cost:

- ❑ stock level at building sites will become higher, the capital freeze will grow by 30%,
- ❑ the capital freeze will grow by 60% in the central warehouse,
- ❑ small growth in the costs of outside transport,
- ❑ considerable growth in costs of information-decision processes by about 50%,
- ❑ cost of works transport will grow by about 40% because of greater number of deliveries from the warehouses to building sites,
- ❑ growth in costs of works transport can be connected with the necessity of certain financial outlay, including for instance a purchase of an additional car or employing an additional driver - these costs are not taken into account in the assumed unit costs of works transport,
- ❑ profit at the change from the base point to the optimum one is 95zl for 5000 pieces a year; it is levelled by bigger expenses connected with the change in elements of the model (additional car, driver, growth in telecommunication services, informatic costs) estimated at 176zl,
- ❑ the conclusion that it is not a good direction of changes,
- ❑ in connection with the above, a series of the 1st experiment was undertaken again, assuming on the basis of its results t_w = 21 days and examining costs at changes in t_z within boundaries {1,5}.

The results of a successive series of the experiment are shown in Fig 3c. The change from experiment 2 (t_w =21, t_z =1) to experiment 4 (t_w = 21, t_z =4 days) is being analysed - optimum in this series.

The conclusions are as follow:

- stock level at building sites diminishes by 20%,
- bigger supplies, a fewer number of supplies, but outside transport without change, while the profit on discounts is bigger,
- reducing outside transport costs and costs of information-decision processes by about 60%,
- reducing costs of works transport by about 50%, it testifies to a possible bad use of works transport - so-called lost chances,
- the profit shown by the change from point 2 to point 4 equals 100zl a year for 5000 pieces, and can be increased if some elements of the model are changed and taken into account in cost function,
- to summarise, the change to t_z =4 days and examining successive changes in t_w are suggested.

In a successive series of experiments t_z was 4 days at points {18,20,21,23,24} (Fig 3d). The conclusion from the analysis of the result is as follows:

- there was no reduction in logistic costs as the received minimum was the same as in the previous series of the experiment 20.30.84/lorry/a year (t_w = 21, t_z =4), it can be stated that changes in this direction do not bring a better solution, thus the point t_w = 21 and t_z = 4 days is assumed as the suboptimum solution.

Taking this solution into practice is connected with lengthening of the demand planning period on the site, which is more advisable from the organisational point of view, and at the same time it is the period in which it is possible to plan precisely enough the execution of building processes. On the other hand, lengthening the period of collecting orders by the Supplies Department is inconsiderable but noticeable in costs.

As a summary of the above studies, it must be mentioned that introducing this solution to company practice should be related to the changes in the elements of the logistic system, ie adapting infrastructure of the logistic system to a change from conditions of "base point" which is characterised by t_w =14 and t_z = 3 days into the conditions of the calculated optimum "base point" with t_w =21 and t_z = 4 days.

7. Conclusion

The range of logistic tasks in building companies is the most extensive in the supply sphere. Rationalisation of logistic management in this sphere should bring desirable effects in the form of accomplishing 6A formula: ***adequate product, adequate quantity, adequate time, adequate place, adequate state and adequate cost of logistic activities.*** Achieving these goals makes it easier to use informatic systems in management.

The suggested methodology of creating informatic systems for the needs of logistics in a company will allow to get a tool which will aid decision-taking in logistic management and achieving the above-mentioned goals. On the other hand, the use of simulation modelling on which informatic system is based, allows:

1) to find out "bottle-necks" and pathological phenomena in logistic processes;
2) re-designing and optimising the structure of logistic system in terms of chosen goals.

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SPRENDIMŲ PARAMOS SISTEMA, NAUDOJAMA LOGISTINIAM VALDYMUI STATYBOS KOMPANIJOJE

A. Sobotka

Santrauka

Vienas iš būdų didinant firmos funkcionavimo efektyvumą yra veiksmų racionalizavimas logistikos srityje. Logistikos tikslai firmos valdyme yra tokie: žaliavų, medžiagų, žmonių, kapitalo ir produktų srautų koordinavimas, šių srautų kainų minimizavimas, logistinės veiklos analizė, siekiant geriau patenkinti užsakovų poreikius. Straipsnyje pateikta logistinio valdymo firmoje esmė; pagrįstas logistikos reikšmingumas aprūpinant statybos firmą medžiagomis ir statybos gaminiais; taip pat pateikta informacinės sistemos DSS, kuri padeda atlikti logistinį valdymą statybos firmoje, kūrimo metodologija. DSS sistema remiasi logistinių sistemų modeliavimo metodais. Pateiktas vienas iš logistinės sistemų panaudojimo pavyzdžių praktikoje. Taip pat pateikta pasiūlyto modelio analizė ir gautų rezultatų paaiškinimas.

Logistinio valdymo racionalizavimas firmos aprūpinimo srityje remiasi šiais pagrindiniais principais: reikiamas produktas, reikiamu kiekiu turi būti pristatomas reikiamu laiku reikiamoje vietoje su norima kaina. Šiems tikslams efektyviau pasiekti ir sukurta sprendimų paramos sistema, naudojama logistiniam valdymui statybos kompanijoje.

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