ESTIMATION OF RISK IN LOGISTIC PROCESS OF TRANSPORT

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Summary: The presence of risk factors in manufacturing companies in the area of logistic processes realization has mainly negative economical aspect, showing the increasing cost of the process, causing the loss of a certain positive value level. Company should make a profit despite the existence of constant contrary tendency in the form of many various risk factors occurrence, to function on the market and be competitive. Logistic processes appear when there is a need to coordinate main processes, which are realized in manufacturing company with each other . The key role here can be assigned to transport logistic processes. Estimating the actual costs of risk factors occurrence in this process is the subject of this article.

Keywords: transport process, risk management, total costs, real costs, the principle of characterization.

1. Introduction

In Poland, studies on risk management, which were started relatively recently, are characterized by a small number of works within a framework of two streams: a) management of speculative risk (with special emphasis on organizational aspects of increased risk projects management), b) management of pure risk (focused on risk handling available methods and their use). The first mentions about risk management in logistics can be noticed in works such as: E.Gołembska, K. Tyc-Szmil, J. Brauer, W. Machowiak, A. Szymonik [9].

In logistic processes, risk means the presence of specific (typical) for logistic processes risk factors, which have determinate probability (frequency of occurrence) and causing certain effects (expressed as a cost). Risk factors appearing in logistic processes have an effect on positive value change realized by main organizational processes. This change has usually negative dimension.

The process in a combination of consecutive actions, which are repeated in particular cycle, which transform resources during input to the result of process. The transformation consists in sending a new value (positive value). Measurable aim of this process is to get a result with the highest possible positive value, which is verified and recognized by a receiver.

This approach makes it easy to realize optimization of company, as a whole, because boundaries between divisions, making communication difficult, are replaced by boundaries between processes.

As a result, the main goal becomes an effect of process, and exactly processes and theirs results are the source of providing to the customer expected products.

Logistic processes – support to functioning of the management system and ensure its effectiveness and efficiency. They include activities and actions, which are related to the preparation of basic structure in the process, administration of information system creation, transport, storage, accounting and finances, reporting and controlling [10].

Coordination of all actions in company is present within a framework of logistic processes. The final aim of coordination is to obtain unanimity in realization of problem, which is consisted of these problems. The key to coordination is a view of performer's internal structure and description of their tasks. Logistic processes appears when there is a need to coordinate main processes with each other, which are realized in a manufacturing company. Here, the key role can be assigned to the logistic process of transport.

2. Transport process in functional and structural term of characterization rule

Taking into consideration multiplicity of possible states which can be taken by risk factors during transport process, we face with situation which implies the need to generate and evaluate a set of several possible solutions which may arise in a specific problematic situation. Since the number of elements in solution ensemble in the majority of practical problems grows in NP-complete method, the possibility of searching and considering every one of them is practically impossible in real time. Hence, there is a need to search solutions which will allow for purposeful selection of variants which are evaluated, allowing for constrain of space and reduce the searching time for interesting solutions. Structural and functional character of relations which are present in logistic processes, points to the possibility using to parameterization of value-added results in logistic processes, known from the systems theory of characterization principle.

Characterization principle is one of the contemporary methodological apparatus in systems theory. The system interpretation of problems in connection with this principle first of all boils to:

1) The determination (searching) not same solutions but their characteristic features.
2) The features of solutions should be related to representatives (invariants) equivalent solutions classes.
3) The class of equivalent solutions is formed as a result of input data interpretation in considered group of tasks in categories of features of solutions [1,2,3,4,5,6,7].

Classes of equivalent solutions than all possible solutions, and the analysis features of solutions can be carried out without their direct (objective) generation. Formally developed and methodically verified in the particular objective area of characterization principle, they form a characterization theory. Its essence is contained in the reciprocal interpretability of the operating model of the examined object with the model of its structure. The reciprocal interpretability of models is obtained by the selection of universal laws of correct functioning (expressed in the operational model) and structural interpretation of the operating model [1].

According to the characterization principle, an object will be operated correctly, if it will be possible to determine and prove the reciprocally consistent interpretation between its operating rules (described thanks to the operational model, which is denoted by ψa) and the executing structure (described by the model of the structure, which is denoted by ψb). In order to determine and to prove the unique interpretation of these two models, the following assumptions are adopted:

- the resource functions adequately to its structure.
- the structure of the resource is adequate to its advisable method of functioning.
- the essence of the characterization principle can be written as [1]:

$$< \psi_{a,} \psi_{b,} P_0 (\psi_{a,} \psi_b) > \tag{1}$$

where:
ψ_a – operating model,
ψ_b – structural model,
$P_0 (\psi_a, \psi_b)$ – atomic predicate.

The P_0 atomic predicate (ψ_a, ψ_b) characterizes the possibility of the ψ_a operating model interpretation in terms of the ψ_b structural model. The P_0 predicate is a special case of the logic variable and takes the value "1" or value "0". "1" means the possibility of transformation, whereas "0" means lack of such a possibility. Application of the characterization principle requires a precise determination:

- What is the operating model in transport logistic processes?
- What is the structural model in transport logistic processes?
- How should the P_0 predicate be interpreted (ψ_a, ψ_b)?

Developing the theory of conditions in transformation of ψ_a model into the ψ_b model to build parameterization model of logistic processes requires:

1) The set of ψ_a operating models with information about:
   - probability (frequency) of risk factors occurrences in the examined transport process,
   - effects of risk factors appearing (defined as the maximum cost which can cause, when they occur in the examined transport process) and,
   - realized (planned) level of value added, adequate for this one from transport process.
2) The set of the ψ_b structural models with information about:
   - continuity of the examined course in transport process,
   - real costs (effects and probability) of specified risk factors appearing in logistic processes,
   - created (real) level of the added value in obtained result of the process.
3) The P_0 atomic predicate (ψ_a, ψ_b) determining the reciprocal interpretability of the operating model in terms of the structural model [8].

3. Application of the characterization principle in estimation of risk in transport process

To formulate a operating model, information about occurring of risk factors in particular transport process was necessary. According to examinations, which were conducted in K Company – the following list of risk factors was established – tab.1.

Estimating all risk factors costs which are mentioned in Table 1 requires to determine all information described probability and the effect of risk factors considered in the transport process in a particular time interval for example 1 year. On this basis, it can be stated, that operating model includes information about overall costs of risk factors occurrence in logistic process of transport, because these data map the current state of research problem fixed on the basis of studies in a particular company and time interval.

To obtain information about real costs which are caused by risk factors, it is necessary to gain and interpret the model structure. Its obtaining requires execution of next characterization principle stages.

The set of Ψ_b structural models must include information about real costs of risk factors occurrence in logistic processes which has an influence on added value size for the company.

Tab. 1. List of risk factors was established in K Company

	RISK FACTORS		
LOGISTIC PROCESS OF TRANSPORT	1. lack of suitable means of transport 2. downtimes because of waiting for the means of transport 3. lack of onsite transportation organization (no system) 4. car breakdowns 5. working time for drivers 6. drivers qualifications and experience 7. deficit of drivers 8. accidents	9. lack of available drivers 10. lack of internal and external integration in supply chain management 11. service process not sufficiently oriented on a customer 12. problems with information flow 13. too low partners' ability to respond to unexpected orders (low flexibility, too slow readjustment to requirements) 14. lack of intervention between processes of production, distribution and provision 15. too high costs of service 16. lack of intervention between customers and suppliers	17. problems with horizontal integration in supply chain 18. employees qualifications and experience 19. deficit of employees 20. lack of experience 21. undervaluation of predicted costs 22. economic consumption of planned solutions 23. failure to comply specified deadlines 24. deficit of capital

Obtaining this result requires, according to the characterization principle, determining conditions of redesigning the operating model into the structural model so as that its $P_i^{\sigma i}$ components create a partially ordered set, i.e. the set whose elements meet the requirements of the partial ordering:

$$R \subset P \times P \left(P_i^{\sigma_i} \in P\right) \tag{2}$$

described with properties:

– reflexivity:

$$\forall (P_i^{\sigma_i} \in M)[(P_i^{\sigma_i}, P_i^{\sigma_i}) \in R] \tag{3}$$

– antisymmetry:

$$\forall (P_i^{\sigma_i}, P_j^{\sigma_j} \in M)\{[(P_i^{\sigma_i}, P_j^{\sigma_j}) \in R] \wedge [(P_j^{\sigma_j}, P_i^{\sigma_i}) \in R] \rightarrow P_i^{\sigma_i} = P_j^{\sigma_j}\} \tag{4}$$

– transitivity:

$$\forall (P_i^{\sigma_i}, P_j^{\sigma_j}, P_k^{\sigma_k} \in M)\{[(P_i^{\sigma_i}, P_j^{\sigma_j}) \in R] \wedge [(P_j^{\sigma_j}, P_k^{\sigma_k}) \in R] \rightarrow (P_i^{\sigma_i}, P_k^{\sigma_k}) \in R\} \tag{5}$$

where:
R – relation symbol,
P – set of risk factors,
$P_i^{\sigma_i}, P_j^{\sigma_j}, P_k^{\sigma_k}$ - elements of risk factors set,
M – the set of propositional variables

An appropriate form of the structural model presentation is the Hasse diagram, because this is a directed graph, which reflects the idea of the transport process realization as a sequence of consecutive steps with the appearing risk factors. Constructing the Hasse diagram requires removing all loops from the graphical presentation of the process, that is repeated or duplicated activities (that corresponds with the reflexivity in the partially ordered set) as well as closing arcs, which reflect for example incorrectly marked internal transport routes, improper or lack of marking fields of storing in magazines, etc. (which corresponds with transitivity in the partially ordered set).

Finding the optimum Hasse diagram requires converting the ψa operating model into the ψb structural model in such a way that the propositional function being in the ψa model would be unequivocally interpreted in the ψb model.

In the assumptions of the characterization theory, the universal laws of correct functioning are expressed by means of so-called prohibited graph figures, defined as abstract structures, which should not appear in form of homeomorphisms in the operating model "under threat" of its incorrectness [6, 9] what originally was applied in the automata theory [1].

For model of cost estimation in logistic process of transport, the most important is identification of restricted figures in the form of Q^A or Q^B graph submodels.

The prohibited Q^A figure is a graph submodel recorded in the form of cycle with odd length whose vertexes are weighed with pairs of cyclically changing weights, which are indexes of appropriate alternative parts [9] .

For cost evaluating model of logistic transport process, such a graphical form informs us about the presence of risk factors in more than one area of significance at this process. It is very important from a point of view of the cost analysis which concerns removing effects of the risk factors presence, since effects will be noticed in many areas (the number depends on a particular case).

The second kind of the prohibited figure is the Q^B figure, which is a graph submodel recorded in the form of triangle with hanging vertexes. Vertexes of the triangle have an identical weight and each of them has the additional weight equal of the hanging vertex weight [9].

This type of a prohibited figure corresponds to the situation when the risk factors present in one area affect the adjacent ones, e.g. a risk factor associated with transport (let's denote it as a) creates a risk factor in supply area (let's denote it as b) and simultaneously creates a risk factor in production area (let's denote as c) as well as in the area of distribution (let's denote it as d). Removing the initiator, prohibited graph figure according to the characterization principle through splitting the factor "a", that will eliminate effects even in four areas.

In terms of prohibited graph figures splitting, it is important to pay attention on the following questions:

- splitting should be realized in order to eliminated all thee prohibited graph figures,
- from amoung the available variants of splitting (variable replicas), we always choose the minimal subset of propositional variables, which will eliminate all prohibited graph figures,
- we use semantic table to select possible variants of propositional variables splitting,
- select of variable/variables to splitting determines the form of a new ψ'_a operating model and thereby form the resulting Hasse diagram.

Getting a new operating model and the particular form of Hasse diagram has consequences for costs of logistic transport process realization. As a result of this operation, propositional variables splitting is present. These variables reflect risk factors considered in the tested transport process, characterized by a certain probability and effect of risk factors occurrence, that is duplication of activities will result in the final costs level. By the application of characterization principle in a simply way you can see that the presence of risk factors has its consequences not only in a place of accident forming. Effects often translate into other areas of company's functioning, and even the whole organization. After characterization, we can calculate real costs of risk factor occurrence.

Obtaining information about real costs for company in connection with the occurrence of risk factors showing the structural and functional dependence of model, are described as an example of researches conducted in K company. The analysis will be realized by AWZR simulator (AWZR simulator is an author program which makes conducting economic experiments according to V.A Gorbatov principle of characterization possible).

4. Example of parameterization model application

Based on data which were obtained during tests realized in 2008 in K Company, propositional function which describes the occurrence of risk factors in logistic transport process was determined. Propositional function is obtained by selecting the first module of the propositional function model (Fig.1). We introduce a list of risk factors in the company and information about the probability and consequences of their appearance. To get the propositional function, we select the Company, select year, and in column "choice" select these risk factors, suitable for us to perform the analysis. (see Fig.1).

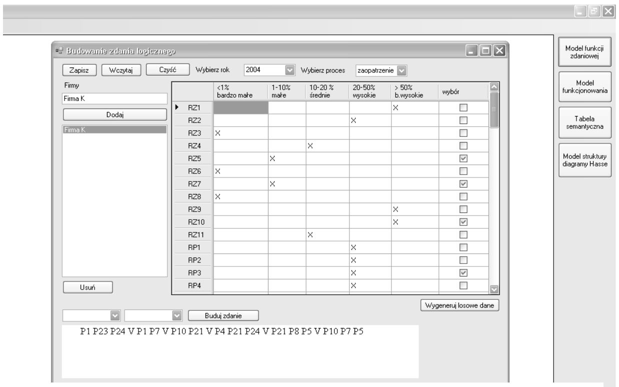


Fig. 1. An active window of the module - a model of a propositional function

The analysis will be realized using 9 from 24 risk factors, which are enumerated in Table 1. On this basis, the propositional function adopted the following form:

$$ZP_x(P_1, P_2, \ldots, P_{24}) = P_1\,P_{23}\,P_{24} \vee P_1\,P_7 \vee P_{10}\,P_{21} \vee P_4\,P_{21}\,P_{24} \vee P_{21}\,P_8\,P_5 \vee P_{10}\,P_7\,P_5$$

ψ_a operating model of ZP propositional function is given as a statement:

$$\psi_a = < M, R_2, R_3 >$$

where:
M - a set of propositional variables.
R2 - a set of relations defined by dual element alternative modules.
R3 - a set of relations defined by three elements alternative modules.

$$M = < P_1, P_4, P_5, P_7, P_8, P_{10}, P_{21}, P_{23}, P_{24} >$$

$$R_2 = \left\{ \{P_1, P_7\}_2, \{P_{10}, P_{21}\}_3 \right\}$$

$$R_3 = \left\{ \{P_1, P_{23}, P_{24}\}_1, \{P_4, P_{21}, P_{24}\}_4, \{P_{21}, P_8, P_5\}_5, \{P_{10}, P_7, P_5\}_6 \right\}$$

The "operating model of the AWZR model" module makes getting a graphical form of operating model possible (Fig.2).

Graphical form is formed in the following way. For each propositional variable occurring in the operational model, a special number of conjunction is determined, and occurs: P_1 (1,2), P_4 (4), P_{30}(3,6), P_{21}(3,4,5), P_{23}(1), P_7(2,6), P_8(5), P_5(5,6), P_{24}(1,4). Propositional variables are vertexes of a graph. Lines are connected to the propositional variables in the same conjunctions. Thus, propositional variables, show on Fig.2 which are present in the first conjunction, are connected by a red line, in a second by a green line, in the third by a blue line, in the fourth by a black line, in the fifth by a yellow line, and in the sixth by a purple line.

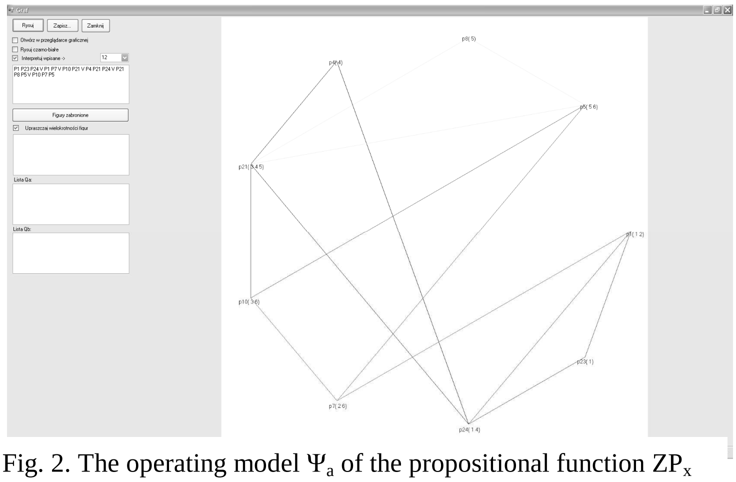


Fig. 2. The operating model Ψ_a of the propositional function ZP_x

It is a structural model that is an aim of modelling and solves a defined research problem, that is searching for actual costs of risk factors presence in logistic transport process. Obtaining the result requires limitation the structural model in such a way that its Pi elements can create a partially systematic set.

Appointing the prohibited figures of the type Q^A and Q^B that is enabled by the module "operating model of the AWZR simulator". For the ZP function there were identified three prohibited figures of the type Q^A and one prohibited figure of the type Q^B. Next vertexes of the prohibited figures Q_1^A, Q_2^A, Q_3^A represent propositional variables, which appear in conjunctions in the fixed order and graphically form a loop – an example of the type prohibited Q^A figure shows Fig.3.

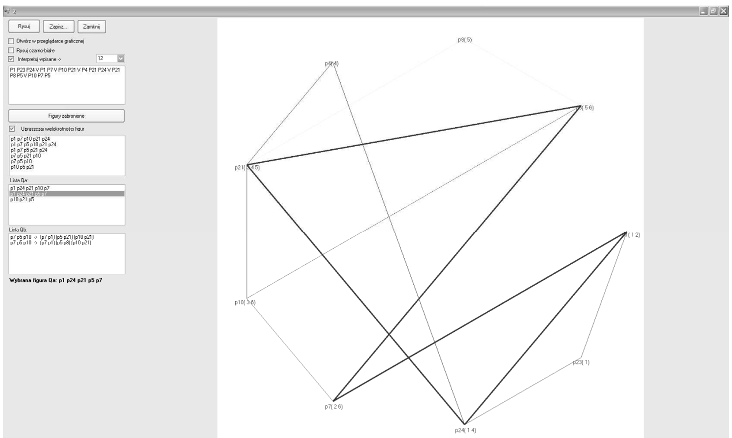


Fig. 3. The graph model of functioning of the function ZP_x with the marked prohibited graph figure of the type Q_1^A

Formal record of Q_1^A prohibited figure:

Q_1^A = {$P_{10}(3,6)$, $P_7(6,2)$, $P_1(2,1)$, $P_{24}(1,4)$, $P_{21}(4,3)$}

The second type of prohibited figure is QB figure which is a graph submodel recorded in the form of a triangle with hanging vertexes. The analyzed function includes a figure of this kind marked in Fig. 4 by bolded line, and hanging vertexes by break line. Formal record of Q_1^B prohibited figure:

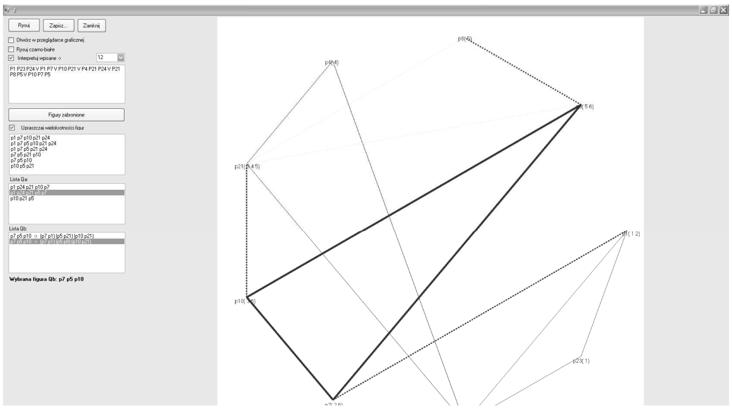
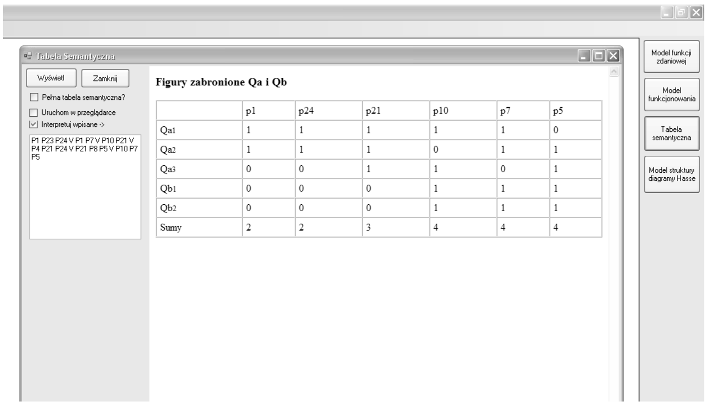


Fig. 4. The graph model of the propositional function ZP_x with the marked prohibited graph figure of the type Q_1^B

$$Q_1^B = \{ \{P_{10}, P_7, P_5\} \{P_{10}, P_{21}\} \{P_7, P_1\} \{P_5, P_8\} \}$$

The occurrence of this type of submodels in the graph representation of propositional function was observed by V.A. Gorbatov. Although in this case we deal only with four "images", but the possibility of their identification and splitting saves many hours of arduous analysis from 5184 possible variants of Hasse diagrams which are available in this function.

To splitting of prohibited figures which have occurred in the graph representation of the analyzed propositional function, a semantic table was built. In the first line of the table was introduced propositional variables that have occurred in all identified prohibited figures. Whereas, in the fist column we introduce prohibited figures. In the following lines we denote by digit "1" propositional variables as vertexes in prohibited graph figure which occurred in the prohibited figure.



	p1	p24	p21	p10	p7	p5
Qa1	1	1	1	1	1	0
Qa2	1	1	1	0	1	1
Qa3	0	0	1	1	0	1
Qb1	0	0	0	1	1	1
Qb2	0	0	0	1	1	1
Sumy	2	2	3	4	4	4

Fig. 5 . Semantic table of ZP_x function

In AWZR simulator, semantic table is drawn automatically base on the typed function. After selecting the "semantic table" modul on the left side of the screen, propositional function is displayed, and adequate for the right side – semantic table (Fig. 5)

The minimum subset of propositional variables which will liquidate all prohibited figures, we select paying attention on frequency of propositional variable occurrence in prohibited figures (the biggest number of digit 1 in semantic table column), and from the viewpoint of transport, we select from alternative solutions these propositional variables which represent risk factors with the lowest probability (frequency) of occurrence and the lowest cost of potential effect.

In analyzed function of all prohibited figures splitting, we have two pairs of variables:

- the first pair: propositional variable $P_{10}(3,6)$ which makes splitting of Q_1^A, Q_2^A, Q_1^B prohibited figures possible and propositional variable $P_{21}(4,5)$ which makes splitting of Q_3^A possible,
- the second pair: propositional variable $P_7(2,6)$ which makes splitting of Q_2^A, Q_3^A, Q_1^B prohibited figures possible and propositional variable $P_{21}(3,5)$ which which makes splitting of Q_1^A possible.

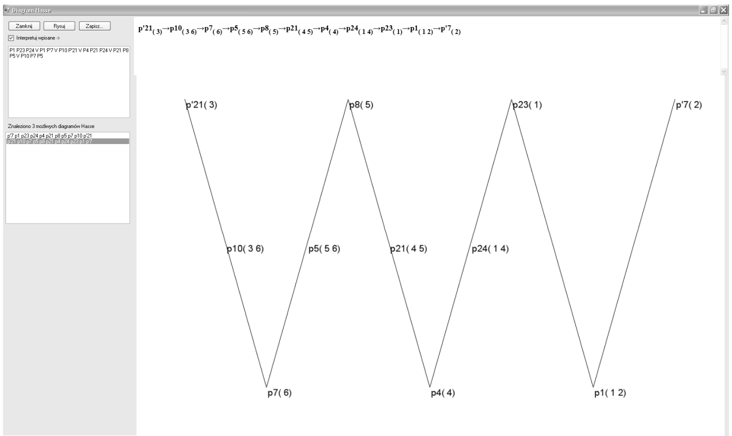


Fig. 6. Model of ψ_b structure in ZP_x propositional function

The selection of variables will be conditioned a form of the new ψ'_a operating model, and thus, form of the resulting Hasse diagram and the level of actual costs connected with risk factors' selection generated in the test process of transport. Taking into consideration both criteria to splitting, we choose $P_7(2,6)$ and $P_{21}(3,5)$ variables. We split in the second conjunction P_7 propositional variable, whereas P_{21} in the third one. As a result of splitting we get a new operating model of which corresponds to an adequate Hasse diagram, shown in Fig. 6.

A new form of ZPx function:

$$ZP_x (P_1, P_2,\dots,P_{24})' = P_1 P_{23} P_{24} \vee P_1 P'_7 \vee P_{10} P'_{21} \vee P_4 P_{21} P_{24} \vee P_{21} P_8 P_5 \vee P_{10} P_7 P_5$$

For which the new ψ'_a operating model takes the following form:

$$\Psi'_a = < M', R'_2, R'_3>$$
$$M' = < P_1, P_4, P_5, P_7, P'_7, P_8, P_{10}, P_{21}, P'_{21}, P_{23}, P_{24}>$$
$$R'_2 = \{ \{P_1, P'_7\}_2, \{P_{10}, P'_{21}\}_3 \}$$
$$R'_3 = \{ \{P_1, P_{23}, P_{24}\}_1, \{P_4, P_{21}, P_{24}\}_4, \{P_{21}, P_8, P_5\}_5, \{P_{10}, P_7, P_5\}_6 \}$$

Each of chosen to the analysis risk factors P_1, P_4, P_5, P_7, P_8, P_{10}, P_{21}, P_{23}, P_{24} incorporates information about the frequency (probability) of risk factors and potential effect (measured by the maximum cost o removing the effects of risk factors occurrence). Taking into account particular companies – K Company – these values developed as follows below – Tab. 2.

Tab. 2. Summary of probability and effect of risk factors occurrence in ZPx function

PROPOSITIONAL VARIABLE	2008		TOTAL COSTS of the particular risk factors (PLN)
	AMOUNT	MAX COST	2008 YEAR
P_1	10	342	3420
P_{23}	34	134	4556
P_{24}	23	544	12512
P_1	12	232	2784
P_7	76	12	9196
P_{10}	23	123	2829
P_{21}	23	123	2829
P_4	21	1244	26124
P_{21}	23	93	2139
P_{24}	12	23	276
P_{21}	35	123	4305
P_8	23	13	299
P_5	32	12	384
P_{10}	12	456	5472
P_7	32	2344	75008
P_5	22	76	1672
Σ total all-in costs of examined risk factors			153805

On this basis, we can determine that the operating model contains information about total costs of risk factors in tested process of transport, because these are data mapping direct information taken from the tested, in a given period of time, company. Taking into consideration only these mentioned factors, the company added value could be higher about 153,805 PLN. In a year of the company's operating, it is not a big amount, but we analyze here only a few risk factors.

Based on the researches we can conclude that the real costs of risk factors are usually higher than those that are recognized in the accounts with results. To get information about the real costs which are caused by risk factors, it is necessary to interpret the model of structure. On its basis, we know that a replicas of variables were obtained in a form: P'21, P'_7. This has consequences in the calculation of risk factors costs occurring in logistics processes. In Tab. 3 shows the cost of the risk factors based on the new ψ'_a operating model. Comparing the total and actual costs of the risk factors (Tab.4), shows that correct calculation has a big sense.

Tab. 3. The cost analysis of the results of removing individual risk factors for the chosen propositional variables - in the ψ'_a operating model of the ZP_x function'

PROPOSITIONAL VARIABLE	2008		ACTUAL COSTS of the particular risk factors (PLN)
	AMOUNT	MAX COST	2008 YEAR
P_1	10	342	3420
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P_{21}	23	123	2829
P_4	21	1244	26124
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P_{24}	12	23	276
P_{21}	35	123	4305
P_8	23	13	299
P_5	32	12	384
P_{10}	12	456	5472
P_7	32	2344	75008
Σ total all-in costs of examined risk factors			165830

After examining a small number of risk factors, the difference amounted to more than 12 000 PLN - Tab.4. It gives an initial idea of this phenomenon's scale.

Tab. 4. The comparison of total and actual costs of the removing effects from the risk factors appearance

BALANCE	
Total costs	Actual costs
153805	165830
Difference: 12025	

The consequences of underestimating costs connected with removing unwanted events, even on the basis of just one of the logistic process are shown in accounts of results in manufacturing companies.

5. Conclusions

Using of the characterization principle for logistic processes parameterization is mainly connected with showing: actual costs, actually incurred in connection with the occurrence of certain risk factors in logistic processes. After this analysis with parameterization model using, we are able to show that actual costs are higher than those included in the calculations (if any are pointed out).

Ignoring real costs of risk factors occurrence, may has significantly impact on creation of added value, resulting in conditions of the company on the market. Risk factors in manufacturing companies in the range of logistic processes has mainly negative economic aspect, manifested in increasing the cost of the process, causing loss a certain level of added value. The company, in order to function in a market, should be competitive and makes a profit, despite the opposite tendency of constant many risk factors occurrence.

Comparing total and actual costs of risk factors occurrence, we can see the importance of the correct calculation. The consequences of underestimating costs connected with removing effects of adverse events are shown in the profit and loss account of each company.

References

1. Gorbatov V.A.: Semantyczna teoria projektowania automatów. Energia, Moskwa, 1979.
2. Gorbatov V.A., Pavlov P.G., Czetwiernikow V.H.: Logiczne sterowanie informatycznymi procesami. Moskwa, 1984.
3. Gorbatov V.A., Krupa T.: Zasada charakteryzacji w logistyce systemu produkcyjnego. Międzynarodowa Konferencja SYPRO’84, nt. Systemy produkcyjne-teoretyczne i praktyczne problemy projektowania, Warszawa, 1984.
4. http://www.e.kulinska.po.opole.pl.
5. Krupa T.: Zasada charakteryzacji w projektowaniu systemów organizacyjno-technicznych. Zeszyty Naukowe IOZ PW, nr 1, Warszawa, 1983.
6. Krupa T., Prokopowicz T.: Modeling of Polish enterprises insolvency processes with the use of Gorbatov characterization principle – research results. Foundations of Management – International Journal, vol.2/2010 (3).
7. Krupa T.: Elementy organizacji. Zasoby i zadania. WNT, Warszawa, 2006.
8. Kulińska E., Krupa T.: Model oceny aksjologicznego wymiaru zarządzania ryzykiem procesów logistycznych. Logistyka 4/2009.
9. Kulińska E.: Aksjologiczny wymiar zarządzania ryzykiem procesów logistycznych. Modele i eksperymenty ekonomiczne. Oficyna Wydawnicza Politechniki Opolskiej, Opole, 2011.
10. Nazaretow W.M., Kim D.P., Krupa T.: Techniczna imitacja intelektu. WNT, Warszawa, 1991. (wydanie polskie rozszerzone).
11. Pabian A.: Uwarunkowania sukcesu przedsiębiorstwa na rynku, zarys problematyki. Seria monografie nr 59, Wyd. Politechniki Częstochowskiej, Częstochowa, 1998.

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