THE RISK ASSESSMENT IN THE LOGISTIC PROCESSES STRUCTURES

Ewa KULIŃSKA

The Faculty of Economy and Management
Department of Marketing and Logistics
The Opole University of Technology, Opole, Poland
e-mail: e.kulinska@po.opole.pl

Abstract: This paper presents the nature of logistic processes functioning in manufacturing companies with special risk factors situations. The author's parameterization model of the value added was generated as a result of the logistic processes. Author refers to differences between all-in and real costs caused by appearance of risk factors in logistic processes. Author also identifies the change of the value added measured with the net profit and its results.

Key words: logistic process, risk, value added, characterization principle, all-in/total cost, real/actual cost.

1 Introduction

It is in the opinion of the author that the risk management in logistic processes has a significant impact on the value added created by a manufacturing company both for customers as well as for the company itself. The comprehensive identification and the quantification of the processes in terms of the value added creation constitute the base of the identification of risk factors and, what is associated with it, also a base for implementing the risk management system in logistic processes. It should be therefore possible to build a parameterization model by means of the tools of the mathematical logic, in particular with the application of the propositional functions in the description of cause-and-effect and structural relationships, which are so characteristic for operations of manufacturing companies.

2 The adopted meaning of the crucial categories of the subject

These are supply, production and distribution that are the fundamental operation areas of any manufacturing company. The logistic processes combine the business process of supplying with the technical production processes and the production with the business process of distribution. These are the activities accomplished by them that are their attributes as: storing, transport, trans-shipment, packing, labelling, handing over and preparing orders [20].

These activities transform initial resources into final resources with the changed value added. Thus the level of the value added acquired at the end of the process, depends on the sum of transformations carried out during individual activities being included in the specific process. Hence, it is the transformation that determines whether we obtain the expected level of the value added. Each step of the process should raise the value of the product, that is create its value added for a customer and/or for the company. Therefore the adequate protection of the transformation, for example by a risk management system, determines the definitive level of the value added obtained as a result of the process.

It is for the purposes of the paper that the processes, which support the main activities of the company during the transformation through coordinated storing, transporting, trans-shipment, sorting, packing and labelling will be ranked among logistic processes enabling maximizing the created value added for outside and internal customers [18].

One should pay attention to the fact, that every organization performing everyday tasks is exposed to many kinds of different risk factors. Many of them are connected one with another, which means that one type of the risk may cause arising another risk factor. Hence, the identification of the reasons and sources of risks determines the reduction or the minimization of the risk to the accepted level [24], which is directly translated into implementation of the objectives of the processes.

The essence of the transformation protection in the logistic processes means the presence of specific (typical) risk factors for the logistic processes, which have certain probability (frequency of appearing) and cause defined effects (expressed as costs). The risk factors appearing in logistic processes affect the change in value added accomplished by main processes of the organisation. This change has most often a negative result [18].

There are not many methods described in the literature on the subject, which are helpful while analysing and controlling risk factors appearing in the logistic processes.[1] Therefore, there is a need of developing a new method in order that one could take optimal decisions and thus reduce the influence of risk factors associated with logistic processes on creating the value added. The effect of the research conducted in this respect was described in the next subsections of the paper.

3 The logistic processes from the functional and structural perspective of the characterization principle

It is according to the adopted definition of the process that it is a juxtaposition of consecutive activities, which are repeated in the determined cycle and which transform resources into the outcome of the process. The transformation consists in conferring a new value (value added). The measurable objective of the process is the achievement of the result of the highest value added verified and recognised by a customer.

Such an approach facilitates the optimization of the company as a whole, since the boundaries amongst departments obstructing the communication, are replaced by the boundaries amongst processes. As a result, it is the outcome of the process that becomes the general objective and these are processes and their results that are the sources of delivering products to customers. The logistic processes support functioning of the management system and ensure its effectiveness and efficiency. They include activities and actions associated with the preparation of the structure of the main processes, the management of the information system creation, transport, storing, accounting, finances, reporting and controlling [22].

It is the coordination of all activities in the company that appears as a part of logistic processes. The aim of the coordination is to obtain the unanimity in the accomplishment of the task, of which components the activities are. The key to the coordination is the insight into the internal structure of contractors and the determination of their objectives. The logistic processes appear, when there is the need to coordinate the main processes one with another in the manufacturing company.

The structural and functional character of the relations appearing in the logistic processes points to the possibility of the use of the characterization principle for the parameterization of the value added of the results of the logistic processes. Moreover, it is taking into account the logistic processes, the risk management as well as problems of the value creation that provides simultaneously the bases of appointing a new area of research in the form of the Axiological Dimension of the Risk Management (ADRM) in the logistic processes. ADRM in the logistic processes should be defined as the integrated, structured instrumentation, being aimed at the identification and the accomplishment of the logistic processes supporting creation of the value added and eliminating risk factors disturbing the process of creating the value for internal and external customers. The base is the use of the potentials inherent in the synergetic effects obtained through the use of the premises integrating the management of logistic processes, of the creation and the accomplishment of the value added and of the risk as a crucial determinant of processes of the value creation [18].

In case of the ADRM modelling of logistic processes, one should simultaneously take into account such parameters as [18]:

- the process of the value creation,
- the identification of the risk factors,
- the probability (frequency) of appearing of risk factors,
- the effects triggered by risk factors,
- the logical, temporary, priority, hierarchical and functional relations,
- the conditions for the transformation,
- the inputs (supply) for processes,
- the outputs (the effects of the accomplishment) of processes,
- the result of the accomplishment of processes.

Given the multiplicity of possible states that can be taken by these parameters, we deal with the situation, which implies the need to generate and to evaluate a set of many possible solutions, which can appear in the given problem situation.

[1] The conclusion was based on the research conducted on the group of manufacturing companies quoted on the Warsaw Stock Exchange in Warsaw in 2004-2008. It is amongst many presented proposals of analysing, controlling or even managing risks that no optimum one was found for the evaluation of the result (value added), which arose as a result of the accomplishment of logistic processes.

As the number of elements of the set of the solutions for most practical problems grows in the NP-complete way, there is no practical possibility of seeking and considering each of them in the real time. Hence, the need of seeking solutions appears, which could enable the selection of the variants to be evaluated and allow for narrowing the space and reducing the time of finding interesting solutions. Such possibilities are provided by the characterization principle developed by V.A. Gorbatov.

The characterization principle is one of the modern methodological apparatus of the systems theory. The system interpretation of tasks in accordance with this principle is based above all on:

- the determination (search for) of not very solutions but their distinctive features,
- the features should be related to representatives (to invariants) of classes of equivalent solutions,
- a class of equivalent solutions is formed as a result of interpretation of input data of the considered group of tasks in categories of features of solutions ([6], [7], [8], [11], [12], [13] and [14]).

There are usually fewer equivalent solutions than all possible solutions, and the analysis of features of solutions can be conducted without their direct generation (objective). The formally developed and verified characterization principles within the given objective area create the characterization theory. Its essence is contained in the mutual interpretability of the operating model of the examined object with the model of its structure. The mutual interpretability of the models is achieved by the selection of universal laws of correct functioning (expressed in the operational model) and structural interpretation of the operating model [6].

According to the characterization principle, an object will function correctly, if it will be possible to identify and to prove a mutually consistent interpretation between its operating rules (described by the operational model, which is denoted by ψ_a) and the implementing structure (described by the model of the structure, which is denoted by ψ_b). It is in order to determine and to prove the explicit interpretation of these two models that the following assumptions are adopted:

- a resource functions adequately to its structure,
- a structure of the resource is appropriate to its desirable way of functioning.

The essence of the characterization principle can be written as [6]:

$$< \psi_a, \psi_b, P_0 (\psi_a, \psi_b) > \quad (1)$$

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

The atomic predicate P_0 (ψ_a, ψ_b) characterizes the possibility of interpretation of the ψ_a operating model in terms of the ψ_b structural model. The P_0 predicate is a particular case of the logic variable and takes the value "1" or value "0". "1" means the possibility of mapping, whereas "0" lack of such possibility.

It is applying the characterization principle in the ADRM of logistic processes that requires precise determination:

- what is the operating model in ADRM of logistic processes?
- what is the structural model in ADRM of logistic processes?
- how should the predicate $P_0 (\psi_a, \psi_b)$ be interpreted?

Developing the theory of the conditions for converting the ψ_a model into the ψ_b model for construction of the ADRM parameterization model of logistic processes requires:

- the set of ψ_a operating models in terms of the ADRM of logistic processes including the information on:
  - probability (frequencies) of appearing of risk factors in logistic processes,
  - effects of appearing of risk factors (defined as the maximum cost caused by them, when they appear in logistic processes) as well as,
  - the achieved (planned) value added, adequate for all examined manufacturing companies with regard to the period of the research (2004-2008).
- the set of the ψ_b structural models in terms of the ADRM of logistic processes including the information on:
  - continuity of the course of logistic processes supporting main processes in the manufacturing company,
  - real costs (the effects and the probability) of appearing of the defined risk factors in logistic processes,

- the achieved (real) level of the value added in the obtained outcome of the process adequate for all examined manufacturing companies with regard to the period of the research (2004-2008).

- the atomic predicate P_0 (ψ_a, ψ_b) determining the mutual interpretability of the operating model in terms of the structural model [18].

The set of ψ_a operating models in terms of the ADRM of logistic processes reflects risk factors identified in all processes supporting the main activity of examined manufacturing companies. After having analysed the literature and the empirical research, it was established that they should be grouped into the risk factors concerning the most essential areas and functions from the point of view of the appearing logistic processes, i.e.: of supply, production, distribution, transport, storing and managing logistic processes.

It is among the risk factors identified that there were such ones, which can be found at any stage of the accomplishment of the supporting processes and such ones, which concern only the chosen logistic areas ([9], [18]). Therefore, the next step was to assign the risk factors to the appropriate logistic areas.

Based on findings, the following assignment of risk areas and risk factors was made:

- supply - the risk factors concerning supply, transport, storing and managing logistic processes,
- production - risk factors concerning production, transport, storing and managing logistic processes,
- distribution - risk factors concerning distribution, transport, storing and managing logistic processes,
- transport - risk factors concerning transport and managing logistic processes,
- storing - risk factors concerning storing and managing logistic processes,
- managing logistic processes - risk factors concerning managing logistic processes [18].

It is for formulating the operating model that the information on the frequency of risk factors appearing in the selected areas of logistics was required. The presence of risk factors in the given area of logistics in the given year was denoted as "1" in the operating model. If the risk factor did not appear in all areas or in all functions in the given year, it was not included in the propositional function.

It is on the basis of the data describing the probability and the effect of appearing of the risk factors in logistic processes for any manufacturing company that it is possible to develop an operating model in the form of the system of propositional functions, which describe relations and the ADRM structure of logistic processes, i.e. such propositional functions, which will include the information on the presence of risk factors with the defined effect and probability in logistic processes and which affect the created value added in the given period of time - here: 1 year.

On this base, it can be concluded that the operating model includes information on all-in costs of the presence of risk factors in logistic processes, since these are the data mapping the current state of the research problem established on the basis of studies in the given company and in the given time period.

In fact, the costs of the presence of the risk factors are most often higher than the ones, which are shown in income statements. It is to obtain the information on the real costs caused by risk factors that an interpretation of the structural model is essential. Obtaining the structural model requires the accomplishment of the consecutive stages of the characterization principle.

The set of Ψ_b structural models in terms of the ADRM of logistic processes must include information on the real costs of the presence of risk factors in logistic processes translating into the size of the value added achieved by the given company. It is achieving this result that requires, according to the characterization principle, determining conditions of redesigning the operating model into the structural model so as that its components would create a partially ordered set, i.e. the set whose elements $P_i^{\sigma_i}$ meet the requirements of the partial ordering:

$$R \subset P \times P \; (P_i^{\sigma_i} \in P)$$

described with properties:

- reflexivity:

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

- antisymmetry:

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

- transitivity:

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

where:

R – the relation symbol,

P – the set of risk factors,

$P_i^{\sigma_i}, P_j^{\sigma_j}, P_k^{\sigma_k}$ – the elements of the set of risk factors,

M – the set of propositional variables.

The partial ordering relation fully corresponds to the assumptions of the ADRM of logistic processes while we consider the need for mapping the processes in the defined areas as well as the specific risk factors resulting from such assignment.

An appropriate way of presentation of the structural model is the Hasse diagram, since it is a directed graph, which reflects the ideas of the process implementation as a sequence of consecutive steps with the appearing risk factors. It is formulating the Hasse diagram that requires removing all loops from the graphical presentation of the process, i.e.: repeated or duplicated activities (that corresponds with the reflexivity in the partially ordered set) as well as closing arcs, which reflect for example improperly marked internal transport routes, improper or lack of marking fields of storing in magazines, etc. (which corresponds with transitivity in the partially ordered set).

It is finding the optimum Hasse diagram that requires converting the ψ_a operating model into the ψ_b structural model in such a way that the propositional function being in the ψ_a model would be unambiguously interpreted in the ψ_b model.

In the assumptions of the characterization theory, the universal laws of correct functioning are expressed by means of the 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 incorrectnesses ([6], [19]) what originally was applied in the automata theory [6].

In particular, the methodology of the complementary support by designing logical structures for automata according to Gorbatov is based on a sequence of model exchanges with regard to the principle of the prohibited graph figures ([5], [4]). Therefore, among other things, the minimization of Boolean functions based on algebraic and logic records with the use of prime implicants can be carried out according to structural properties ([1], [2] and [3]), but such issues of the minimization from the automata theory, have not to be directly applied from the standpoint of logistics processes.

It is for the ADRM parameterization model of logistic processes that the identification of the prohibited figures in the form of graph Q^A or Q^B submodels is most significant. The prohibited Q^A figure is a graph submodel recorded in the form of cycle with odd length, whose apexes are weighed with pairs of cyclically changing weights, which are indexes of appropriate alternative elements [19] (see Fig. 1).

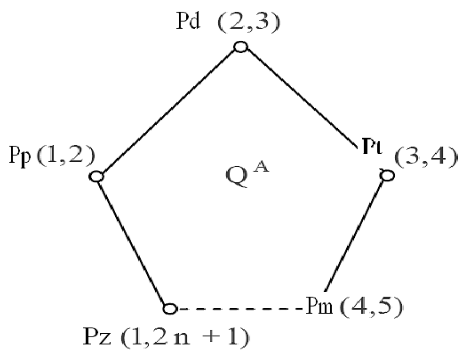


Figure 1. The Q^A prohibited graph figure
(*source: drawn up on the base of: [19, p. 144]*)

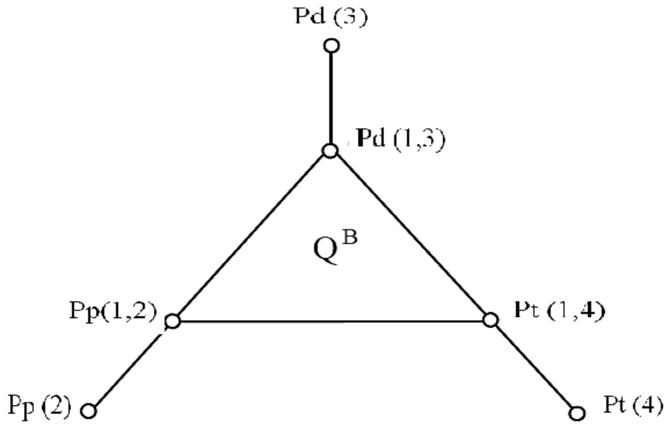


Figure 2. The forbidden graph figure Q^B
(*source: drawn up on the base of: [19], p. 144]*)

It is for the ADRM parameterization model of logistic processes that such a graphical form informs us about the presence of risk factors in more than one area of significance of processes. It is very important from a point of view of the cost analysis concerning removing effects of the presence of risk factors, since the effects will be noticed in many areas (the number depends on a specific case) of functioning of any company and this will multiply costs and translate into a reduction in the value added in this way. The second kind of the prohibited figure is the Q^B figure, which is a graph submodel recorded in the form of the triangle with hanging vertexes (see Fig. 2). Vertexes of the triangle have an identical weight and additionally each of them has the additional weight equal of the weight of the hanging vertex [19].

This kind 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) triggers a risk factor in supply (let's denote it as b) and simultaneously triggers a risk factor in production (let's denote as c) as well as in the area of distribution (let's denote it as d). It is removing the initiator, that is splitting the prohibited graph figure according to the characterization principle through splitting the factor "a", that will eliminate effects in four areas.

While splitting prohibited graph figures, one should take the following issues into account:

- the splitting should be carried out in such a way that all prohibited graph figures will be eliminated,
- it is out of possible variants of splits (replicas of variables) that we always choose the minimal subset of propositional variables, which will cause the elimination of all prohibited graph figures,
- it is to choose from possible variants of splitting propositional variables that we use a semantic decision table,
- the choice of a variable/variables for splitting conditions the form of the new ψ'_a operating model, and hence the form of the resultative Hasse diagram.

It is obtaining the new operating model and the determined form of the Hasse diagram that has its consequences for ADRM of logistic processes. The conducted operations are followed by splitting the propositional variables. In terms of ADRM of logistic processes, these variables reflect risk factors present in the studied areas of logistic processes, being characterized by a determined probability and an effect of presence of risk factors, i.e. doubling activities will be reflected by the final cost level. Through applying the characterization principle, it can be noticed in a simple way that the presence of risk factors has its consequences not only at the place of the occurrence but also the effects often affect other areas of functioning of an enterprise and even of the entire organization. Once the characterization is completed, we can calculate real costs of the appearance of risk factors.

It is through comparing total and real costs of the appearance of risk factors that it is easy to notice how important their proper calculation is. The consequences of underestimating the costs associated with removing the effects of undesired events are visible in the profit and loss account of each enterprise.

The application of the characterization principle to the ADRM parameterization of logistic processes is associated above all with showing actual costs actually incurred in connection with the occurrence of certain risk factors in logistic processes. After having conducted the analysis with the use of the ADRM parameterization model of logistic processes, it is possible to demonstrate that actual costs of the risk are higher, than the ones included in calculations (if they are reported at all). The disregard of the real costs of the presence of risk factors, can significantly affect creation of the value added, translating into conditions for functioning of an enterprise on the market.

The presence of risk factors in manufacturing companies while caring out logistic processes has mainly negative economic influence, which manifests itself in increasing costs of logistic processes, causing loss of the determined level of the value added. It is in order to be able to operate on the market that any company has to be competitive and has to make profit, despite the existence of a constant opposite trend in the form of the presence of many risk factors.

4 The application of the characterization principle in the risk assessment in logistic processes

Following the requirements of the characterization principle, one should for the ADRM of logistic processes:

- make a formal record of the studied fragment of reality in the form of the system of propositional functions,
- develop an operating model of the studied fragment of reality, through the analysis of the function, the elimination of the forbidden graph figures from the model of the propositional function with the use of the semantic decision table as well as splitting the ψ_a graph operating model,
- find its structural (technical) interpretation in the form of the graph structural model in the form of Hasse diagrams for the developed operating model.

It is obtaining information on actual costs, which are incurred by the company in relation to the presence of risk factors showing structural-functional relations of the model that was described on two examples. For carrying out the analysis, the ADRM[2] simulator will be used. It is basing on the data obtained in the E Company during conducted examinations in the years 2004 - 2008 that we determine propositional function describing the presence of risk factors in logistic processes, which translate into creation of the value added of the company. The propositional function is obtained by selecting the first module of the model of the propositional function. We enter the list of risk factors present in the company and information on the probability and the effects of their presence. It is in order to obtain the propositional function that we choose the company, the determined year and we mark these risk factors in the "choice" column, which are supposed to be analysed by us (see Fig. 3).

It is on the basis of the data of the E Company that there were indicated 9 of 81 important risk factors from the point of view of logistic processes of this company (the full list of risk factors of the E Company: [9]). On this base, the propositional function adopted the following form:

$$ZP_x(P_1, P_2,\ldots, P_{81}) = P_7 P_{49} P_{81} \vee P_7 P_{52} \vee P_{30} P_{46} \vee P_8 P_{46} P_{81} \vee P_{46} P_{60} P_{67} \vee P_{30} P_{52} P_{67}$$

The semantic interpretation of the propositional function shows that it was amongst crucial ones that there were the following factors in the area of supply: promptness of deliveries (P_7), decrease in the number of orders (P_{49}), shortage of capital (P_{81}); in the area of production: promptness of deliveries (P_7), lack of a system of the in-house transport (P_{52}); in the area of distribution: mistake in estimating profitability of a customer (P_{30}), not keeping order fulfilment times (P_{46}); in the area of transport: changes in supply conditions (P_8), not keeping order fulfilment times (P_{46}), shortage of capital (P_{81}); in the area of storing: not keeping order fulfilment times (P_{46}), lack of the detailed data regarding individual stocks (P_{60}), problems in the flow of information (P_{67}); whereas in the area of managing logistic processes: mistakes in estimating the profitability of a customer (P_{30}), lack of organization of in-house transport (P_{52}), problems in the flow of information (P_{67}).

[2] The ADRM simulator is an author's software, which among others enables conducting economical experiments according to the characterization principle of V.A. Gorbatov. The application is available on: www.e.kulinska.po.opole.pl. It is for conducting experiments according to the characterization principles that there are four modules placed on the right side of the screen: the propositional function model, operating model, semantic decision table, structural model - Hasse diagrams.

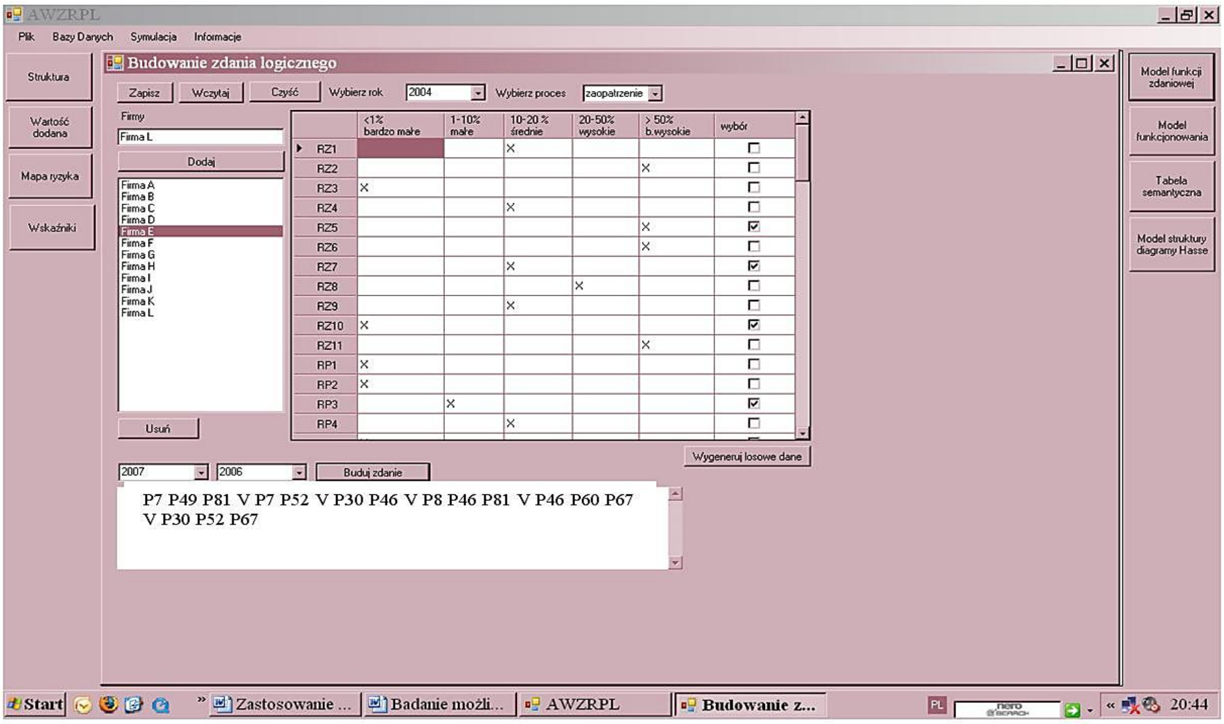


Figure 3. An active window of the module - a model of a propositional function
(*source: own study*)

The ψ_a operating model of the ZP_x propositional function is set as the juxtaposition:

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

where

M - the set of propositional variables;.

R_2 - the set of relations defined by dual element alternative modules describing the areas of production and distribution.

R_3 - a set of relations defined by three elements alternative modules describing the areas of supply, transport, storing and managing logistic processes).

$M = < P_7, P_8, P_{30}, P_{46}, P_{49}, P_{52}, P_{60}, P_{67}, P_{81}>$

$R_2 = \{\{P_7, P_{52},\}_2, \{P_{30}, P_{46}\}_3$

$R_3 = \{\{P_7, P_{49}, P_{81}\}_1, \{P_8, P_{46}, P_{81}\}_4,$
$\{P_{46}, P_{60}, P_{67}\}_5, \{P_{30}, P_{52}, P_{67}\}_6\}$

The module "operating model of the ADRM simulator" enables to obtain a graphic form of the operating model Fig. 6.

The graphic form is created in the following way. It is for each propositional variable present in the operating model that the number of the conjunction is determined, in which there are: $P_7(1,2)$, $P_8(4)$, $P_{30}(3,6)$, $P_{46}(3,4,5)$, $P_{49}(1)$, $P_{52}(2,6)$, $P_{60}(5)$, $P_{67}(5,6)$, $P_{81}(1,4)$.

The propositional variables are vertexes of the graph. The propositional variables present in the same conjunctions are connected with lines. Thus, it is in the Fig. 4 that the propositional variables present in the first conjunction are connected with the red line, in the second one with the green line, in the third one with the blue line, in the fourth one with the black line, in the fifth one with yellow line, in the sixth one with purple line.

It is a structural model that is an aim of modelling and solves a defined research problem, that is searching for actual costs of presence of risk factors in logistic processes, which are translated into reduction in the value added realized by a company. It is obtaining the result that requires limiting the structural model in such a way that its P_i elements would create a partially ordered set, i.e. the set, whose elements keep partial ordering relation.

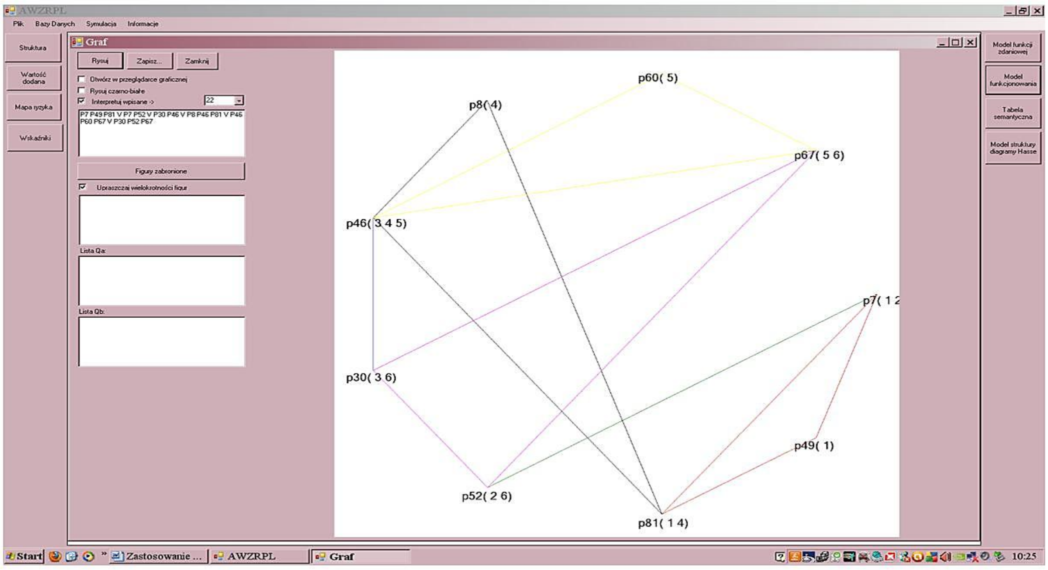


Figure 4. the operating model ψ_a of the propositional function ZP_x
(*source: own study*)

If we omitted the characterization principle then searching for the optimum Hasse diagram for the considered function would require analysing 3! * 2! * 2! * 3! * 3! * 3! = 5184 possible variants of Hasse diagrams. Even so, it would be impossible to find an optimum diagram because of forbidden figures in form of the Q^A and Q^B submodels present in the graph ψ_a model.

It is appointing the prohibited figures of the type Q^A and Q^B that is enabled by the module "operating model of the ADRM 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 form loops graphically (see Figs. 5-8).

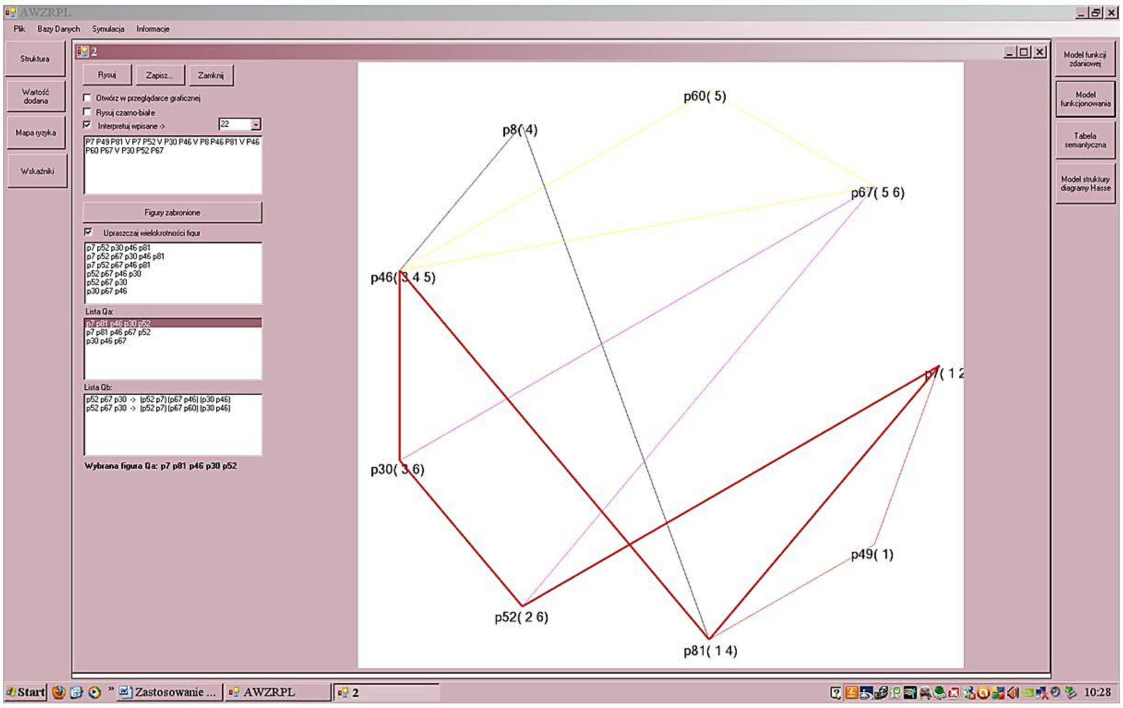


Figure 5. The graph model of functioning of the function ZP_x
with the marked prohibited graph figure of the type Q_1^A
(*source: own study*)

The formal record of the prohibited figure Q_1^A: $Q_1^A = \{P_{30}(3,6), P_{52}(6,2), P_7(2,1), P_{81}(1,4), P_{46}(4,3)\}$

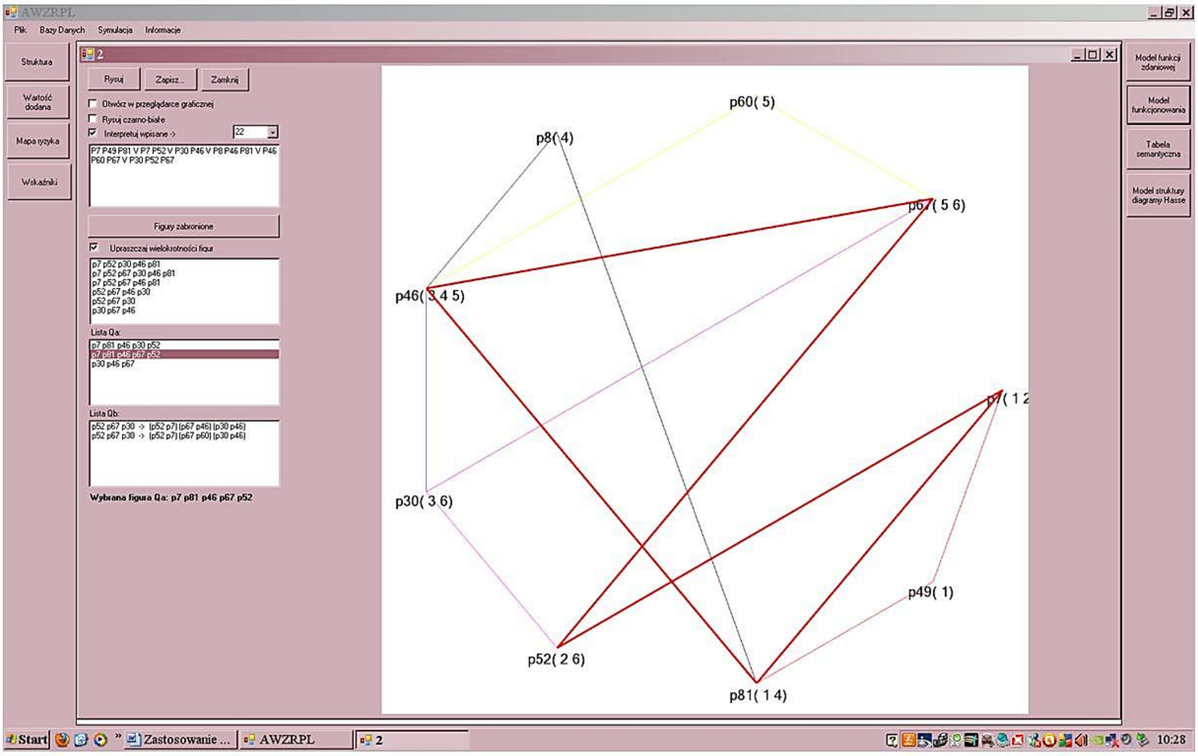


Figure 6. The graph model of functioning of the function ZP_x with the marked prohibited graph figure of the type Q_2^A (*source: own study*)

The formal record of the prohibited figure Q_2^A : $Q_2^A = \{P_{67}(6,5), P_{46}(5,4), P_{81}(4,1), P_7(1,2), P_{52}(2,6)\}$

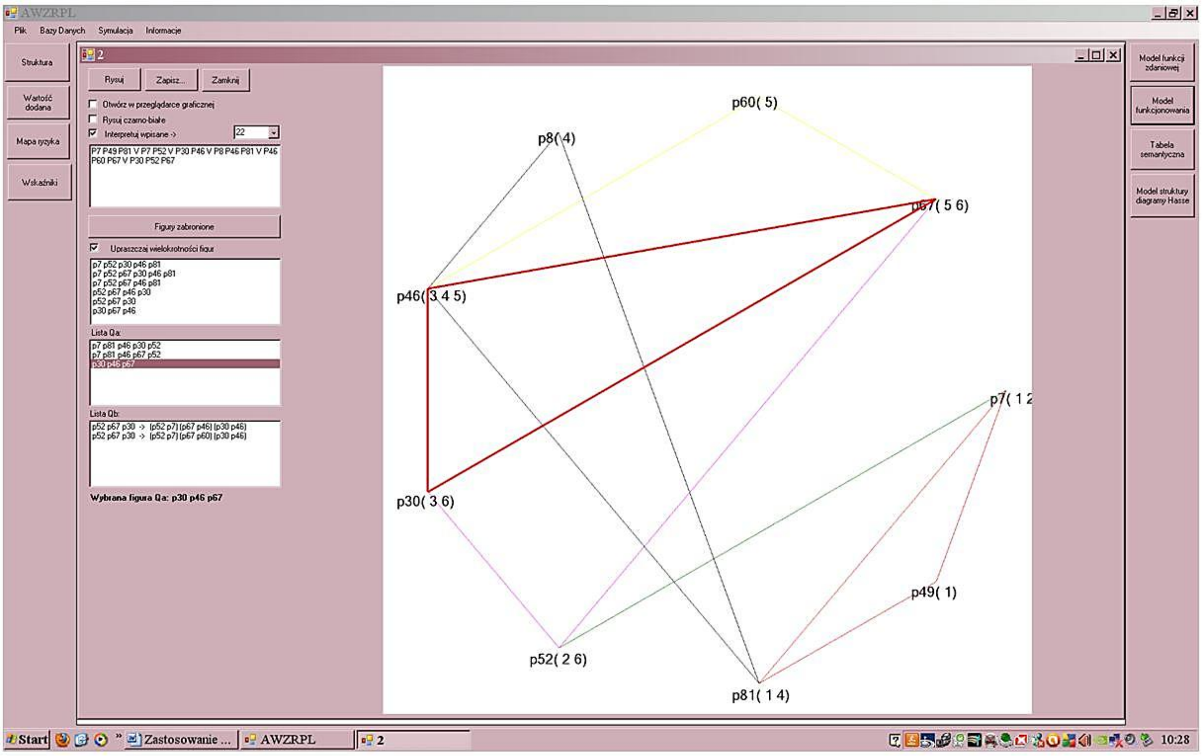


Figure 7. The graph model of functioning of the function ZP_x with the marked prohibited graph figure of the type Q_3^A (*source: own study*)

The formal record of the prohibited figure Q_3^A : Q_3^A: = {P_{30}(3,6), P_{67}(6,5), P_{46}(5,3)}

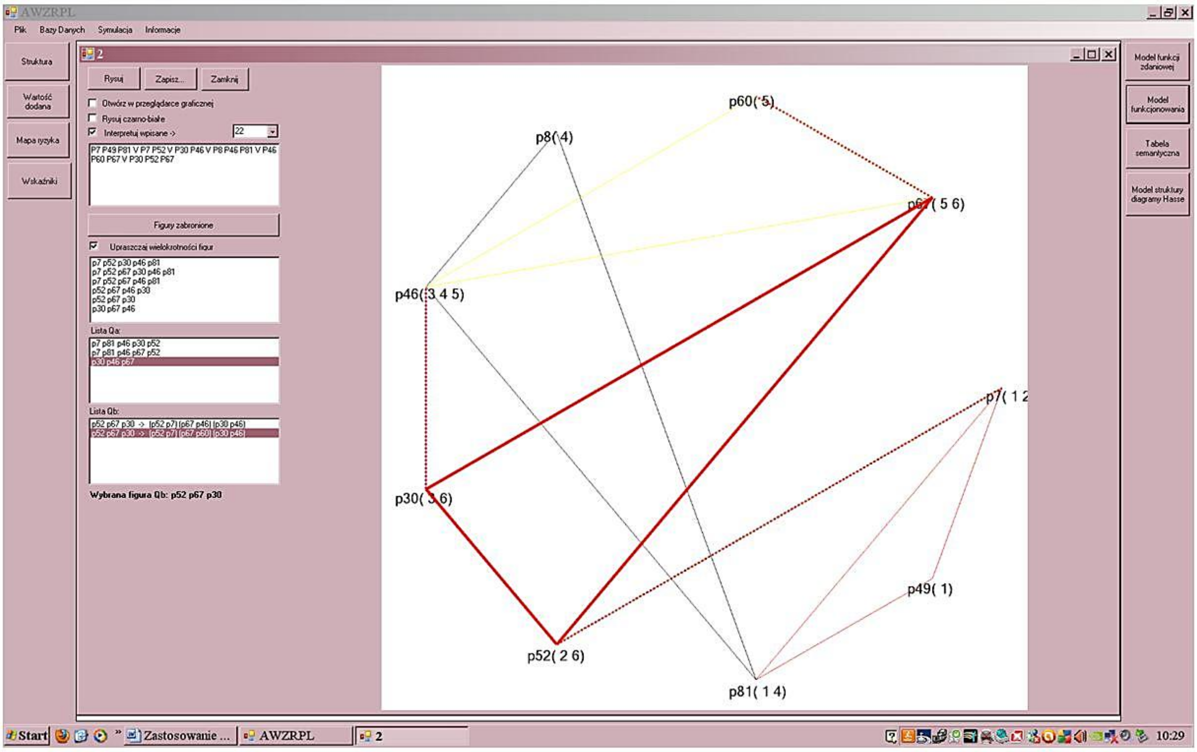


Figure 8. The graph model of the propositional function ZP_x
with the marked prohibited graph figure of the type Q_1^B
(*source: own study*)

The second type of the prohibited figure is the QB figure, which is a graph submodel recorded in the form of the triangle with hanging vertexes. The analysed function also contains one figure of this type marked with the thickened line on the Fig. 8 and the hanging vertexes are marked with the broken line.

The formal record of the figure of this type Q_1^B:

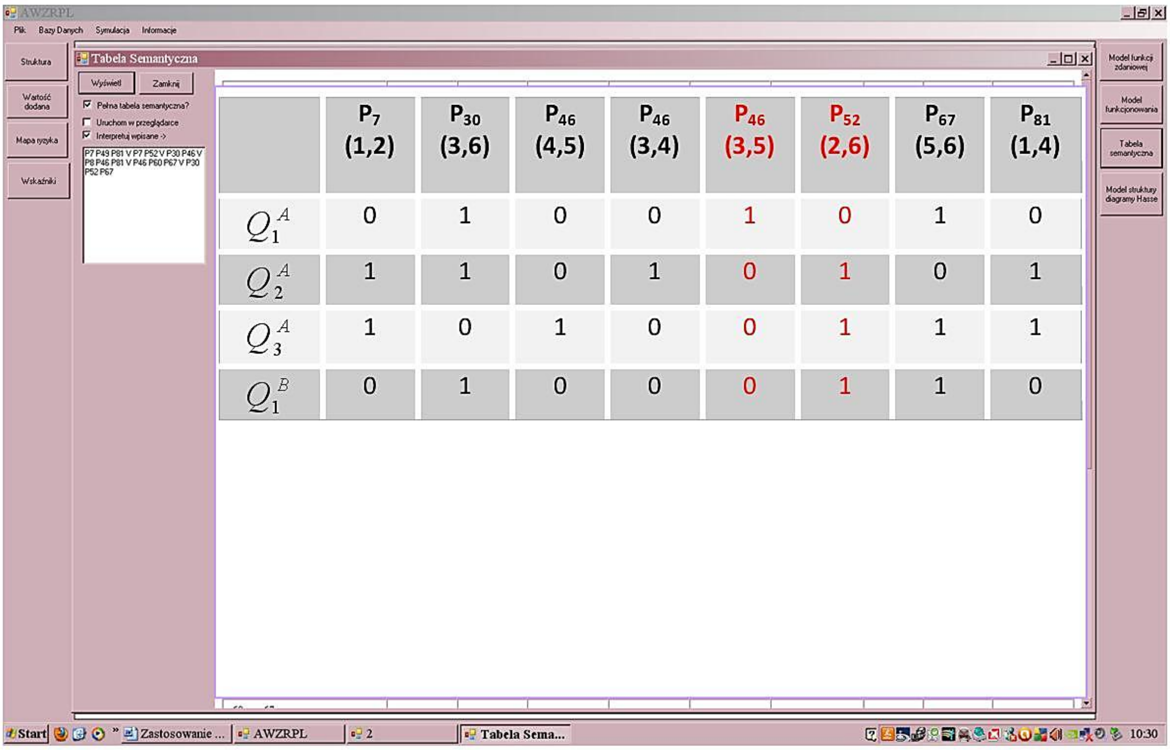
$$Q_1^B = \{\{P_{30}, P_{52}, P_{67}\}\{P_{30}, P_{46}\}\{P_{52}, P_7\}\{P_{67}, P_{60}\}\}$$

The presence of this type of submodels in the graph representation of the propositional function was noticed by V.A. Gorbatov. Admittedly, it is in the analysed case that we deal only with the four "images", but the possibility of their identification and their split spares many hours of work and analyses of 5184 possible variants of Hasse diagrams, which this function has.

It is for splitting the prohibited figures, which appeared in the graph representation of the analysed propositional function that a semantic decision table was built. In the first line of the table, there were entered propositional variables, which appeared in all identified prohibited figures. Whereas the prohibited figures were entered in the first column. In next lines, we mark with the digit 1 the propositional variables as a vertex in the prohibited graph figure, which appeared in the given prohibited figure.

In the ADRM simulator, the semantic decision table is drawn on automatically based on the entered function. After having chosen the module "the semantic decision table", it is in the window on the left of the screen that a propositional function is shown, and on the right the semantic decision table adequate for it (see Fig. 9).

We choose the minimal subset of propositional variables, which will cause the elimination of all prohibited figures taking into account the frequency of the presence of the propositional variable in the prohibited figures (the largest number of "1" in the column of the semantic decision table), as well as it is from a point of view of the ADRM of logistic processes that we choose these propositional variables out of alternative solutions, which represent the risk factors of the lowest probability (frequency) of presence and of the lowest cost of potential effects of appearing.



	P_7 (1,2)	P_{30} (3,6)	P_{46} (4,5)	P_{46} (3,4)	P_{46} (3,5)	P_{52} (2,6)	P_{67} (5,6)	P_{81} (1,4)
Q_1^A	0	1	0	0	1	0	1	0
Q_2^A	1	1	0	1	0	1	0	1
Q_3^A	1	0	1	0	0	1	1	1
Q_1^B	0	1	0	0	0	1	1	0

Figure 9. The semantic decision table of the function ZP_x
(*source: own study*)

It is in the analysed function that two pairs of variables enable splitting all prohibited figures:

- The first pair: the propositional variable $P_{30}(3,6)$, which will enable to split prohibited figures Q_1^A Q_2^A Q_1^B, and the propositional variable $P_{46}(4,5)$, which will enable to split the propositional variable Q_3^A.
- The second pair: the propositional variable $P_{52}(2,6)$, which will enable to split the prohibited figures Q_2^A Q_3^A Q_1^B, and the propositional variable $P_{46}(3,5)$, which will enable to split the propositional variable Q_1^A.

The choice of variables will condition the form of the new ψ'_a operating model, and hence the character of the ultimate Hasse diagram and the level of actual costs of marking out of risk factors in logistic processes, which translate into the level of the obtained value added. After taking into account both criteria for splitting, we choose variables $P_{52}(2,6)$ and $P_{46}(3,5)$. The propositional variable P_{52} is split by us in the second conjunction, whereas the variable P_{46} in the third conjunction (see Fig. 10).

As a result of splitting we receive a new operating model Fig. 10, which corresponds with the appropriate Hasse diagram, presented on the Fig. 11.

A new form of the function ZP'_x :

$$ZP_x (P_1, P_2,\dots,P_{81})' = P_7\, P_{49}\, P_{81} \vee P_7\, P'_{52} \vee P_{30}\, P'_{46} \vee P_8\, P_{46}\, P_{81} \vee P_{46}\, P_{60}\, P_{67} \vee P_{30}\, P_{52}\, P_{67}$$

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

$$\Psi'_a = \langle M', R'_2, R'_3 \rangle$$

$$M' = \langle P_7, P_8, P_{30}, P_{46}, P'_{46}, P_{49}, P_{52}, P'_{52}, P_{60}, P_{67}, P_{81} \rangle$$

$$R'_2 = \{P_7, P'_{52}\}_2,\ \{P_{30}, P'_{46}\}_3$$

$$R'_3 = \{P_7, P_{49}, P_{81}\}_1,\ \{P_8, P_{46}, P_{81}\}_4,\ \{P_{46}, P_{60}, P_{67}\}_5,\ P_{30}, P_{52}, P_{67}\}_6$$

Each of the risk factors selected for the analysis P_7, P_8, P_{30}, P_{46}, P_{49}, P_{52}, P_{60}, P_{67}, P_{81} includes information on the frequency (the probability) of appearances of risk factors as well as potential effect (measured with the maximum cost of removing the effects of the appearance of the risk factors). Taking into account the data of the E Company, these values were as follows – Table 1.

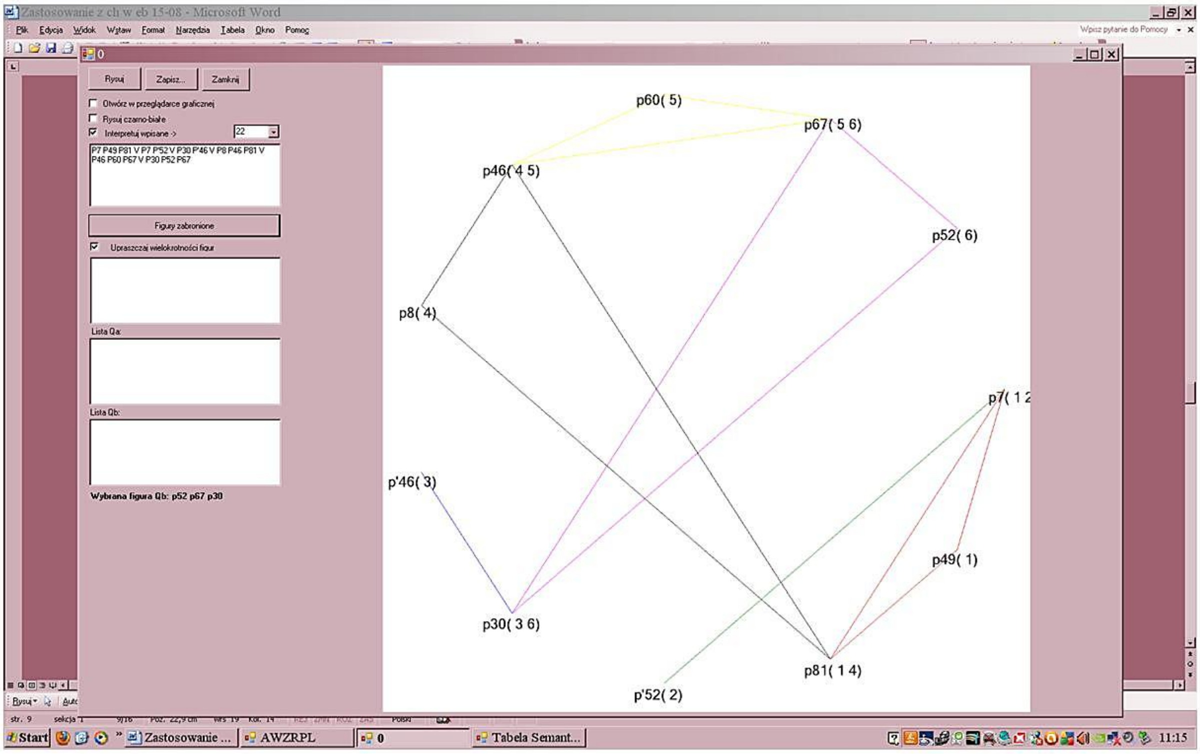


Figure 10. The new graph model of functioning of the ψ'a propositional function ZP_x after splitting the prohibited graph figures (*source: own study*)

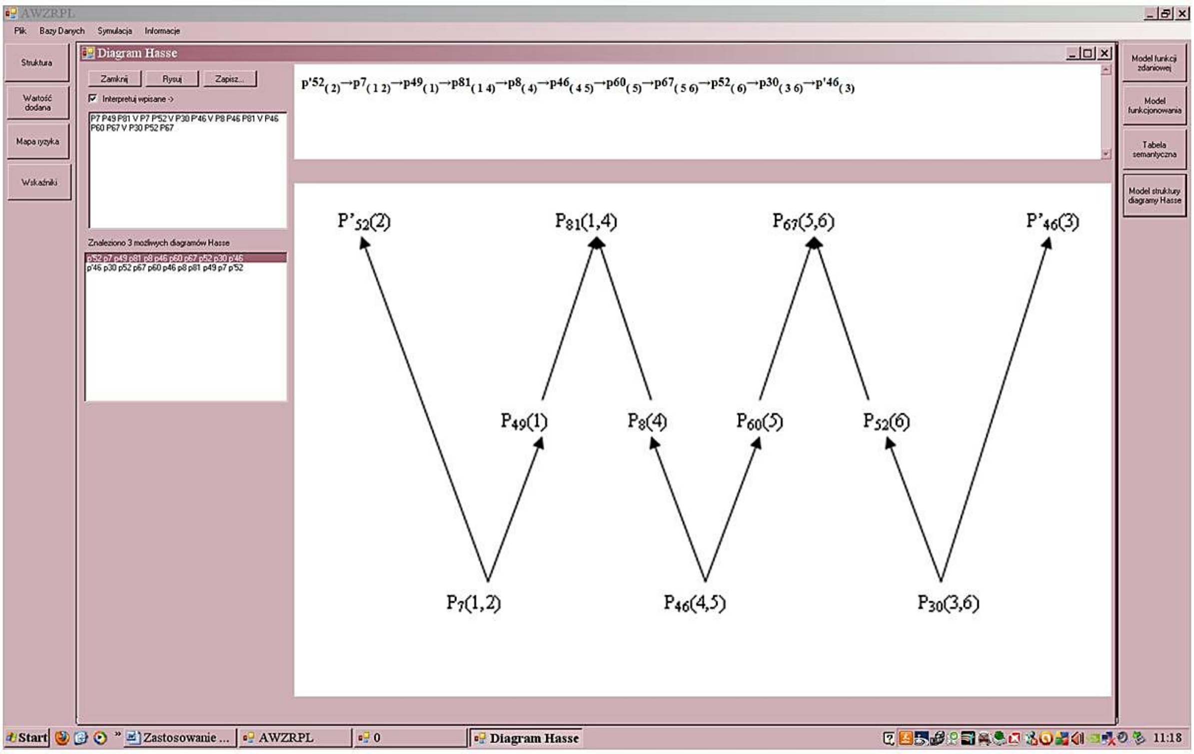


Figure 11. The structural model ψ'b of the propositional function ZP_x (*source: own study*)

Table 1. The juxtaposition of the probability and the effect of appearing of risk factors in the function ZP_x (*source: own study on the basis of the results of the questionnaire survey*)

the area of the risk factors appearance	propositional variable	2004		actual costs of individual risk factors (PLN)
		amount	max cost	2004
supply	P_7	16	840	13440
	P_{49}	14	478	6692
	P_{81}	23	199	4577
production	P_7	16	840	13440
	P_{52}	19	45	855
distribution	P_{30}	32	84	2688
	P_{46}	14	478	6692
transport	P_8	12	373	4476
	P_{46}	14	478	6692
	P_{81}	23	199	4577
storing	P_{46}	14	478	6692
	P_{60}	18	47	846
	P_{67}	19	74	1406
managing logistic processes	P_{30}	32	84	2688
	P_{52}	19	45	855
	P_{67}	19	74	1406
Σ total all-in costs of examined risk factors				**78022**

It is on this base that we can determine that the operating model includes information on all-in costs of the presence of risk factors in logistic processes, since it is data mapping the direct information from the company examined in the given period of time. While limiting to these factors, we can state that the value added of the company could be higher by about PLN 78 022. On the annual basis of the operations of the company listed on the Warsaw Stock Exchange, it seems not to be a large amount but we have analysed just a few risk factors here.

In fact, the costs of the presence of risk factors are most often higher than the ones, which are shown in income statements. It is for obtaining information on actual costs, which result from risk factors that the interpretation of the structural model is essential. On this basis we know that the replica of variables in the following form were obtained: P'_{46}, P'_{52} . It has it consequences in the cost accounting of risk factors present in logistic processes. It is in the Table 2 that the costs of risk factors were put together on the basis of the new ψ'_a operating model.

While comparing the total and actual costs of the appearance of risk factors (see Table 3), one can notice the importance of their correct calculation. After examining a small number of risk factors, the difference was more than PLN 7 000 - Table 4,what gives the preliminary idea of the scale of the phenomenon.

Table 2. The cost analysis of the results of removing individual risk factors for the chosen propositional variables - in the ψ'_a operating model of the ZPx function'

the area of the risk factors appearance	propositional variable	2004		real costs of individual risk factors (PLN)
		amount	max cost	2004
supply	P_7	16	840	13440
	P_{49}	14	478	6692
	P_{81}	23	199	4577
production	P_7	16	840	13440
	P_{52}	19	45	855
	P'_{52}	19	45	855
distribution	P_{30}	32	84	2688
	P_{46}	14	478	6692
	P'_{46}	14	478	6692
transport	P_8	12	373	4476
	P_{46}	14	478	6692
	P_{81}	23	199	4577
storing	P_{46}	14	478	6692
	P_{60}	18	47	846
	P_{67}	19	74	1406
managing logistic processes	P_{30}	32	84	2688
	P_{52}	19	45	855
	P_{67}	19	74	1406
σ total all-in costs of examined risk factors				**85569**

Table 3. The comparison of all-in costs and actual costs of the removing effects of the appearance of risk factors

balance	
all-in costs	actual costs
78022	85569
difference: **7547**	

The consequences of underestimating the costs associated with eliminating the effects of undesired events are visible in income statements of each of examined company.

There are also cases of underestimating costs of risk factors, what will be illustrated by the second example. This time, we choose 6 of 81 risk factors out of the data of the E Company, which are characterized by the highest cost of removing the effects of their appearance. They include: promptness of deliveries (P_7), breakdowns of machines and devices (P_{20}), not keeping order fulfilment time (P_{46}), breakdowns of cars (P_{53}), possession of unnecessary inventories (P_{63}), problems in the flow of information (P_{67}). The ZP_y propositional function takes the following form:

$$ZP_y (P_1, P_2, \ldots, P_{81}) = P_7P_{53}P_{63}P_{67} \vee P_{20}P_{53}P_{63}P_{67} \vee P_{46}P_{53}P_{63}P_{67} \vee P_{53}P_{67}P_T \vee P_{63}P_{67}P_M \vee P_{67}P_{Zl}$$

It is for saving the correctness of the modelling both in management studies and Boolean algebra (there has to remain 6 conjunctions because of the number of the considered logistic areas, however when viewed from algebra of logic, some conjunctions are included in other ones, what would require the implementation of the corresponding mathematical operations and losing the number of areas), that the apparent propositional variables P_T, P_M, P_{Zl} were entered into appropriate conjunctions, (representing neither costs nor the frequency of risk factors appearance - described in the mathematical way).

It is checking the possibility of obtaining of the logical structure (the ψ_b model) in the form of the Hasse diagram that we begin with the analysis of the function, which will enable the development of an operating model (the ψ_a model).

The resulting function is a logical product of two functions of the type:

$$[\alpha \vee \beta] \,\&\, [\gamma \vee \delta] = [P_{67}] \,\&\, [P_7P_{53}P_{63} \vee P_{20}P_{53}P_{63} \vee P_{46}P_{53}P_{63} \vee P_{53}P_T \vee P_{63}P_M \vee P_{Zl}]$$

where:

$[\alpha \vee \beta]$ - the first function P_{67}

$[\gamma \vee \delta]$ - the second function $P_7P_{53}P_{63} \vee P_{20}P_{53}P_{63} \vee P_{46}P_{53}P_{63} \vee P_{53}P_T \vee P_{63}P_M \vee P_{Zl}$

It is for the first function $[\alpha \vee \beta]$ that the Hasse diagram is a single vertex marked as P_{67}. This vertex will be a beginning or an end of all branches of the Hasse diagram of the second function $[\gamma \vee \delta]$.

The second function $[\gamma \vee \delta]$ cannot be shown as a product of logic functions (decomposition of the product of the logical function) but it can be considered as a starting point for further analysis and construction of the ψ_a and ψ_b models. The function $[\gamma \vee \delta]$ can be presented as a logical sum (decomposition with regard to the logical sum of the function) of two functions in the form:.

$$[\gamma \vee \delta] = [P_7 P_{53} P_{63} \vee P_{20} P_{53} P_{63} \vee P_{46} P_{53} P_{63} \vee P_{53} P_T \vee P_{63} P_M] \vee [P_{Zl}]$$

The decomposition with regard to the logical sum of the function is not essential, however it greatly simplifies the process of searching for prohibited figures. It is thanks to the decomposition that all "false" prohibited figures are eliminated and the real ones Q^A and Q^B remain.

For the analysed function, the actions carried out, cause that a significant simplification of the function subjected to conversions with the characterization principle is completed. It is also much more easy to draw the ψ_a model obtained directly from the function $[\gamma \vee \delta]$.

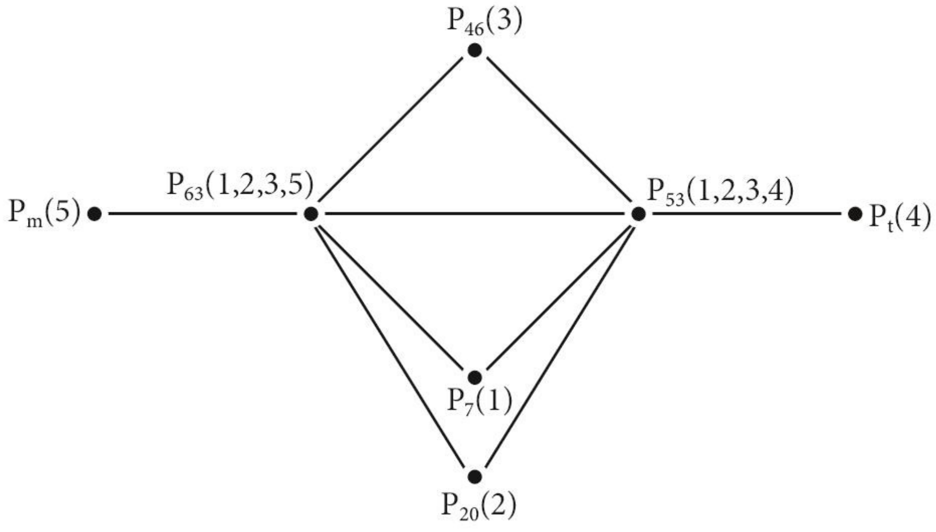


Figure 13. The drawn manually ψ_a operating model
(*source: own study*)

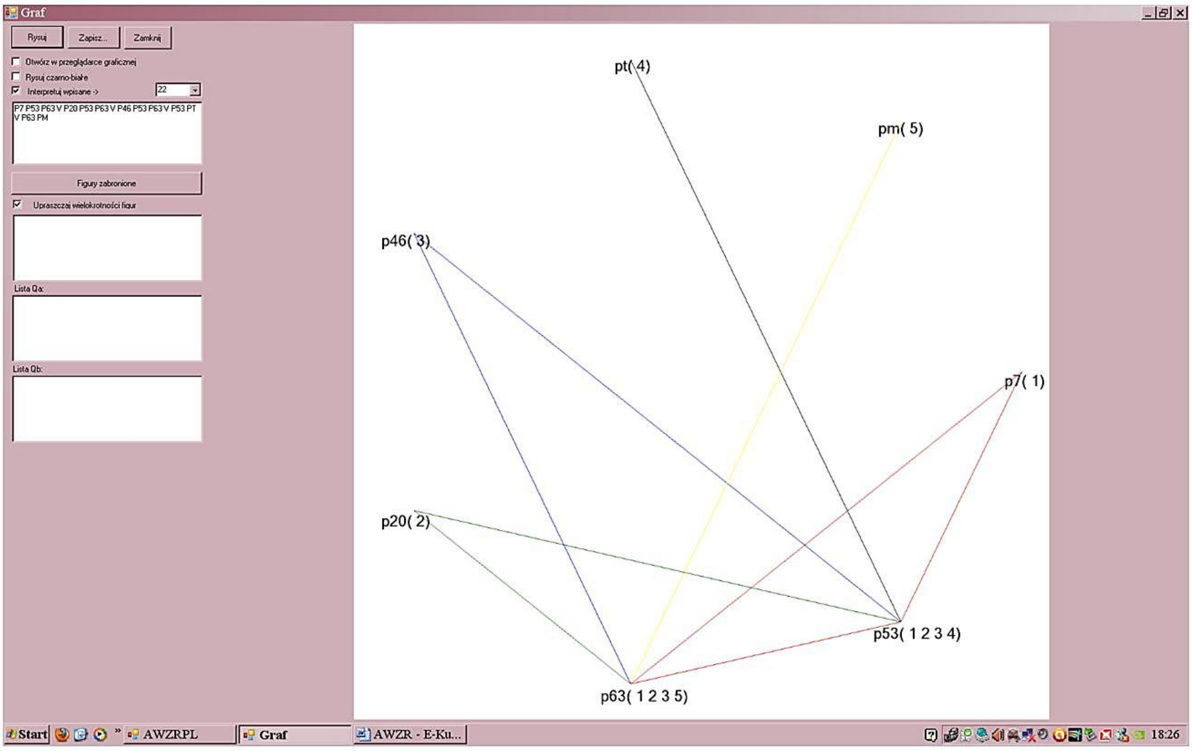


Figure 14. The ψ_a operating model obtained in the ADRM simulator
(*source: own study*)

It is on both figures that we can see that there is no prohibited Q^A or Q^B figure - which means that there is a possibility of drawing a correct Hasse diagram without the need of splitting the variables (vertexes of the graph) of the model.

Thanks to the disintegration of the function [γ V δ] with regard to the logical sum, we obtain information on branches which will appear in the structural model. The full form of the base of the Hasse diagram - Fig. 15.

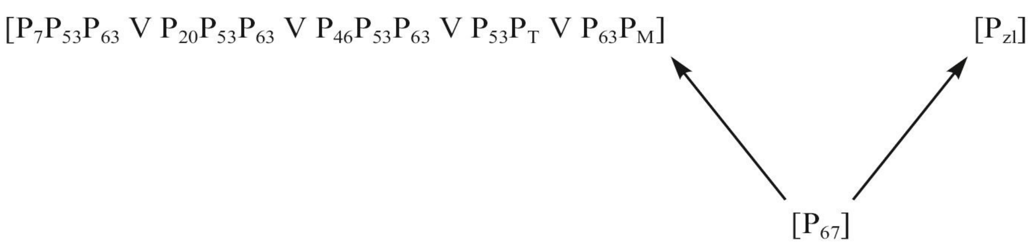


Figure 15. The full form of the base of the Hasse diagram
(*source: own study*)

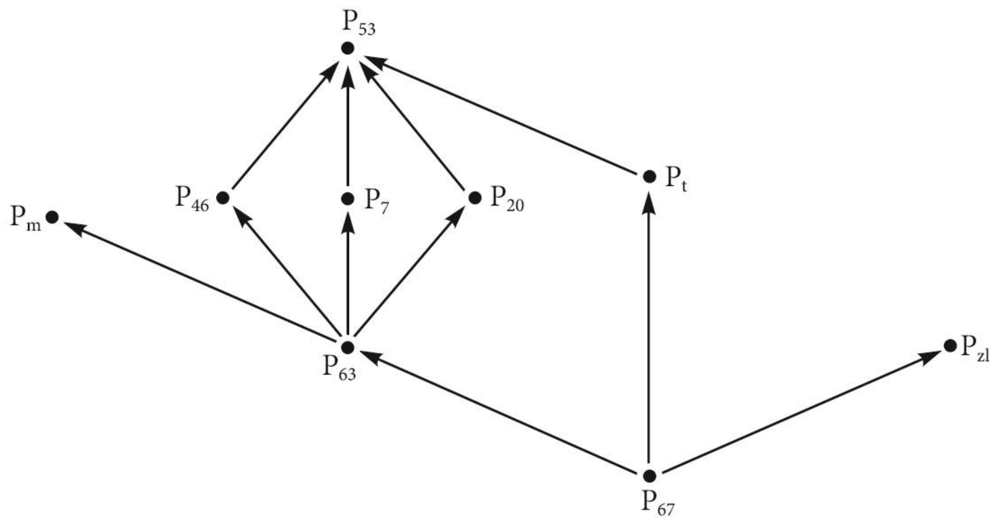


Figure 16. The full form of the Hasse diagram for the function ZP_y
(*source: own study*)

Table 4. Actual costs of the appearance of risk factors - The E Company
(*source: own study on the basis of the results of the questionnaire survey*)

the area of the risk factors appearance	propositional variable	2004		actual costs of individual risk factors (PLN)
		amount	max cost	2004
supply	P_7	16	840	13440
	P_{53}	17	85	1445
	P_{63}	12	47	564
	P_{67}	14	74	1036
production	P_{20}	15	1010	15150
	P_{53}	17	85	1445
	P_{63}	18	47	846
	P_{67}	14	74	1036
distribution	P_{46}	14	478	6692
	P_{53}	15	85	1275
	P_{63}	13	47	611
	P_{67}	14	74	1036
transport	P_{53}	15	85	1275
	P_{67}	19	74	1406
storing	P_{63}	17	47	799
	P_{67}	18	74	1332
managing logistic processes	P_{67}	18	74	1332
Σ total all-in costs of all risk factors				**50720**

Table 5. The real costs of the appearance of risk factors - The E Company
(*source: own study on the basis of the results of the questionnaire survey*)

propositional variable	2004		real costs of individual risk factors (PLN)
	amount	max cost	2004
P_7	16	840	13440
P_{20}	15	1010	15150
P_{46}	14	478	6692
P_{53}	15	85	1275
P_{63}	17	47	799
P_{67}	18	74	1332
Σ total actual costs of analysed risk factors			**38688**

Table 6. The comparison of all-in costs and actual costs of the removing effects of the appearance of risk factors

balance	
all-in costs	actual costs
50720	38688
difference: **12032**	

Taking into account the total Hasse diagram based on the primal ZPy function, it will adopt the form as on the scheme from the Fig. 16.

As can be seen on the basis of the conducted analysis, the number of propositional variables of the operating model is 20, including 17 variables representing the determined value of the effect and the probability. It is on the structural model that there are 9 of them including 6 variables representing the determined value of the effect and the probability.

Taking into account the data analysed on the example of the E Company, the values were as follows - Table 4.

While limiting the analysis to the presented risk factors, we can state that the value added of the company could be higher by about PLN 50720. It is for obtaining the information on actual costs caused by the risk factors that the interpretation of the structural model is essential. The conducted decomposition of the propositional function is tantamount to showing the possibility of limiting the scope of the influence of risk factors by introducing appropriate proceedings and anticipation measures. As a result of the executed decomposition of the propositional function, the number of propositional variables was successfully reduced, i.e. the scope of the influence of some risk factors. The actual cost of the presence of the analysed risk factors in logistic processes are shown in the Table 5.

While comparing total and actual costs of the appearance of risk factors, one can notice how important their correct calculation is (see Table 6).

5 Conclusions

In summary, while interpreting the results of the conducted analysis according to the characterization principle, one should take following information into consideration:

- the all-in cost is obtained by aggregating the costs of all propositional variables present in the function,
- the maximum actual cost is a sum of costs of all propositional variables including the necessary replicas of variables resulting from splitting,
- the minimum actual cost is obtained if the branches of the Hasse diagram are overlapping: that means

that a reduction in propositional variables is taking place so it is obvious cost reduction.

The application of the characterization principle to the ADRM parameterization of logistic processes is associated mainly with showing actual costs, in fact incurred, in relation to the presence of the determined risk factors in logistic processes
The analyses conducted in experiments showed that actual costs of the presence of risk factors were as a rule higher than the ones included in financial results. It was in the studies carried out in the E company that there were noticed 81 different risk factors concerning logistic processes, which allowed to demonstrate that actual costs of the presence of risk factors exceeded all-in costs shown in the profit and loss account (even though other result was achieved for 6 chosen factors).

It is not including actual costs of the presence of risk factors that can significantly affect the creation of value added translating into the conditions for the functioning of the company on the market.

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