European Research Studies Journal
Volume XXIII, Issue 3, 2020

pp. 613-628

The Importance of Risk Costs in the Logistics Supply Process

Submitted 15/04/20, 1st revision 30/04/20, 2nd revision 25/05/20, accepted 20/06/20

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Abstract:

Purpose: *The aim of the article was to describe the importance of the cost of risk in business management in the context of logistic processes. In this article, the costs of risk refer to the procurement process.*
Approach/Methodology/Design: *During the research, the logistic process of interpretation was interpreted as a reliable security of the spatiotemporal availability of directly production materials, i.e. raw materials, construction materials, products and semi-finished products, as well as spare parts, elements, subassemblies, modules, etc. keeping the company in full production readiness.*
Findings: *Based on the data of enterprises in the different industries and activities: trade, production, services, mixed, trade and services., six risk factors have been identified which are important from the point of view of decisions taken in managing the logistics process of supply. The example demonstrates that the characterization principle allows showing a significant difference between the total and actual costs of risk factors.*
Practical Implications: *The recording of logistics costs is a very strong basis for dynamic control of these costs, both by type and in particular time periods, as well as by place of origin. The theory of logistics costs and the issue of their minimization is the main task of logistics managers in the process of planning and organizing logistics supply chains, on the scale of the entire enterprise and in all phases of economic activity.*
Originality/Value: *Parameterization of the risk costs of logistics processes gives new possibilities in this regard. Empirical verification of the parameterization model in the delivery logistics process is an opportunity for companies to develop and avoid the undesirable effects of bad financial calculations.*

Keywords: *Risk, Logistics cost, Logistics process*

JEL classification: *O14, P42, P51.*

Paper Type: *Research study.*

Acknowledgment:
Research financed from the NCN research project no. UMO-2012/05 / B / HS4 / 04139.

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1. Introduction

The implementation of flows, i.e., the essence of logistics processes, could not be implemented without an efficiently functioning supply sphere. The procurement process can be interpreted in two ways. In functional terms, as a supply process, it means acquiring from the outside the material factors necessary to conduct a business. In a material sense, the supply process covers all of the work items that an enterprise must obtain from outside to ensure business continuity. The main task of supply logistics is to provide the company with efficient supply of all materials necessary to conduct continuous and rhythmic business. The essence of supply logistics is, therefore, maximum protection of all material needs of the enterprise, at minimal logistic costs of market supply deliveries (Ficoń, 2001; Pisz, Sęk, and Zielicki 2013).

During the research, the logistic process of interpretation was interpreted as a reliable security of the spatiotemporal availability of directly production materials, i.e., raw materials, construction materials, products and semi-finished products, as well as spare parts, elements, subassemblies, modules, etc., keeping the company in full production readiness. Materials can be purchased directly from the supplier, manufacturer or broker, or made in-house (Ficoń, 2008; Kulińska, 2014).

2. Cost Problems in Managing the Supply Process

As a result of the implementation of supply processes, purchased raw materials, construction materials, products and semi-finished products, spare parts, elements, subassemblies, modules, etc., flow from internal and external suppliers operating on the material market to the company's supply warehouses. Planning, organization and efficient implementation of the physical flow of supply materials from suppliers to supply warehouses is the essence of the logistics supply process (Singh, Jain, and Mishra 2009).

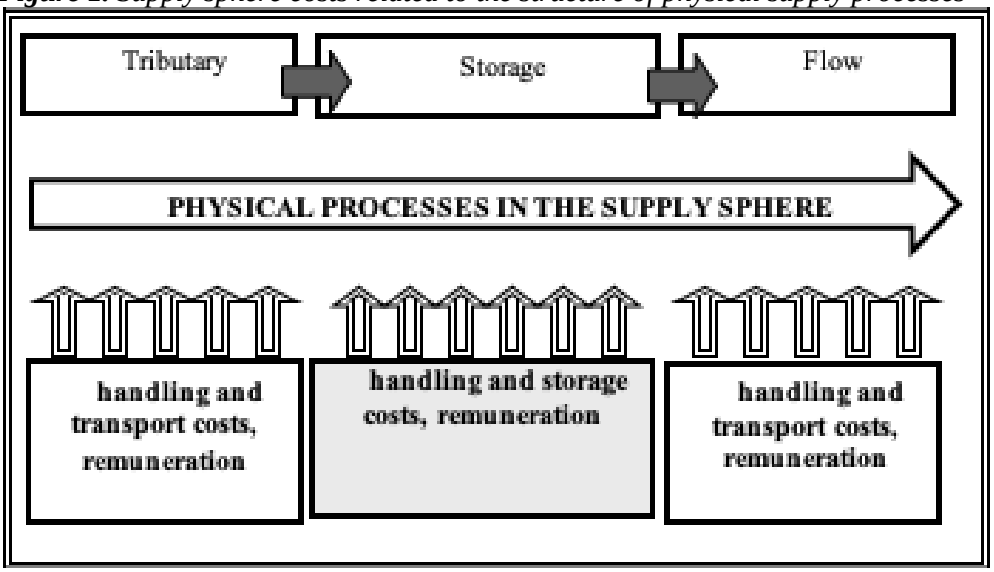
The number and size of supply warehouses and the costs associated with their maintenance depend on the size of the enterprise, the nature of the business and the specificity of technological processes. Smaller enterprises usually have one universal supply warehouse, supporting all technological processes. Large enterprises - with complex production - have specific strings and interrelated supply warehouse complexes that create specific warehouse management systems (Ficoń, 2008; Musa, 2012; ZandHessami and Savoji, 2011). The costs in the sphere of supply logistics of an enterprise (Figure 1) are associated with three main phases of material flows:

- with the inflow of supply and cooperative materials to the enterprise - costs of handling, transport, remuneration,
- with the receipt and storage of materials in supply warehouses - costs of handling, storage, remuneration,

- with the organization of the flow of materials from supply warehouses to the first workstation in the production process - costs of handling, transport, remuneration.

Supply costs include all costs related to the physical flows of raw materials and supplies from primary sources of raw materials and market supply to the company's supply warehouses. The logistics supply costs include, costs of physical flows of raw materials and materials in the form of supply streams from producers to supply warehouses, costs of collecting and maintaining material stocks in the company's supply warehouses, costs of handling information streams controlling the physical processes of material flows in the supply sphere (Ficoń, 2001).

Figure 1. *Supply sphere costs related to the structure of physical supply processes*



Source: *Own.*

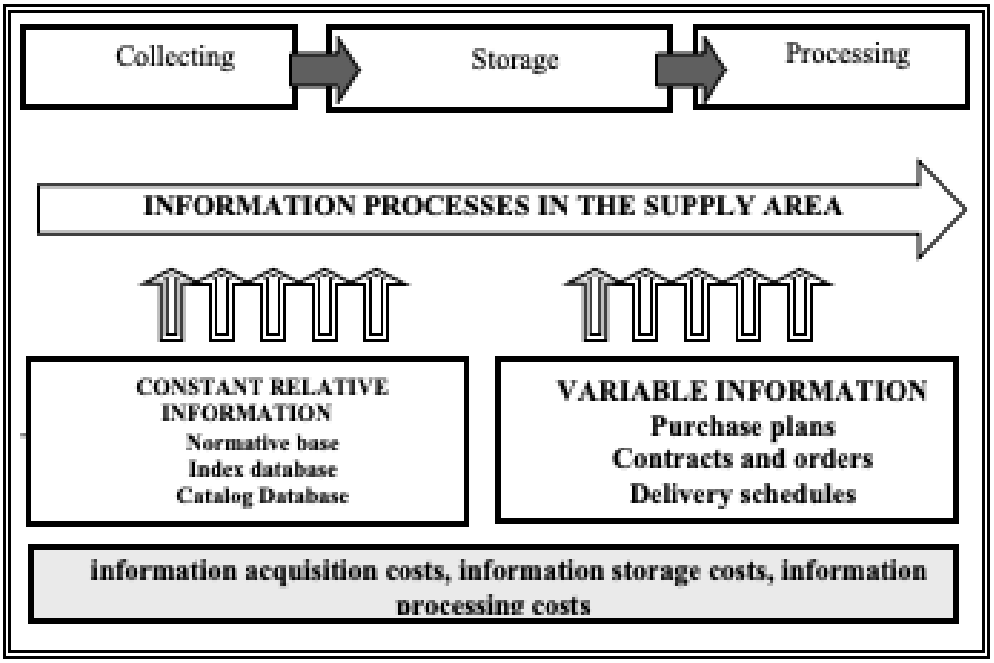
Factors affecting the costs of supply logistics are high costs of supply processes, freezing of current assets through extended transport time, high inventory, high expenditure on transport, high material losses (defects), insufficient relationships with suppliers (Kulińska, 2014). The efficient flow of physical procurement processes, not burdened with risk factors and excessive costs, condition adequate information processes, which generally include (Ficoń, 2001; Koliński, 2016):

- searching, collecting, verifying and collecting input information,
- selection, processing and use of information necessary for the implementation of ongoing activities related to the physical flow of supply processes,
- generating planning information.

This information is divided into relatively constant and current information operative (Figure 2). They belong to a relatively constant data set (Ficoń, 2008):

- supply logistics index database (material indexes, bar codes, addresses of suppliers and recipients, financial operations codes and others),
- normative base of supply logistics (consumption norms and indicators, material inventory norms, supply assortment lists, supplier lists, etc.),
- catalog database (catalogs and price lists of materials, commercial offers, brochures and guides, etc.).

Figure 2. *Costs of supply processes information processes*

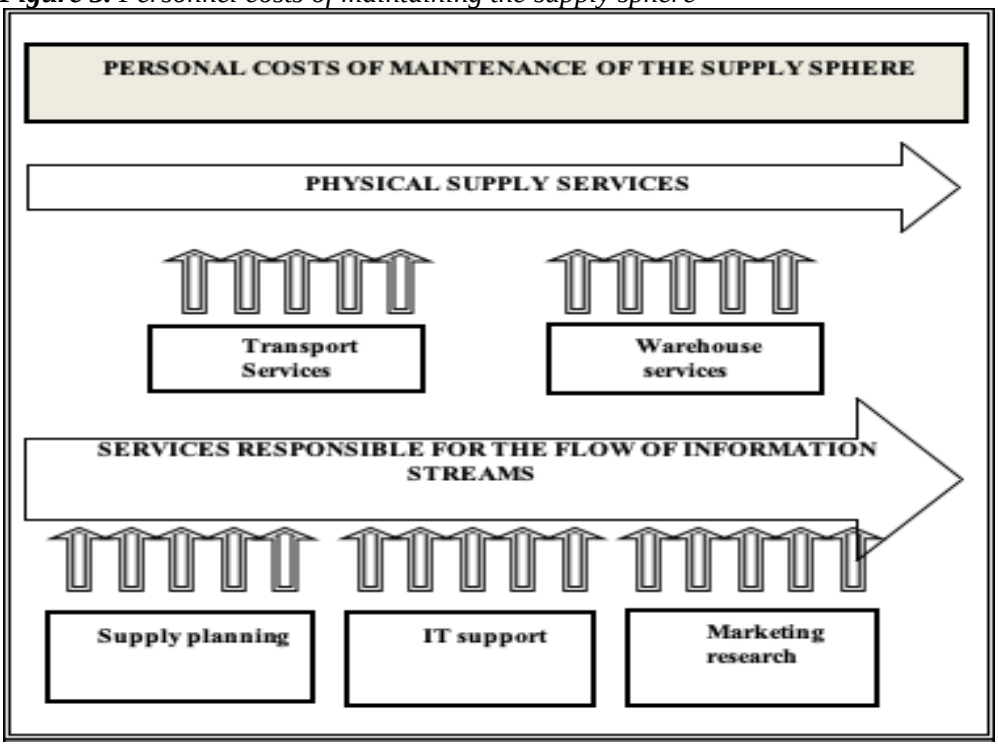


Source: *Own.*

Material supply planning is the final stage of logistics planning and is a derivative of the primary sales plan and the secondary production plan that implies specific material supply needs. Great importance should be attached to the organization of deliveries, which minimizes the cost of material inventory, which means the need for precise planning of deliveries within strictly defined dates and in fixed quantities.

The procurement service is responsible for comprehensive planning and implementation of information and decision-making processes in the sphere of procurement, which includes specialized IT and marketing research units (Figure 3). The transport and storage services of companies usually deal with the physical supply processes.

Figure 3. *Personnel costs of maintaining the supply sphere*



Source: *Own.*

In developed enterprises, a group of broadly understood procurement services consists of: specialized supply marketing departments, economic and financial departments, sometimes combined with IT departments, forwarding and transport departments and units, warehouse management departments (Ficoń, 2008). The management of the supply sphere, which is usually included in the strategic management of the enterprise, coordinates the activities of all procurement services (Krawczyk, 1996). Very often, procurement services use the services of the same marketing cells of the enterprise as the distribution department. In the marketing sense, supply, i.e. material purchases, is the reverse of distribution processes that mean the sale of finished goods on markets.

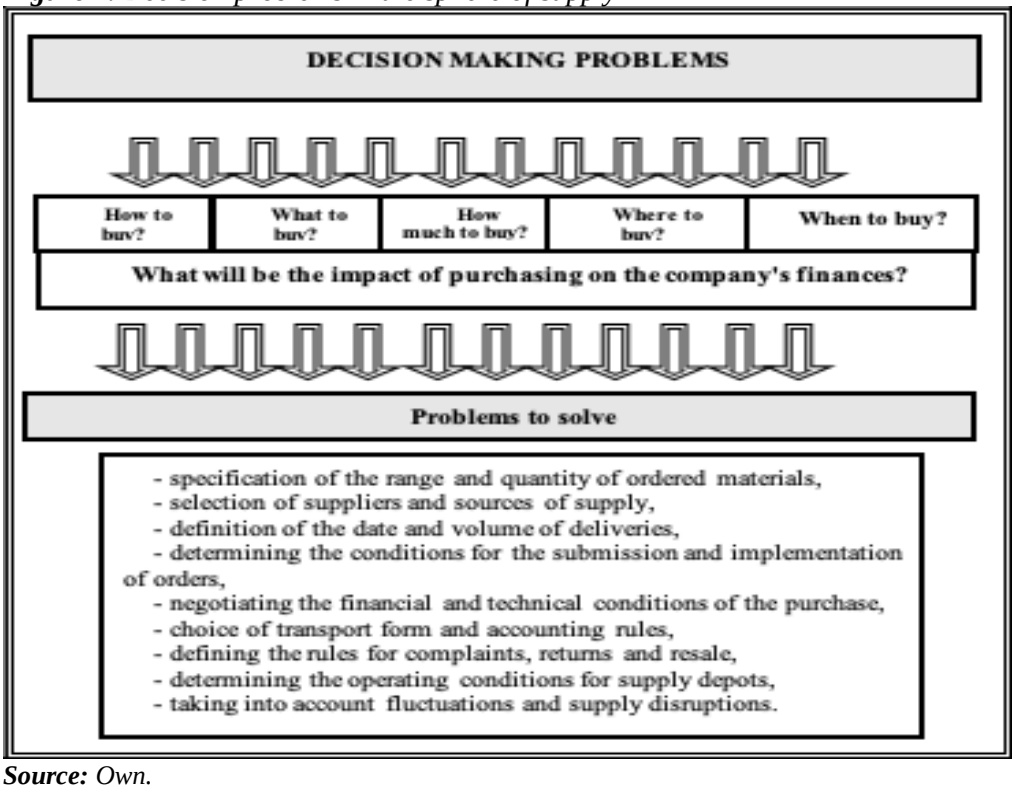
3. Decision Problems as Implication of Risk Factors and Source of Costs

From the point of view of the conducted research regarding cost aspects of the supply sphere, decision-making problems are important. The essence of logistic decisions in the field of material supply, while maintaining superior purchasing standards, is formally answering the main questions: How to buy? What to buy? How much to buy? Where to buy? When to buy? What will be the impact of purchasing on the company's finances?

In a market economy, the comprehensive answer to the above questions is subordinated to the superior customer service requirements that apply in this case to the supplier of supply materials. It should be noted that the group of these standards includes, among others the price of material, which is a basic economic criterion, in a mature market economy (except for monopolistic suppliers) is encapsulated with a number of additional standards and elements of marketing mix applicable in traditional purchase and sale transactions on contemporary supply (material) markets. In order to optimally solve the main decision problems (Figure 4) of supply logistics, the following tasks should be specified in detail (Koliński, 2016):

- specification of the range and quantity of ordered materials,
- selection of suppliers and sources of supply,
- definition of the date and volume of deliveries,
- determining the conditions for the submission and implementation of orders,
- negotiating the financial and technical conditions of the purchase,
- choice of transport form and accounting rules,
- defining the rules for complaints, returns and resale,
- determining the operating conditions for supply depots,
- taking into account fluctuations and supply disruptions (Ficoń, 2001).

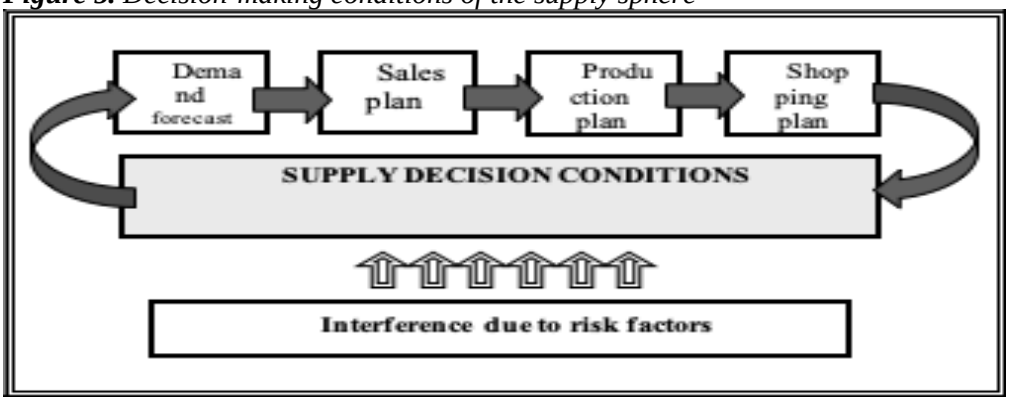
Figure 4. *Decision problems in the sphere of supply*



Source: *Own.*

Making decisions in this area is conditioned by knowledge of production plans, which in turn are developed on the basis of sales plans, and these are generated as derivatives of market forecasts of the demand for our products and services.

Figure 5. *Decision-making conditions of the supply sphere*



Source: *Own.*

The occurrence of seasonal or random distortions of forecasts and plans should also be taken into account, which will directly translate into the intensity of individual flows throughout the enterprise (Figure 5).

One of the most difficult decision-making problems in the sphere of supply is the implementation of material orders. For physical movement of materials from the supplier to the recipient, so-called transport orders. This streamlines material requirements planning and enables pre-planning of delivery costs. The purchase price of the upcoming material includes the agreed purchase price plus additional delivery costs. In the case of materials valued at average market price, this price may be subject to successive changes after each receipt of material to the warehouse. The market material handling procedure includes the following steps (Kulińska, 2011):

1. The receiving company orders the material from the issuing company and initially plans the delivery cost, including items such as freight, customs, transport insurance, unloading costs, etc.
2. The issuing company shall record the issue of materials in accordance with the transport order received. The amount of material released from an inventory at the issuing enterprise is recorded as in-transit inventory at the receiving enterprise.
3. The receiving company introduces the goods receipt to the warehouse on the basis of the transport order. Acceptance of material increases inventory and simultaneously reduces inventory on the road and reduces the volume of open purchases at the receiving enterprise (Ficoń, 2001).

4. Analysis of Risk Factors in Strategic Decision Areas

The logistics supply process, as well as other logistics processes, is burdened with numerous risk factors. The most frequently mentioned risk factors in this sphere in the literature include delays in delivery times, failure to comply with contractual terms by carriers, logistics operators, etc., lack of close cooperation with suppliers, lack of overall assessment of all basic suppliers, volatility of material prices, default by suppliers of technical standards, timely deliveries, changes in delivery conditions, relations with contractors, inadequate supplies of materials in terms of quantity, quality, time, place and costs, problems with information flow, qualifications and experience of employees, shortage of employees (Nazaretow, Kim, and Krupa 2006).

Risk management in the logistics supply process should cover all activities of the company, because planning, organization and efficient implementation of the physical flow of supply materials from suppliers to supply warehouses condition the smooth functioning of the entire enterprise. It should focus on identifying potential events that may negatively affect their goals, assessing the risk associated with it, and then defining and implementing solutions that have the risk to reduce and keep within controlled limits (Kulińska, 2011). Risk factors can be identified at various levels of detail, selected are shown in Figure 6.

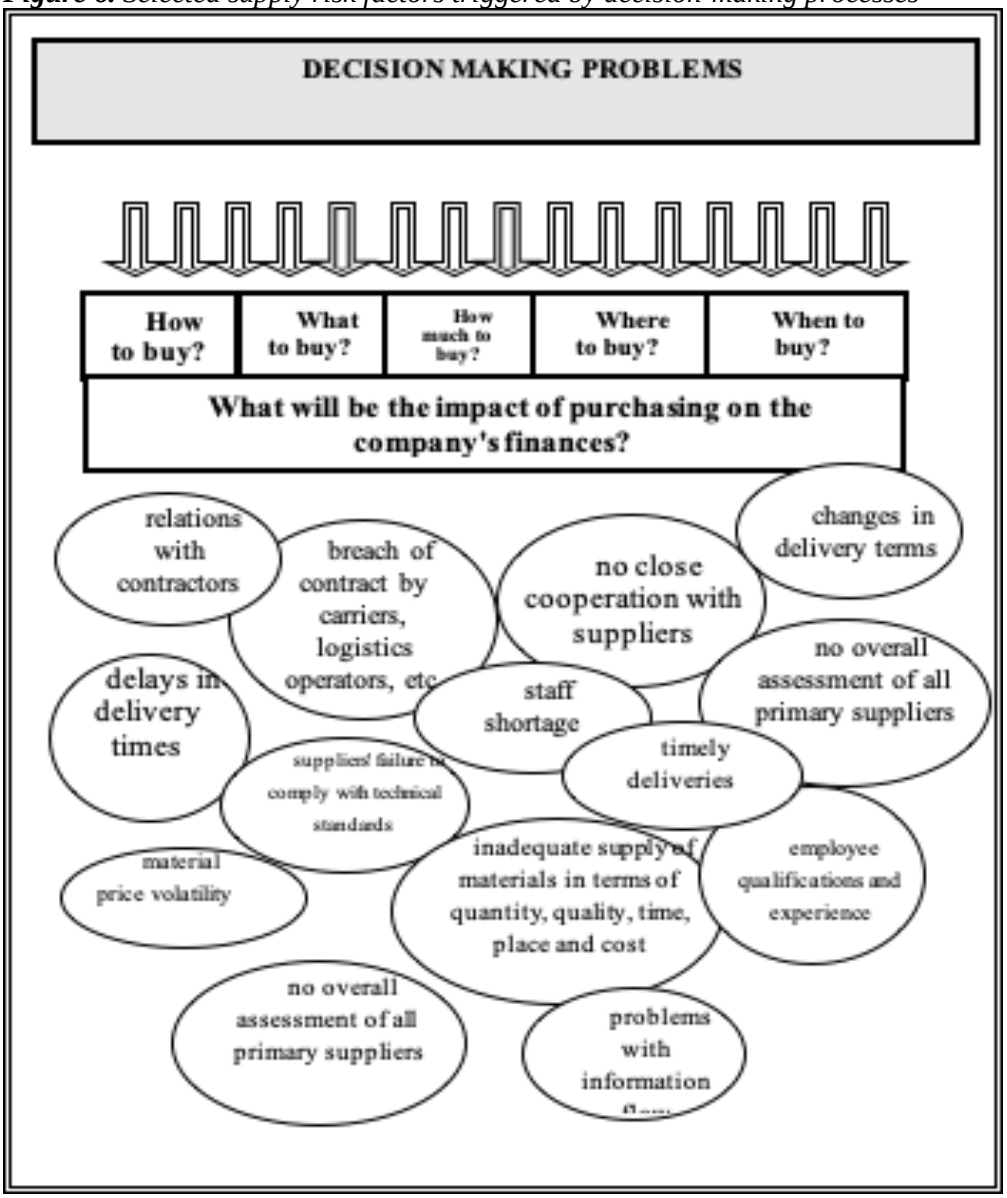
The specification of selected supply sphere risk factors caused by decision-making processes presented in Figure 6 is not the only one possible and does not exhaust the catalog of risk factors that may occur in this area. Rather, it is a starting point for consideration in this regard. Detailed analyses of the risk factors in the sphere of supply are presented in Figure 1.

5. Reasearch Sample

Conceptual work on measuring risk costs in logistics processes most often focus on basic measurement categories and statistical proposals and model solutions. Practical analyzes show a tendency to focus attention on a specific range and measurement processes. Until now, few studies have concerned the impact of risk factors on functioning, flow in logistics processes, and the resulting increase in operating costs.

Thematic research was carried out in 2013-2018 as part of the research project of the National Science Center, among 112 logistics managers in enterprises operating in the Opolskie, Śląskie and Dolnośląskie voivodships. The choice of enterprises was random, while the basic research instrument was a questionnaire consisting of 18 questions. The managers' task was to identify the most common risk factors in the enterprise, taking into account the division into individual spheres of operation and the connection of risk factors with selected cost items shown in the income statement. In order to increase the accuracy of the answers, the information was collected through direct personal interviews with respondents. In this way, full answers to all survey questions were received.

Figure 6. *Selected supply risk factors triggered by decision-making processes*



Source: *Own.*

The research was carried out in enterprises belonging to various industries and types of activity trade, production, services, mixed production, trade and service activities. In the structure of the surveyed enterprises (60%) were medium-sized enterprises, large enterprises (1%) and small enterprises (39%). The survey results indicated that over 70% of the surveyed enterprises do not keep risk registers or cost measurement systems for the operation of individual logistics processes: supply and purchasing, pro-duction, sales and distribution, materials management, transport, storage.

6. Empirical Verification of the Parameterization Model

Based on the data of enterprises in the food industry, six risk factors have been identified which are important from the point of view of decisions taken in managing the logistics process of supply. On this basis, the sentence function was determined (1).

$$ZPx(P1, P2,\ldots,P32) = X1\ X15\ V\ X7\ X14\ V\ \ X7\ X15\ X20\ V\ X7\ X14\ V\ X1\ X30\ X15\ V\ X1\ X7\ X30 \quad (1)$$

Each of the analyzed risk factors arose as a result of decision making mistakes of the FOOD INDUSTRY enterprise X1 X7 X14 X15 X20 X30 it contains information about the frequency (probability) of risk factors and the potential effect (measured by the maximum cost of removing the effects of risk factors). Taking into account the analyzed enterprise, these values were as follows (Table 1).

Table 1. *Summary of the probability and effect of risk factors in function ZPx*

Decision problem	**Variable Propositional**	**Average for years 2013-2018**		**Quantity * Cost**
		Quantity	**Max Cost**	
How to buy?	X_1	12	200	2400
	X_{15}	8	340	2720
What to buy?	X_7	4	187	748
	X_{14}	8	430	3440
How much to buy?	X_7	4	187	748
	X_{15}	8	340	2720
	X_{20}	21	500	10500
Where to buy?	X_7	4	187	748
	X_{14}	8	430	3440
When to buy?	X_1	12	200	2400
	X_{30}	5	290	1450
	X_{15}	8	340	2720
What will be the impact of purchasing on the company's finances?	X_1	12	200	2400
	X_7	4	187	748
	X_{30}	5	290	1450
	$\sum$			**38632**

Source: *Own.*

Data are compiled for 2013-2018. On this basis, we can determine that the functioning model contains information on the total costs of risk factors in managing the supply process in a food industry company. By limiting themselves to these factors, the value added of the company could have been PLN 38,632 higher. Determining the actual costs requires an analysis according to the Gorbatov characterization rules. Model of functioning ψa sentence function ZPx is given as a summary (equations 2 and 3):

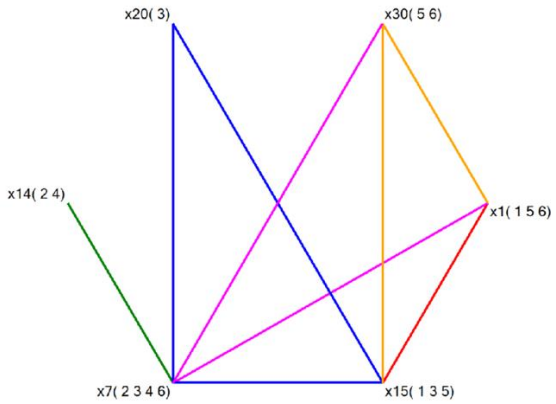
$$\psi a = < M, R2, R3> \quad (2)$$

where:
M - set of sentence variables,
R2 - a set of relations defined by 2-element alternative members,
R3 - set of relations defined by 3-element alternative members,

$$M = < X_1\ X_7\ X_{14}\ X_{15} X_{20}\ X_{30} >$$
$$R_2 = \{\ \{\ X_1\ X_{15}\ \}_1 \{\ X_7\ X_{14}\ \}_2 \{\ X_7\ X_{14}\ \}_4 \} \quad (3)$$
$$R_3 = \{\ \{X_7\ X_{15}\ X_{20}\}_3, \{X_1\ X_{30}\ X_{15}\}_5, \{X_1\ X_7\ X_{30}\}_6\ \}$$

The graphic form of the functioning model is shown in Figure 7.

Figure 7. *Functioning* ψa *model sentence function* ZP_x.



Source: *Own.*

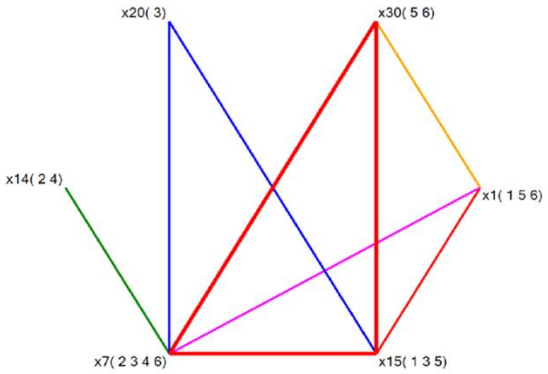
The purpose of modeling is to obtain a structure model that solves a specific research problem, i.e. searching for the real costs of occurrence of risk factors in managing the logistics process of supply within implemented logistics processes. Obtaining the result requires limiting the structure model so that its elements X_i they formed a partially ordered set, i.e. a set whose elements meet the partial ordering relationship. Therefore, prohibited figures should be designated Q^A i Q^B.

For function ZP_x 3 prohibited figures were identified Q^A and 1 prohibited figure Q^B. Identified figures of the type Q^A to:

- $Q_1^A = \{X_1, X_{15}, X_7\}$
- $Q_2^A = \{X_1, X_{15}, X_{30}\}$
- $Q_3^A = \{X_{15}, X_7, X_{30}\}$

Graphic representation of the figure Q_3^A presents Figure 8.

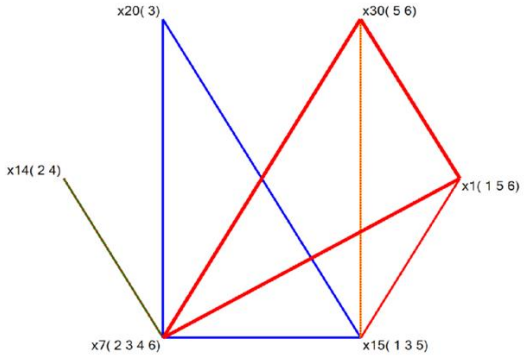
Figure 8. *Graph model of the function's functioning ZP_x with the forbidden graph figure of the type marked Q_3^A.*



Source: *Own.*

The analyzed function also contains 1 forbidden figure QB, which is graph-ically a sub-model written in the form of triangles with hanging vertices. Identified type figure QB to Figure 9.

Figure 9. *Graph model of the sentence function ZP_x with a forbidden graph figure of the type Q_1^B.*



Source: *Own.*

To split the forbidden figures that appeared in the graph representation of the analyzed sentence function, a semantic table was built (Table 2):

Table 2. *Function semantic table ZP_x*

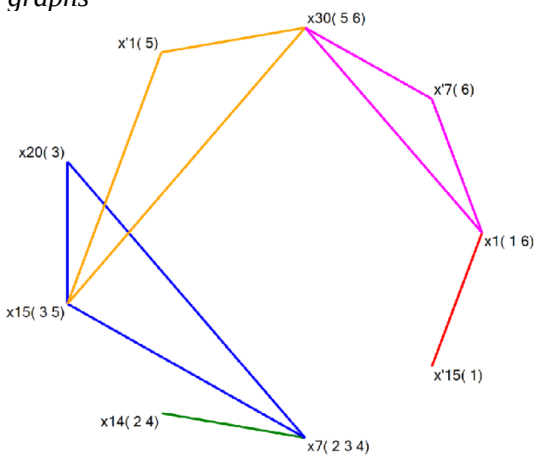
	X1	X30	X15	X7
	1	0	1	1
	1	1	1	0
	0	1	1	1
	1	1	0	1

Source: *Own.*

The first line of Table 2 introduces sentence variables that occurred in all identified prohibited figures. In the first column, however, we introduce prohibited figures. In the following lines, the number 1 denotes sentence variables as a vertex in the forbidden graph figure that occurred in a given forbidden figure (Table 2). The minimum subset of sentence variables that will eliminate all forbidden figures is selected based on the frequency of the occurrence of the sentence variable in the forbidden figures (the largest number of ones in the semantic table column), and from the point of view of analyzing the costs of logistic processes, we choose these sentence variables from alternative solutions, which represent risk factors with the lowest probability (frequency) of occurrence and the lowest cost of potential effects of occurrence.

In the analyzed function, the splitting of all forbidden figures is obtained by the sentence variables X1, X7 and X15. The choice of variables determines the form of the new functioning model ψ'_a, and thus the form of the resulting Hasse diagram and the level of actual costs of selecting risk factors in the supply process of the examined enterprise. The form of a new functioning model ψ'_a (Figure 10).

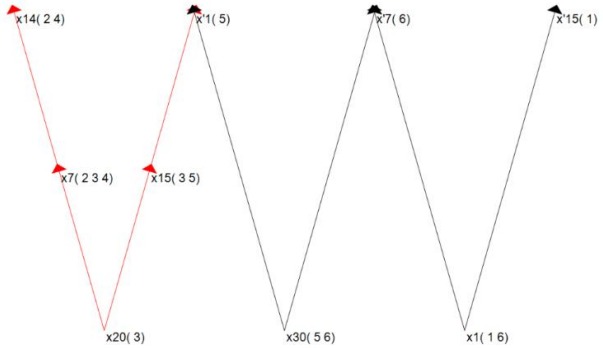
Figure 10. *A new graph model of functioning ψ'_a sentence function ZP_x after splitting prohibited graphs*



Source: *Own.*

As a result of splitting, we obtain a new model of functioning of Figure 10, which corresponds to an adequate Hasse diagram, shown in Figure 11.

Figure 11. *Structure model Ψ_b sentence function ZP_x.*



Source: *Own.*

A new form of the function ZP'_x is in equation 4.

$$M = < X'_1\ X'_7\ X_{14}\ X'_{15} X_{20}\ X_{30} >$$
$$R_2 = \{\ \{\ X_1\ X'_{15}\ \}_1 \{\ X_7\ X_{14}\ \}_2 \{\ X_7\ X_{14}\ \}_4\ \} \quad (4)$$
$$R_3 = \{\ \{X_7\ X_{15}\ X_{20}\}_3,\ \{X'_1\ X_{30}\ X_{15}\}_5,\ \{X_1\ X'_7\ X_{30}\}_6\ \}$$

After analyzing the functioning model, establishing prohibited figures, and analyzing the semantic table, a structure model was obtained (Gorbatov, 1979; Kulińska, 2011). To obtain information on the actual costs caused by risk factors in the logistics process of supplying the examined enterprise, its interpretation is necessary. Based on the structure model, we know that variable replicas were obtained: X'_1, X'_7, X'_{30}. This has consequences in calculating the costs of risk factors for managing the logistics process of supplying the examined enterprise. In tab 3 lists the costs of risk factors based on the new functioning model obtained ψ'_a.

Table 3. *Cost analysis of the effects of removing individual risk factors for selected sentence variables - in the functioning model ψ'_a function ZP_x'*

Decision problem	**Variable Propositional**	**Average for years 2013-2014**		**Quantity * Cost**
		Quantity	**Max Cost**	
How to buy?	X_1	12	200	2400
	X_{15}	8	340	2720
	X_{15}	8	340	2720
	X_7	4	187	748
What to buy?	X_{14}	8	430	3440
	X_7	4	187	748
How much to buy?	X_{15}	8	340	2720
	X_{20}	21	500	10500

	X_7	4	187	748
Where to buy?	X_{14}	8	430	3440
	X_1	12	200	2400
When to buy?	X_1	12	200	2400
	X_{30}	5	290	1450
	X_{15}	8	340	2720
What will be the impact of purchasing on the company's finances?	X_1	12	200	2400
	X_7	4	187	748
	X_7	4	187	748
	X_{30}	5	290	1450
	$\sum$			**44500**

Source: *Own.*

Comparing the total and actual costs of risk factors, one can see how important their correct calculation is. After examining a small number of risk factors, the difference was PLN 5868 (Table 4), it gives a preliminary idea of the scale of the phenomenon.

Table 4. *Comparison of total costs and real costs of removing the effects of risk factors*

BALANCE	
Total costs	**Real costs**
38632	44500
5868	

Source: *Own.*

The example demonstrates that the characterization principle allows showing a significant difference between the total and actual costs of risk factors in the logistics management of the procurement process. The cost difference shown on the basis of the characterizations made shows that not all expenses incurred in the enterprise were correctly qualified, i.e. they were not associated with costs caused by risk factors.

7. Conclusion

Logistic processes condition the spatial and temporal conduct of business activity. The financial result is primarily reflected in the costs of implementing logistics processes. In this example, the costs related to the procurement process, which has an inherent impact on the activities of each enterprise. Effective development of a competitive strategy and a positive financial result of the organization depends primarily on cost analysis. Parameterization of the risk costs of logistics processes gives new possibilities in this regard.

The costs associated with logistics processes relate primarily to fixed assets, which include buildings and structures, transport equipment, machinery and auxiliary equipment, technical equipment and specialized telecommunications infrastructure

of information processes that constitute the company's logistics infrastructure. An important source of costs are also inventories of fixed assets in the form of raw material supply stocks, material, semi-finished products, production stocks, such as work in progress, or semi-finished products, and distribution stocks in the form of finished goods and goods. Labor resources generating personnel costs constitute a very large group of costs.

The recording of logistics costs is a very strong basis for dynamic control of these costs, both by type and in particular time periods, as well as by place of origin. The exact division of costs due to logistics processes enables accurate specification of expenses incurred in the enterprise. Monitoring logistics costs rationalizes the strategy for managing these costs, which should result in minimizing logistics costs. It should be remembered that the goal of logistics is to find a strategy for managing logistics processes that minimizes global costs assuming that a certain level of customer service is maintained. The theory of logistics costs and the issue of their minimization is the main task of logistics managers in the process of planning and organizing logistics supply chains, on the scale of the entire enterprise and in all phases of economic activity.

References:

Gorbatov, V.A. 1979. Semantic theory of machine design. Energia, Moskwa.

Ficoń, K. 2001. Logistics processes in the company. Impuls Plus Consulting, Gdynia.

Ficoń, K. 2008. Economic logistics, logistic processes. BEL Studio, Warszawa.

Ficoń, K. 2004. Outline of microbiology. BEL Studio, Warszawa.

Koliński, A. 2016. Logistics Management – modern development trends. Poznan School of Logistics, Poznań.

Krawczyk, S. 1996. Operational research for managers. AE, Wrocław.

Kulińska, E. 2011. Axiological dimension of risk management of logistic processes. Models and economic experiments. Oficyna Wydawnicza Politechniki Opolskiej, Opole.

Kulińska, E. 2014. Importance of Costs of Risks in Material Management. Foundations of Management, 6(1), 7-20.

Musa, N.S. 2012. Supply Chain Risk Management: Identification, Evaluation and Mitigation Techniques. Linköping Studies in Science and Technology Dissertations, No. 1459.

Nazaretow, W.M., Kim, W.M., Krupa, D.P.T. 2006. Technical imitation of the intellect. WNT, Warszawa.

Pisz, I., Sęk, T., Zielecki, W. 2013. Corporate logistics. Polskie Wydawnictwo Ekonomiczne, Warszawa.

Singh, A.R., Jain, R., Mishra, P.K. 2009. Risk in Supply Chain Management. Proceedings of National Conference on Advances in Mechanical Engineering (NCAME), 326-337.

Zand-Hessami, H., Savoji, A. 2011. Risk Management in Supply Chain Management. International Journal of Economics and Management Sciences, 1(3), 60-72.