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## The distribution network - risk factors from the perspective of the flagship enterprise *Sieć dystrybucji – czynniki ryzyka z perspektywy przedsiębiorstwa flagowego*

*The aim of the study presented in the paper was to identify the key factors which are the source of interference and cause deviations in material flows. Disturbances in material flows, reducing the efficiency of entire supply chains and the efficiency of individual chain links, are treated as risk factors. The realization of distributional tasks based on the internal resources and the resources of network partners is, on one hand, an opportunity to adapt to market changes and create innovative products and services, yet, on the other hand, it increases and enlarges the complexity of the system and is a source of interference in material flows. Also, the complexity of the network increases together with the growth of the differentiation of the realized tasks. Consequently, distributional enterprises' taking over tasks connected with the differentiation of base products according to the needs reported by the customers (postponed production tasks) also increases the risk of disturbances in material flows.*

**Key words:** *distribution network, flagship enterprise, risk factor*

### Introduction

Distribution channels based on strong relations between their participants are indispensable in the organization of distribution processes in an integrated supply chain. From the perspective of the remaining chain links of a supply chain, the results achieved by the distributor are essential. These results can be achieved by the distributor using exclusively its own resources and competences including its own distribution network (central warehouses, regional warehouses, local warehouses together with the warehouse infrastructure, skilfully organized shipment, provision of high penetration of the market and a suitable width of the assortment, etc.), or building a neutral (or mixed) network, composed of independent subjects offering a different scope of distributional services, with different degrees of specialization or regions of customer service differentiated in respect of their location and range. The enterprise which makes a decision about formation of network relations, widening its own supply potential by the resources of its network partners in order to react effectively to the needs of the market, defined in the literature as the core of the network, the heart of the network, the flagship enterprise or the coordinator. In this paper, the central enterprise in a distribution network was named the flagship distributor.

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## Literature review

The turbulent environment, the uncertainty and differentiated preferences of recipients concerning not only the manner of purchasing the product but also the product features are the reason of the changing role of distributional enterprises. Supply chains of products differentiated in accordance with the needs reported by customers take different structures. A strongly highlighted strategy allowing adaptation of the product to the recipients' needs and at the same time providing the resistance of the supply chain, is the postponed production strategy. Removal of the last stage of the production process responsible for the differentiation of the product (the postponed production) can run in two variants of the organization of a supply chain. In the first variant an industrial company produces indirect commodity and differentiates this commodity in accordance with market forecasts concerning the demand for individual variants of the product. In this model the distributional enterprise receives different variants of the product and allocates them according to the actual demand of individual market segments. In the second variant the industrial company produces the base product and supplies it to the distributional enterprise. While realizing tasks of the postponed production, the distributor differentiates the product in accordance with the actual needs reported by individual market segments.

The necessity of building different types of relations in a distribution network is connected with the fact that resources possessed by individual enterprises are insufficient for complex and punctual realization of orders. Moreover, including the realization of the postponed production processes in the tasks of distributional enterprises, the problem of accessibility of production resources broadens the research and allows looking at such a network as an especially complicated system. The network perspective of distribution stresses the complexity of the system because of the number of feedback including factors strengthening the disturbances. The core of the distribution network (the central enterprise) broadens interorganizational bonds built on an individual level of the supply chain by weaker relations. Such an interpretation of the network was presented, amongst others by Ettl M., Feigin G., Lin G., Yao D. (2000), Podolny J., Baron J. (1997). Golicic S., Foggin J., Mentzer J. (2003) and also Golicic S., Mentzer J. (2006) all stress in their publications that the paradigm of relations based on partnership is essential in the supply chain management. According to this thesis one introduced a concept of ranks of relations, as measures of the power of the bond between the participants of the network. However, the differentiation of relations should aid adaptation to changes of the environment, and even creating changes through catching opportunities appearing in the environment<sup>1</sup>.

Consequently, distribution networks are an answer to the turbulence of the environment and aim at increasing the adaptivity of individual enterprises<sup>2</sup> and entire supply chains and, on the operational level, flexible responsiveness to variable needs of recipients.

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<sup>1</sup> Krupski R. (red.): Zarządzanie przedsiębiorstwem w turbulentnym otoczeniu. PWE, Warszawa 2005

<sup>2</sup> Saniuk A., Witkowski K., Saniuk S., Management of production orders in metalworking production, 22nd International Conference on Metallurgy and Materials - METAL 2013, TANGER, Czech Republic, Brno 2013, s. [6] CD-ROM, ISBN: 978-80-87294-39-0.

Therefore, the structure of a distribution network depends on the characterization of the demand, the competitive strategy of the leader of the supply chain and the distributional enterprise and the marketing strategy and the logistic aims resulting from it and realized by all the participants of the supply chain. Consequently, marketing strategies and logistic tasks connected with translate into the strategic distribution objectives.

The strategic distribution objectives include such parameters as the sale dynamics, distribution costs, the market share, the risk diversification, reduction of negative results of the uncertainty of demand, the enlargement of penetration of the market thanks to the increase in distribution channels or the increase in the width of the offered assortment. The aims of distribution in the logistic perspective can be extended by enlarging the utilization of storage capacities or elimination of empty runs which consequently translate into reduction of costs of the distribution logistics. An additional strategic objective of the formation of neutral networks in distribution can be reduction of the bargaining power of suppliers (producers) in a supply chain. However, the key measure of the assessment of the efficiency of the flagship distributor is the ability to satisfy the customers' needs as regards the time, punctuality, complexity, flexibility and reliability of realized orders.

In a distribution network one does not strive for developing a common strategy for the entire network because the boundaries of such a system are blurred and a certain number of nodes adopt the nature of loose chain links cooperating with the core of the network, i.e. with the base enterprise, on a short-term basis. It must also be stressed that two types of network participants appearing in the distribution system: distribution enterprises (wholesalers, retailers, agents) and logistic enterprises (logistic centres, distribution centres, shipping companies and carriers) are differentiated subjects of research, forming network relations on different rules. What is extremely essential in this case is the community of aims, served markets and the similarity of realized processes. Consequently, network relations are shaped in a completely different manner by a distributor establishing collaboration with a chosen logistic enterprise and in a different way with another distributor. Together with an increase in the complexity of the supply network, including an increase in the number of actors, with the differentiation of models of strategic actors, with a growth and differentiation of relations among actors, there is an increase in the risk and the scale of problems connected with disturbances in material flows and informational flows.

Handfield R., McCormack K. (2008) define the disturbance as the main delay in production, distribution or supply nodes which has its consequences in operation of other nodes of the supply chain. Disturbances are usually a bottleneck in one of the nodes which effects in spreading its results in the entire supply chain. Each event such as: a fire, problems with the quality of manufactured products, failures of machinery, delayed orders from customers, can cause essential disturbances in the entire supply chain.

The character of the bonds in distribution networks, where relations between the subjects are often weaker than in integrated distribution channels, can cause partners' autonomous processes, which are not the subject of collaboration, to disturb the realization of processes between organizations across, e.g. bottlenecks in realization of the postponed production tasks, arising in a partner. Consequently, it is proper to make an attempt to separate factors which generate disturbances in flows realized in networks

of cooperating distribution enterprises. Factors causing disturbances have their effects in deviations from the established flow parameters. So, examples of deviations can be unpunctually realised orders, incompletely realized orders, unrealised orders, deviations from appointed levels of reserve, extraordinary transport.

The carried our literature studies [Handfield, McCormack 2008, Kovacs, Tatham 2009] allowed selecting 32 factors causing disturbances: unpunctual delivery (CWZ<sup>3</sup>1), incomplete delivery (CWZ2), defective delivery (CWZ3), bad quality of delivered materials (CWZ4), lack of delivery (CWZ5), modification of the terms of the placed order (quantities, assortment, date and time) (CWZ6), recipient's withdrawal from the contract (CWZ7), too short expected lead time (CWZ8), incomplete data in the order (CWZ9), insufficient production capacities of the subcontractor (CWZ10), delays in the realization of the subcontractor's processes (CWZ11), shipping process realized unpunctually (CWZ12), damage during transport (CWZ13), incorrect data on the shipping document (CWZ14), too small production capacity (CWZ15), office employees' errors (CWZ16), bad IT system (CWZ17), the conditions of order realization inadequate to the capacity of the base enterprise (CWZ18), limited production capacity (CWZ19), badly selected business partners (CWZ20), badly designed relations in the supply network (CWZ21), inadequate material management (CWZ22), bad quality of inspection on the part of the base enterprise (CWZ 23), damage during the loading/the stockpiling (CWZ24), financial problems of the base enterprise (CWZ25), bad organization of logistic processes - superfluous movement of people, materials or information (CWZ26), HR difficulties of the base enterprises (CWZ27), strikes (outside the enterprise) (CWZ28), machinery failures (CWZ29), using wrong procedures in the production process and/or the logistic process (CWZ30), long periods of stoppage (inactivity of people, information, materials) (CWZ31), wrong organization of worksites (CWZ32). These factors were investigated in a distribution network of metallurgic products from the perspective of the frequency of occurrence and their effects on the organization.

The preliminary analysis of the correlation between selected variables showed essential relations between variables, hence a decision was made to carry out a factor analysis in order to combine strongly correlated variables and thereby limit the number of variables. Also, the authors assessed the influence of the distinguished factors on deviations in flows in the investigated distribution network of metallurgic products.

## **Deviations in material flows in the distribution network of metallurgic products**

The distribution network of metallurgic products is a network clearly dominated by separated flagship enterprises. Apart from their basic distributional tasks, including marketing and logistic tasks, flag enterprises realize the postponed production tasks. On one hand they integrate processes along the value added stream and, on the other hand, they establish network relations with enterprises which possess similar or complementary resources. These relations increase the efficiency of enterprises in their

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<sup>3</sup> CZW (czynnik wywołujący zakłócenia – inducer of disruption, evaluation of the frequency)

reaction to the recipients' needs. The distribution network includes flows of products of different degrees of processing, to begin with sheet metals, tubing, through sections, profiled products until details for manufacturing processes of next chain links of the supply chain. Simultaneously, as indicated in the literature, one of the major factors determining the formation of network relations is product differentiation. Therefore, the authors formulated Hypothesis 1: "The degree of product processing and the degree of product differentiation in the distribution enterprise affect deviations in material flows in distribution networks of metallurgic products" and Hypothesis 2: "Factors causing disturbances assessed in respect of the frequency affect deviations in material flows in distribution networks of metallurgic products" and Hypothesis 3: "Factors causing disturbances assessed in respect of the results of the influence on the organization affect deviations in material flows in distribution networks of metallurgic products".

The research was carried out by means of questionnaire survey based on a questionnaire prepared for this purpose. The research group was limited to enterprises offering metallurgic products to institutional buyers, and consequently, it did not involve retailers. However, the research took into account logistic enterprises. From among enterprises of the distribution network of metallurgic products (distributors realizing the postponed production tasks, classical wholesalers, logistic enterprises) 48 correctly filled in questionnaires were obtained.

In particular stages of the research the authors used factor analysis grouping factors causing disturbances into 6-factor groups in respect of the frequency of appearing disturbances, and then into 6-factor groups in respect of the strength of the influence of disturbances on the organization. The authors also examined correlations between the distinguished factors and deviations in material flows. While analysing deviations in material flows realized in the distribution network of metallurgic products the authors found that the frequency of unrealised orders decreases together with the degree of the product processing (Spearman's  $R = -0.52$ ,  $p=0.0001$ ). Moreover, the researchers also obtained an essential relation showing that the frequency of unrealised orders decreases together with the growth of the degree of the product differentiation (Spearman's  $R = -0.44$ ,  $p=0.0017$ ). Fig. 1 presents the influence of the degree of product processing on all the investigated deviations in material flows (O1 - Unpunctual realization of the order, O2 - Incomplete realization of the order, O3 - unrealized order, O4 - Deviations from the appointed stock levels, O5 - extraordinary transport).

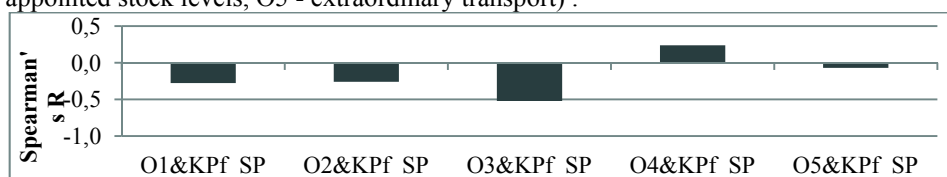


Fig. 1. Deviations in material flows depending on the degree of product processing

Rys.1. Odchylenia w przepływach materiałowych w zależności od stopnia przetworzenia wyrobu

Source: The authors' study

The degree of product processing is also negatively correlated with unpunctually realized orders and incompletely realized orders. However, the growth of the degree of the product differentiation is accompanied by deviations in the assigned stock levels. The obtained results do not allow rejection of Hypothesis 1 "The degree of product processing and the degree of product differentiation in the distribution enterprise

affect deviations in material flows in distribution networks of metallurgic products". Fig. 2 shows average horizontal levels of the frequency of individual factors causing disturbances in material flows of the investigated distribution network.

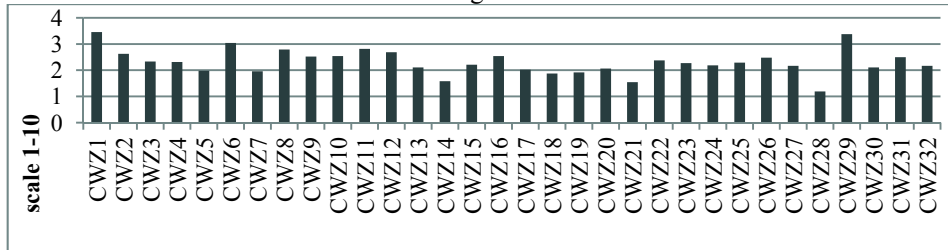


Fig. 2. Disturbance in respect of the frequency of the occurrence  
Rys.2. Zakłócenia pod względem częstotliwości występowania  
Source: The authors' study

Unpunctual deliveries and machinery failures are factors causing disturbances assessed as occurring most frequently in material flows in distribution networks of metallurgic products. Disturbances are also generated on the part of shipping companies as a result of errors in shipping documents and unpunctual realization of the shipping process. Attention must be paid to the fact that not all disturbances generated in one chain link or edge of the network are transferred to other nodes, even when they occur with a large frequency. Therefore, the distinguished factors causing disturbances were assessed not only in respect of the frequency of the occurrence in the network but also in respect of effects which such an incident has on the organization. The intensity of the influence of factors disturbing the organization was presented in Fig. 3.

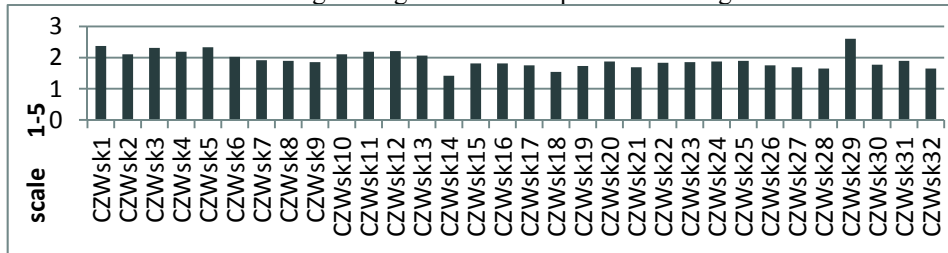


Fig. 3 The strength of the influence of factors disturbing the organization.  
Rys. 3 Siła wpływu czynników zakłócających na organizację.  
Source: The authors' study

The strength of the influence of factors disturbing the organization was assessed according to the rules presented in Table 1.

Table 1. Criteria of assessment of the strength of the influence of factors disturbing the organization  
Kryteria oceny siły wpływu czynników zakłócających na organizację

Score for effects	Description	Organizational criteria
5	disastrous	Lack of realization of the key aims of the organization
4	serious	Lack of realization of the key aim of the process, long-term change in the realized processes
3	average	Requiring changes in the organization of processes
2	small	Requiring slight, short-term changes in the realized processes
1	insignificant	Compensated by protections to date

Source: The authors' study

The most serious results are caused by machinery failures. Unpunctual or defective deliveries and lack of delivery are factors whose occurrence requires changes in the organization of the process. Disturbances caused by other factors require slight, short-term changes in the realized processes or are compensated by protections created by organizations.

When comparing the assessment of the frequency of occurrence of disturbing factors with the assessment of the results of their occurrence, it can be noticed that a number of factors, despite their large frequency of occurrence does not cause serious results in the realized processes. The most strongly revealed factors assessed in unison in respect of frequencies and effects are failures of machines and unpunctual deliveries.

### **The identification of risk factors in the distribution network of metallurgic products**

The analysis of correlations between the factors causing disturbance (32 variable) showed essential relations. In connection with the above the authors carried out the factor analysis. The distinguished factors were defined as "risk factors in the distribution network". Risk factors were distinguished according to the assessment of the frequency of the occurrence of disturbing factors and then according to the influence of the appearance of disturbing factors on the organization. The factor analysis allows reduction of the number of variables through combining in factors variable correlated. Each factor is represented by all the variables (the factor is a linear combination of all the variables) but the variables take different balances describing weights (the factor load<sup>4</sup>). The factor is defined by those variables whose factor load exceeds 0.7.

From among the 32 investigated variables (factors causing disturbances in distribution networks assessed according to the frequency of occurrence) 19 factors have loads of more than 0.7, other variables are not correlated, and consequently they do not define any factors. In the first step the authors distinguished 12 risk factors. The participation of the output variance of these 12 factors in the entire variance and the accumulative value, indicate that these variables in 88% explain the entire variability of all the investigated factors causing disturbance in the distribution network.

In the second step the authors reduced the number of factors to 6. The 6-factor system provides 67% explanation of the variance. 15 variables have loads of more than 0.7 and these variables define the distinguished factors. The content-related assessment of the distinguished 6 risk factors allowed adopting such a perspective for further analysis.

Table 2. The representation of individual factors through the variables which obtained loads of more than 0.7  
Reprezentacja poszczególnych czynników przez zmienne, które uzyskały ładunki powyżej 0,7

Factor	Variables defining the factor	Interpretation of the factor
Factor1	CZW30 - using wrong procedures in the production process and/or the logistic process, CZW31 - long periods of stoppage (inactivity of people, information, materials), CZW32 - wrong organization of worksites	Factor 1 concerns the organization of the production processes and logistic processes, disturbances are generated by muddy-lean.
Factor2	CZW3 - defective delivery, CZW4 - bad quality	Factor 2 concerns deliveries, disturbances

<sup>4</sup> Factor load is determined as a coefficient of the correlation of a particular variable with the factor.

	of delivered materials, CZW5 - lack of delivery	are generated by suppliers.
Factor3	CZW12 – shipping process realized unpunctually, CZW20 - badly selected business partners, CZW24 - damage during the loading/the stockpiling	Disturbances arisen on the stage of the realization of logistic processes between the base enterprise and the customer
Factor4	CZW10 - insufficient production capacities of the subcontractor, CZW11 - delays in the realization of the processes by the subcontractor	Factor 4 involves disturbances generated by the subcontractor.
Factor5	CZW1 - unpunctual delivery, CZW2 - incomplete delivery	Factor 5 involves disturbances generated by the supplier as regards reliability of deliveries.
Factor6	CZW18 - the conditions of order realization inadequate to the capacity of the base enterprise, CZW23 -bad quality of inspection on the part of the base enterprise	Factor 6 involves disturbances generated by the base enterprise in the area of order realization including the inspection and processing of orders.

Source: The authors' study

The analysis of canonical correlation did not show any essential relations between the variable representing deviations and the variable representing risk factors according to the frequency of the occurrence in the distribution network of metallurgic products. Consequently, the findings do not allow adopting Hypothesis 2 "Factors causing disturbances assessed in respect of the frequency affect deviations in material flows in distribution networks of metallurgic products".

Essential but slight relations were shown only on the level of individual relations between risk factors assessed according to the frequency of the occurrence and with some deviations in material flows. The growth of the frequency of the occurrence of factors generated by suppliers is accompanied by an increase in the frequency of unpunctual orders (Spearman's  $R = 0.2$ ) and extraordinary transport (Spearman's  $R = 0.3$ ). The intensity of deviations from the assigned stock levels increases together with the growth of the frequency of the occurrence of "mud" (Spearman's  $R = 0.4$ ) and together with the growth of disturbances generated by the subcontractor (Spearman's  $R = 0.3$ ).

An analogously similar research procedure was used for testing Hypothesis 3 for distinguishing and assessing risk factors assessed according to the influence of their occurrence on the organization.

In the first phase the authors distinguished 12 factors defined altogether by 15 variables, which gave 87% representation of the variability of the results of disturbances. Since factors without essential representation of variables appeared again, the number of risk factors was limited to 6.

In the second phase 6 factors represent 12 variables at 70% explanation of the variability of results of disturbances.

Table 3. The representation of individual factors through variables which obtained loads of more than 0.7  
Reprezentacja poszczególnych czynników przez zmienne, które uzyskały ładunki powyżej 0,7

Factor	Variables defining the factor	Interpretation of the factor
Factor1	CZWsk 17 - bad IT system, CZWsk27 - HR difficulties of the base enterprises, CZWsk32 - wrong organization of worksites	effects resulting from underinvestment in the infrastructure and human resources in the base enterprise
Factor2	CZWsk2 - incomplete delivery, CZWsk3 - defective delivery, CZWsk4 - bad quality of delivered materials, CZWsk5 - lack of delivery, CZWsk12 – shipping process realized unpunctually	effects resulting from lack of necessary material for the production process generated both by the supplier and the shipping company
Factor3	CZWsk29 - machinery failures	Machinery failures
Factor4	CZWsk28 - strikes (outside the enterprise)	Congestion



Factor5	long periods of stoppage	Bad organization of processes in the base enterprise
Factor6	CZWsk15 - too small production capacity of the base enterprise, CZWsk19 - limited production capacities of the cooperating enterprise	effects resulting from the difficulty of realisation of orders as a result of insufficient production capacities

Source: The authors' study

The analysis of canonical correlation between the variable representing the intensity of deviations and the results of the occurrence of factors causing disturbances showed an essential relation with the significance level  $p=0.0042$  and the canonical coefficient  $R=0.74$ .

The growth of the effects: underinvestment of resources in the base enterprise, factors outside the supply chain (congestions, strikes), long periods of stoppage and difficulties in realisation of order resulting from limited capacities in the base enterprise and at cooperators', causes a decrease in the intensity of deviations in the punctuality of realized deliveries and the extraordinary transport, and an increase in the intensity of deviations: completeness of the realized orders, unrealized orders, deviations from the assigned stock levels. Increasing results of disturbances caused by suppliers and shipping companies and resulting from the machinery failure in the base enterprise cause an increase of the intensity of deviations: unpunctual deliveries and extraordinary shipments and a decrease in deviations: incompletely realized orders, unrealized orders, deviations from the appointed stock levels. The obtained results in this part of the study allow adopting Hypothesis 3 "Factors causing disturbances assessed in respect of the results of the influence on the organization affect deviations in material flows in distribution networks of metallurgic products".

## Conclusions

In the distribution network, an increase in the complexity of the network shaped by the flagship enterprise affects disturbances in material flows. These disturbances have their reflection in deviations from the planned processes of realisation of customers' orders. The carried out research identified factors which are the source of interference in a network of cooperating distribution enterprises in the sector of metallurgic products distribution. The prepared risk factors were defined through identified factors causing disturbances assessed according to their frequency and their influence on the organization. The research indicated that the essential influence on deviations in material flows comes from risk factors defined with factors causing disturbances with assessed according to the influence of their occurrence on the organization.

Risk factors are generated both by the suppliers of the base enterprise, by the enterprise itself and cooperators in the network and even customers. The most serious results in material flows are caused by machinery failures and unpunctually realized orders. The growth of the results of disturbances generated by the base enterprise (machinery failures, bad work organization) significantly affects such deviations as: incompletely realized orders and deviations in the stock level. The growth of results of disturbances generated by the supplier and the shippers increases the frequency of unpunctual deliveries and the number of extraordinary shipments, however, it weakens deviations in the stock level. The carried out research are a stage of realization of the authors; own research project: "An IT system to assist the management of material flows in a network as exemplified by metallurgic products."

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## Streszczenie

Realizacja zadań dystrybucyjnych w oparciu o zasoby własne i partnerów w sieci jest z jednej strony szansą adaptowania się do zmian rynkowych i kreowania innowacyjnych produktów i usług lecz z drugiej strony zwiększa złożoność systemu i jest źródłem zakłóceń w przepływach materiałowych. Złożoność sieci wzrasta także wraz ze wzrostem różnicowania realizowanych zadań. Tym samym przejęcie przez przedsiębiorstwa dystrybucyjne zadań związanych z różnicowaniem produktów bazowych zgodnie z potrzebami zgłaszanymi przez klientów (zadania odroczonej produkcji) także zwiększa ryzyko zakłóceń w przepływach materiałowych. Sieć dystrybucji wyrobów hutniczych zdiagnozowano jako sieć zdominowaną. Centralne ogniwo sieci dystrybucji nazwano w artykule flagowym dystrybutorem.

Celem badań zaprezentowanych w artykule była identyfikacja kluczowych czynników będących źródłem zakłóceń i wywołujących odchylenia w przepływach materiałowych. Zakłócenia w przepływach materiałowych, zmniejszające sprawność całych łańcuchów dostaw i skuteczność poszczególnych ogniw są traktowane jako czynniki ryzyka.

**Słowa kluczowe:** sieć dystrybucji, przedsiębiorstwo flagowe, czynniki ryzyka

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