

# THE IDENTIFICATION OF ZONES OF AMPLIFICATION OF DISRUPTIONS IN NETWORK SUPPLY CHAINS OF METALLURGIC PRODUCTS

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An increase in the number of participants in a supply chain and network relations results in an increase in the complexity of the entire logistic and production system. Consequently, there appear additional potential sources of disruptions in material flows. The aim of the research presented in the article is to identify the zones of amplification of disruptions in network supply chains of metallurgic products.

*Key words:* metallurgy sector, risk factor, zones of amplification of disruptions, network supply chain

## INTRODUCTION

Numerous challenges faced by enterprises in supply chains in connection with the stormy and insecure environment, can be undertaken thanks to established relations with many suppliers, competitive production organizations or a complex distribution network. Network relations allow catching market opportunities, the growth of innovativeness both in the area of products as and the manners of their delivery. They also shape a greater flexibility of the system, allowing its adaptivity at the same time. As a result of the growth of the number of participants in supply chains and network relations, there is an increase in the complexity of the entire system, consequently there appear additional potential sources of disruptions in material flows. The aim of this research in the area of factors of amplification of disruptions is to identify the zones of amplification of disruptions in network supply chains of metallurgic products. The research was carried out in three stages:

- Identification of potential factors of amplification of disruptions in network supply chains (literature study)
- Assessment of factors of amplification of disruptions in network supply chains of metallurgic products (questionnaire research based on cards for measurement of disruptions)
- Distinguishing zones of amplification of disruptions in network supply chains of metallurgic products (factor analysis)

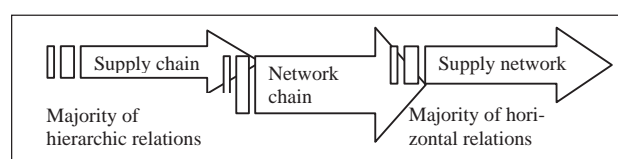
## NETWORK SUPPLY CHAINS

The complexity of relations between organizations in supply chains induces explorers to develop both the-

oretical interpretations of the notion: a supply chain and research areas connected with it. The literature reveals a number of notions which attempt to describe the complex relations of co-operating enterprises, including: supply networks, business networks, multidimensional networks of collaborating enterprises or network supply chains. Most explorers of this problem define supply networks as co-operating enterprises, independent legally and organizationally, which compete and cooperate at the same time [1]. Similar definitions can be found in the literature quoting the notions of: business networks and multidimensional networks of collaborating enterprises [2-4]. It is stressed more and more frequently that definitions of a supply chain require supplementing with the essence of network relations between nodes [5]. The complex and multidirectional relations can be shaped at different stages of the value chain and such a complex structure is defined as a network supply chain.

For the needs of the research presented in the paper the authors proposed a classification of cooperation of enterprises according to the criterion of poly-centric and hierarchical relations (Figure 1).

Construction of the flexibility and the adaptivity of a supply chain will aim at creating different options, scenarios and possible ways of their realization through formation of complex diverse relations between numerous organizations in the cooperation network. At the same time the growth of the complexity of supply chains



**Figure 1** A network supply chain  
Source: The authors' study

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is a source of additional disruptions which are the stronger, the weaker are bonds built between the partners.

## DISRUPTIONS AND FACTORS AMPLIFICATION OF DISRUPTIONS

The identification and the analysis of disruptions in material flows are the basis for building the risk management strategy in supply chains [6, 7]. Also, Kleindorfer and Saad (2005) notice that the assessment of the probability of disruptions and smoothing of deviations emerging in connection with their occurrence are fundamental for the risk management in supply chains. The risk management strategy should be included not only in the business model of an enterprise but also in the strategic model of a supply chain.

Disruptions were defined as unforeseeable events which disrupt the planned processes or the stability of the organization [8]. The intensity of the results of disruptions in network supply chains depends on two categories of variables: the network scale (the width of a network and the length of a supply chain, the geographical distance between nodes) and the degree of the complexity of relations between nodes [9].

Handfield and all (2008) indicated classes of factors of amplification of disruption in supply chains:

- the influence of disruptions in supply chains which are a result of the globalization of the sources of supply or sale, is strengthened with the enlargement of the following parameters: the supplier's geographical distance, the number of brokers and operators, the length of the lead time, the workforce availability, customs regulations, warehouse requirements, safety requirements, legislative activities connected with import and export, infrastructural problems of ports and railways, terrorism, natural disasters, lack of transparency of the entire supply chain.
- the influence of disruptions in supply chains connected with the growth of the complexity of processes increases with an increase in any of the following parameters: the degree of the complexity of products, the product value, limitation of the supplier's production capacities, the uniqueness of materials and parts, the non-standard size of parts.

In the research the authors focused on defining zones of amplification of disruptions in network supply chains of metallurgic products [10]. The groups of factors of amplification of disruptions with a similar effect on disruptions in material flows of metallurgic products were called zones of amplification of disruptions.

## NETWORK SUPPLY CHAINS OF METALLURGIC PRODUCTS

Supply chains of metallurgic products more and more strongly a tendency of designing structures in compliance with the variant of late differentiation. Tasks connected with the realization of postponed production

are pushed in this variant onto distribution enterprises or subsequent links realizing the supply processes for enterprises of the machine construction industry, the motor industry, the home appliances industry, etc..

The metal industry is gradually changing its production offer towards deep-processed products. Part of enterprises specializes and the strongest organizations on the market try to take the role of an integrator, combining processes in the value added stream. Such tendencies refer both to the production part of the supply chain and its distributional part. Offering additional services by distributional enterprises in order to diversify metallurgic products according to specification of the placed orders, is a response to changes both in the environment of the supply chain and in its structure itself. Integrators of distribution networks combine tasks resulting from the realization of the push strategy and tasks resulting from the realization of the pull strategy [10]. Subsequent chain links are responsible for an increase in the degree of processing of the product. Realization of production and logistic tasks entails necessity of building many cooperative relations in order to gain substitutional and complementary resources. Production and logistic systems design in this way allow complex and punctual realization of complex orders.

Supply networks of metallurgic products are composed of many cooperating nodes combined with different formal and irregular relations [11]. Such a structure allows configuration of the network to the current market needs. Supply chains of metallurgic products are characterized with relations built both vertically and horizontally, because of which it can be claimed that they have a network structure.

## ZONES OF AMPLIFICATION OF DISRUPTIONS IN MATERIAL FLOWS OF METALLURGIC PRODUCTS

The carried out literature and pilot research allowed selecting 32 factors causing disruptions in material flows in a network supply chain of metallurgic products for the motor industry. The initial analysis of the relevance of the relationship between selected variables, showed correlations between certain variables, therefore the authors decided to carry out the factor analysis in order to connect strongly correlated variables, and consequently reduce the number of variables. Risk factors distinguished in this way were analysed in respect of the factual justification of connecting definite variables in a given risk factor. As a result of the carried out analysis the authors selected 6 risk factors significantly diversified in respect of the frequency of occurrence of disruptions.

- Factor 1 refers to the organization of production and logistic processes, disruptions are generated by wastage ('muda' according to Lean)
- Factor 2 refers to supplies, disruptions are generated by suppliers

- Factor 3 involves disruptions arisen at the stage of the realization of logistic processes between the base enterprise and the customer
- Factor 4 involves disruptions generated by the subcontractor
- Factor 5 involves disruptions generated by the supplier in the area of the reliability of supplies
- Factor 6 involves disruptions generated by the base enterprise in the area of the realization of an order including monitoring and processing of orders

The distinguished risk factors not only represent significantly the variability of disruptions in respect of the frequency of their occurrence but also have their essential reason. The division of the factors is compatible with the phasic (system) perspective in logistics so it involves suppliers, the base enterprise, logistic enterprises, customers. The authors distinguished two types of risk factors within the base enterprise itself. The first risk factor expresses disruptions resulting from bad organization of work. Variables forming this factor refer to wastage factors in an organization (*muda*), well-known from the literature. The sixth risk factor referring to the risk generated by the base enterprise refers to events happening as a result of the maladjustment of the supply base of the organization and inspection procedures of the quality inspection to the real requirements of material flows. Similarly, disruptions generated by the supplier in respect of the frequency constituted two risk factors. The second risk factor comprises events connected with completeness, quality or lack of supply, and the fifth risk factor contains events associated with the time of delivery realization.

Disruption in material flows can become stronger through the influence of other factors which in the literature are defined as factors of amplification of disruptions. The assessment of factors of amplification of disruptions was carried out on a research sample of 54 enterprises of a network supply chain of metallurgic products for the motor industry. Particular zones were selected on the basis of the factor analysis. Taking into account the findings of the literature research (finished with the selection of factors of amplification of disruptions) and also the findings of the empirical research carried out in earlier stages (including especially separating risk factors in respect of frequency) zones of amplification of disruptions were indicated.

The factor analysis was carried out in two steps. At the first step the authors singled out 12 groups of factors which were represented by 20 factors of amplification of disruptions and 97 % explained the variability of the examined phenomenon. Not all groups were characterized with a significant representation of factors of amplification of disruptions. At the second step the authors distinguished 5 zones of amplification of disruptions. The description of zones of amplification of disruptions was presented in Table 1. The distinguished 5 zones is represented altogether by 17 factors of amplification of disruptions:

Zone 1 - Zone of amplification of disruptions in the micro-environment of the base enterprise in the suppliers' environment

Zone 2 - Zone of amplification of disruptions in material flows on the line of communication between the nodes of the network supply chain

Zone 3 - Zone of amplification of disruptions in the area of the market

Zone 4 - Zone of amplification of disruptions resulting from limitations of capacity

Zone 5 - Zone of amplification of disruption in the area of macro-environment of the network supply chain.

The factors mentioned in zones of amplification of disruptions in 93 % explain the variability of factors of amplification of disruptions. The content-related analysis of factors of amplification of disruptions representing particular zones of amplification of disruptions allows acceptance of the division received by means of the factor analysis. The authors indicated a possibility of dividing the factors of amplification of disruptions into homogeneous, in respect of the effect on the frequency of disruptions presented in risk factors, groups defined with zones of amplification of disruptions.

## CONCLUSION

Taking into account the results of the research it is proposed that the resistance of the supply chain to disruptions be interpreted as the ability of the supply chain to return to the state of equilibrium after occurrence of disruptions which additionally are influenced by different zones of amplification of disruptions. Such an approach is indicated by both the literature research and the empirical research. The added value, enriching the management theory is a group of disruptions in risk factors distinguished in respect of the frequency of occurrence of disruptions. Moreover, the authors proposed and defined the notion of zones of amplification of disruptions. The zones are formed from the groups of factors of amplification of disruptions, having a similar effect on their frequency.

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**Note:** The translator for English language is U. Bednarski, Poland