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Identification of Threats in the Supply Chain of a Production Process

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Abstract:

Purpose: *Economic growth, along with aggressive competition, directly influences the functioning of supply chains and equally shapes all internal and external threats. This publication aims to present the identification process and analyse the significance of threats in supply chains at the stage of the production process of structural elements.*
Design/Methodology/Approach: *An appropriate questionnaire and checklist have been developed to determine the frequency of threats. The analysis of measurement scale reliability was performed using the α-Cronbach coefficient and Guttman split-half method. Finally, the research results were analysed using the proprietary ranking method based on the adopted measurement scale.*
Findings: *The empirical results indicate that the survey conducted using the adopted questionnaire and the checklist allows for identifying threats in the supply chains occurring in the manufacturing process. In contrast, the frequencies of threat occurrence determined using a survey questionnaire allow for appropriate ranking.*
Practical Implications: *The study should be treated as a pilot for a group of medium-sized manufacturing companies implementing a sustainable development policy.*
Originality/Value: *Threat assessment in production processes and supply chains can have a practical impact on shaping enterprises' policy of sustainable development.*

Keywords: *Threat, risk, ranking of threats, supply chain, production process, questionnaire-based research.*

JEL Classification: *R0, R1.*

Research type: *Research article.*

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1. Introduction

Globalization and continuous market growth bring new opportunities to the companies, allowing them to attain ever higher effectiveness and realize the adopted goals. However, threats and the risk generated by them harm the improvement of supply chain functioning (Kalogeraki *et al.,* 2018) and the whole enterprise. Therefore, proper, and systematic identification of threats present in the supply chains is no longer an alternative but a necessity for these companies which strive to attain success in their business.

The rapid growth of the building industry relates to a heightened level of uncertainty. Companies in this sector struggle with such problems as variable profit margins, tendering procedures, variable atmospheric conditions and productivity on construction sites, local political situation, rights are emanating from contracts, competition on the market, etc. Therefore, building industry companies should use a broad range of risk management tools (Reza *et al.,* 2011). Many researchers in Poland and the world have written about the risk and threats encountered in production processes, including building industry structural elements (Posadzińska, 2017; Stonehouse *et al.,* 2004). However, these threats are located at various places (Boholm and Corvellec, 2011; Corvellec, 2010) and exert their impact on different stages of the production process, which brings about their differing character and frequency (Fung, Lo, and Tung, 2011; Yildiz, Dikmen, and Birgonu, 2014).

The publication aims to present identification and analysis performed on the threats occurring in the production process supply chains. The following research hypotheses have been adopted:

H1: The survey conducted based on the adopted questionnaire and the checklist allow for the identification of threats occurring in production process supply chains.
H2: The frequency of threat occurrence in the production process determined using a survey questionnaire allows for their ranking.

The article first defines threat and its relation to risk, as encountered in the supply chains. Next, theoretical foundations for the selected threat identification and assessment methods are provided. Then, the results of a conducted survey are given together with the list of threats occurring in the examined part of supply chains as found in the production company in question. In the end, a self-developed method is used for ranking the threats occurring in the examined field.

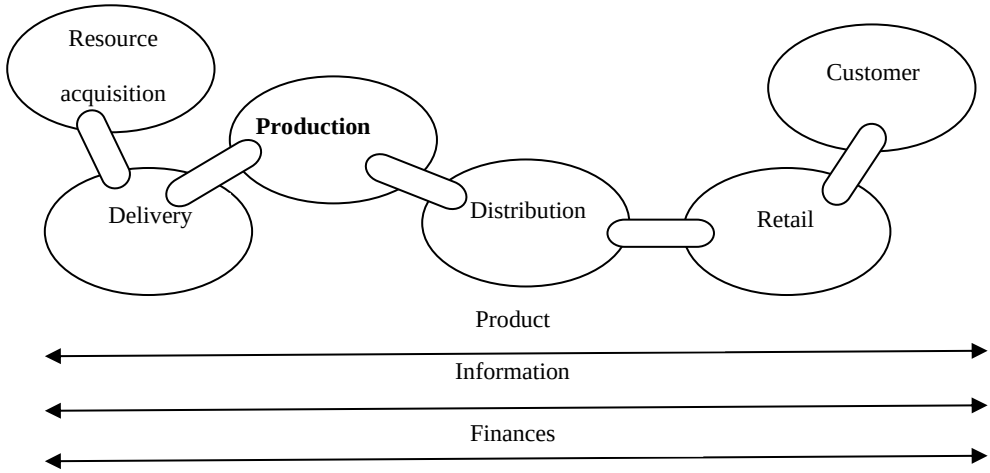
2. Literature Review

2.1 The Essence of Supply Chain Operation

The supply chain is one of the most rapidly developing concepts, currently a primary research subject into economic activities. Its popularity grew not only as a result of

market globalization leading to world economic growth and continuous birth of better management methods but also due to a necessity to catch up with the efficiency levels achieved by competing companies and meet the ever more sophisticated needs of the customers (Manuj and Mentzer, 2008; Mentzer, 2001). A supply chain is a specific type of network created by the demand and supply from suppliers, manufacturers, wholesale traders, and a final customer, which features rapid reaction times and practical cooperation in quality control and cost reduction. Thus, supply chain management is an advanced 21st-century theory (Wu X *et al.*, 2006).

Figure 1. *Supply chain diagram*



Source: *Own creation.*

Proper management of the supply chain leads the companies to financial gains resulting not only from the maintenance of appropriate stocks and their optimal utilization but also from the ability to react to changing demand quickly (Fine, 1998; Lee, Padmanabhan, and Whang, 1997; Noordewier, John and Nevin, 1990). Moreover, pressure to maintain the quality of manufactured products never ceases, as according to Gołembska (2009), the main aim of supply chain management is to minimize the flow costs while maintaining the quality of service expected by the customers. This may be achieved by implementing ever newer computer technologies facilitating the efficient management of supply chains and practical cooperation between their links (Logan, 2000).

The idea of supply chains is based on strict cooperation between the suppliers and the recipients, which should constitute a tool for achieving the adopted goals, both quality-related and financial (Mentzer *et al.*, 2001). In such a context, the supply chain is also a network of interconnected and interrelated organizations, which co-operate in controlling, managing, and improving the material, financial, and information flows going from suppliers to final users (Pisz, 2011).

2.2 Threats and Risks Encountered in Supply Chains

The risk management concept has been introduced to facilitate the effective functioning of enterprises and limit the negative impact of threats. As a result of the rapid growth and continuous progress of globalization in manufacturing, it has enjoyed ever-growing popularity in recent years. The main aim of risk management is risk identification, analysis, evaluation, and its final elimination using various methods (Aven, 2007).

The need for risk management (PKN, 2012) is crucially important because each of the tasks performed by any given enterprise is charged with uncertainty regarding its proper completion (Aven, 2011). This threatens the success in attaining goals set out by a given organization, which naturally lowers the effectiveness of its functioning (Ale, 2002).

The discussion of risk should be initiated by defining the threats, which are the primary risk sources (Lu and Yan, 2013). This subject is described in detail by Boholm and Corvellec (2011) in their comparison of the views of many researchers (Hilgarter, 1992; Rescher, 1983; Rosa, 1998; Kendra, 2007), where doubt became cast over the concept of risk, which includes subject and object, the subject being the risk source and the object being subjected to risk. At the same time, it is emphasized that the relational theory of risk suggests that effective communication relations exist between risk objects and threatened objects and that risk management at the organizational or institutional level should start from the same identification tasks.

Following the definition contained in the Polish Language Dictionary, the threat is a "situation or condition which threaten someone or in which someone feels threatened" (The Polish Language Dictionary, 2008). In the military, a *threat* is defined as a situation that is a cause for a reduction in environmental safety (The National Safety Dictionary, 2002). For industrial enterprises, this may be defined as the work environment condition, which may cause an accident or illness, whose elements or elements do not correspond with safety requirements (Wieteska, 2016). A more complex definition is presented by Młyńczak (2016), who considers that a threat is understood about a single undesired event, and then defines it as:

- a condition, situation, a set of conditions, possessing a capability to cause losses or initiate a series of events leading to an accident,
- a source or a cause of the arising of losses,
- an ability to cause a loss because of a single undesired event.

Three main threats responsible for losses can be differentiated. These are all the products of human labour, nature, and human beings who may create a danger to other people or enterprises consciously and intentionally, apart from being capable of various negligence.

Halvorson (2011) proposed that threat prediction is an active process of predicting future risk based on identified or noted weaknesses. This may apply to many fields of activity in an enterprise, including:

- strategic and other general threats such as failures to meet the requirements,
- tactical threats, based on weak points of the enterprise, including inappropriate or ineffective projects,
- operational threats whose sources lie in the technical infrastructure of an enterprise.

Summing up the above notes by various authors, we may define the threat as a configuration of events and objects co-occurring, which is a potential source of risk and may lead to unintended losses. The degree of threat identification stimulates the risk management process in the enterprise and throughout the supply chain in which it participates. Therefore, we should agree with Raftery (1994), Flanagan and Norman (1993) that this is a multi-stage process involving: risk management planning, risk identification, risk analysis, reaction to risk, risk monitoring, and communication threats, and informing about the risks.

2.3 Threat Identification Methods

Following the words of Młyńczak (2016), risk analysis ought to be understood as the reconnaissance of threats within a given technical system stemming from its operational service. Such a reconnaissance is performed based on technical documentation and team discussions following the selected technology diagram and identifying threats. On the other hand, threat identification is understood as a process of determining whether a given threat exists, together with the determination of its characteristics (Wieteska, 2016).

There is a wide range of possibilities in choosing threat identification and evaluation methods. These methods differ from one another not only in ineffectiveness but also in the difficulty of their execution. We can distinguish such methods where the subjective evaluation is their main trait and is based on mathematical sciences and probability calculus (Yang and Haugen, 2015).

One of the classification systems found in the literature is the division into quality- and quantity-based methods. The first group above is used when the risk cannot be subjected to mathematical calculations. Moreover, these methods require knowledge and experience on the part of the researcher. Quantitative methods, however, find their application in more complex situations. Therefore, another requirement is that accurate information must be available (Wolnowska, 2012). One of the simplest but, at the same time, highly effective qualitative threat identification methods is the survey questionnaire form. This tool is based on a list of issues and questions, which should induce a team to discuss threats constituting direct causes of risk (Pujawan and Geraldin, 2009).

One similar and highly effective approach to quality-based threat identification is the Checklist Analysis (CL). *The checklist* is a written interview prepared by professionals in particular fields of knowledge. Questions constituting the checklist allow for the identification of threats that may be encountered within a given enterprise. Checklist Analysis is a convenient threat identification method due to the possibility of having it carried out by persons who do not possess experience reaching the level of specialists in particular fields (Beohm, 1989). However, the disadvantage of this method is that it cannot evaluate any threats that have not been identified before (Maragakis *et al.*, 2009).

Another qualitative method allowing for the reconnaissance of threats is the brainstorming session. This method consists of a conversation undertaken by a group of experts to identify the errors and make the decisions concerning their elimination. The essence of brainstorming is to stimulate the participants' imagination in the meeting and enumerate as many potential threats as possible to have them later evaluated and selected (Proctor, 1995). The advantage of this method is not only the fact of its simplicity but also its capability to be used within various systems. Moreover, it may be used alongside other techniques used to reconnaissance threats (Valis and Koucky, 2009). The chief weakness of this method is that its effectiveness is largely dependent on the execution of other, quality-based threat identification procedures such as the HAZOP (IEC, 2016). Therefore, the basis for identifying threats is then a discussion focused on a series of keywords and carried out by a team of a few experts (Valis and Koucky, 2009). Apart from the reconnaissance of threats, their causes and effects, the persons taking part in such a meeting also determine the actions to minimize the risk of having undesirable phenomena occur (Młyńczak, 2016).

A significant similarity to brainstorming is found in a Delphi method, also quality based. It also consists of the exchange of ideas and opinions inside a group of experts. However, the technique does not require the gathering of persons at a specific time and place. In contrast to brainstorming, there is no ordinary meeting of the experts, which reduces the opportunities for inspiration arising between the team members and the chances for mutual support coming from the opinions of other persons. However, the number of experts who may participate in the performed threat identification session is unlimited (Okoli and Pawlowski, 2004; Mitchell, 1991).

The analysis of processes taking part within an enterprise may also bring about qualitative identification of threats that affect the attainment of adopted goals. This method also contributes to the control exercised over the processes to meet the specific requirements that should be observed. Also, the technical documentation may be the basis for identifying threats, which provides an opportunity for their qualitative evaluation like the methods listed above. More complex qualitative methods may be used to identify the threats as well, with Failure Mode Effects Analysis (FMEA) being one such method. FMEA is a technique whose effectiveness is due to the systematic

analysis of potential errors and the causes of their occurrence and working out of a list of preventative measures if needed (Pietre-Cambacedes and Bouissou, 2013).

The determination of threat level takes place based on establishing three related points: occurrence probability (O), the significance of a given threat (S), and its detection probability (D). Then, basing 0n the product of the above values, we can calculate the risk numbers allowing for the ranking of the problems encountered in their importance (PKN, 2009).

It is one of the most popular methods of systematic error prevention. It has been developed for the needs of the American defense industry with the aim being the analysis and identification of necessary or possible events which should lead to the improvement of a process or product quality. Its most typical use lies in the production processes of complex products where numerous agencies are involved. Its use as a supplementary tool for the hazards analysis in a HACCP approach is also spreading in the food and medicine industry to investigate the risk associated with medical practice.

Wolnowska states that this method is flexible, which provides for its use in the analysis of various phenomena and issues encountered in commercial enterprises (Wolnowska and Rawska, 2010). It may be used for:

- design of a new product, process, or technology,
- modification of the existing product or process,
- adaptation of the existing product or the application of the existing process for a new environment, siting, or functionality.

Depending on the FMEA analysis subject, the following application areas may be distinguished: systems (SFMEA), products/designs (DFMEA), manufacturing processes or services (PFMEA), machinery, means of production (MFMEA), environmental impact aspect of an organization (EFMEA), software (SWFMEA).

Because FMEA allows for the evaluation and the elimination of threats, one of the execution stages of this method is the highlighting of measures that may be used for the reduction or total elimination of the existing errors. Each of the sources of risk has then been assigned a concept of a procedure aimed at improving the investigated process, which is the functioning of the supply chain.

The product of severity S, probability of threat occurrence O, and detection level D constitutes a risk rank number, or, as in this case, the risk priority number RPN for a given threat:

$$RPN = S \cdot O \cdot D \tag{1}$$

One more qualitative method that can be used for risk analysis, same as the FMEA method, is best applicable during the design process, is the Preliminary Hazard

Analysis (PHA). It applies not only to the used machinery, equipment, and materials but also to evaluate the impacts of the environment and all kinds of procedures (Vincoli, 2014).

One of the most popular and, at the same time, most effective methods for the qualitative evaluation of already identified threats is the Pareto – Lorenz analysis. The name of this method comes from the names of its independent discoverers - the Italian Vilfred Pareto and M.O. Lorenz (Bank, 1992). The idea of this method is based on the 20:80 rule, which means that 20 % of causes generate 80% of losses.

3. Research Methodology

The broad range of methods used to identify threats lets the companies select them to suit their local conditions. The company's needs and structure are then the main criteria deciding about applying a particular method. Also, the complexity of a specific method is significant. The highest popularity is enjoyed by those methods which require no special training and experience. This way, a chance is provided to many persons not directly involved in the research field in question to participate in the threat identification process.

The selection of threat identification methods also depends on a given research field and the characteristics of the obtained results (Fung, Lo and Tung, 2011). There is then a possibility to implement various methods at the same time to obtain better and more accurate results. The survey had a quantitative character. The preliminary identification of the threats influencing the production process and the functioning of supply chains in the examined organization has been based on a checklist including 20 threats that are significant in the authors' opinion. The respondents ticked "Yes" or "No" boxes against threats, thus providing their opinion about their occurrence in the company's business. A survey questionnaire has been developed based on preliminary verification as a method to encourage discussion within the team about the threats occurring in the company and the frequencies of their occurrence. The criteria decisive in selecting the methods used herein were their ease of application and the capability to involve a significant group of employees.

The selected methods allowed for the quantification of the obtained results and subjecting them to statistical analysis. The questionnaire was created after researching the available literature, the analysis of checklist results, and consultations with the representatives of medium-sized manufacturing companies. Reliability analysis (Ferguson and Takane, 1989) was carried out using the Statistica software for the 5-steps scale adopted for the questionnaire, including 34 questions. The α-Cronbach coefficient amounted to 0.777, which testifies to the correct adoption of the measurement scale used by the authors about the questionnaire results.

The mean correlation between the items amounted to 0.3. Also, the Guttmann split-half reliability came out with a high value, equalling 0.918. The mean assessed frequency for threats has been determined using a formula:

$$r_{lm} = \frac{1}{R_{lm}} \sum_{k=1}^{R_{lm}} r_{klm} \tag{2}$$

Where;

Z_{lm} - *m*-th threat in *l*-th group, e.g., Z_{24} – fourth threat in second group;
r_{klm} - Z_{lm} threat assessment by *k* -th respondent;
R_{lm} – number of respondents assessing the Z_{lm} threat (for $Z_{52} \Rightarrow R_{52} = 91$)
k – $\in \{1,2,3, \dots, R_{lm}\}$;
l – number of threat group $l \in \{1,2, \dots, i\}$;
i – number of threat groups included in the questionnaire;
m – threat number in a particular group $m \in \{1,2, \dots, n_l\}$;
n_l – number of threats in *l*-th group.

The ranking of threats may be carried out on the basis of r_{lm} assessment. The mean assessment for a group of threats has been determined using the equation:

$$r_l = \frac{1}{\sum_{m=1}^{n_l} R_{lm}} \sum_{m=1}^{n_l} \sum_{k=1}^{R_{lm}} r_{lm} \tag{3}$$

The percentage of threat perceptions has been determined using the formula:

$$\frac{100\%}{4R_{lm}} \cdot \left(5R_{lm} - \sum_{k=1}^{R_{lm}} r_{klm}\right) \tag{4}$$

Using the percentages of respondents perceiving a given threat (grouped into particular intervals) allowed for defining the scale of identified threat frequencies:

- very rare threats: 0% - 20%,
- rare threats: 21% - 40%,
- mid-frequency threats: 41% - 60%,
- frequent threats: 61% - 80%,
- very frequent threats: 81% - 100%.

This scale may constitute a basis for the expansion of research in scope of threat assessment and the related losses.

4. Data Analysis and Discussions

Market dynamics and the ever-changing competition conditions bring about new opportunities to companies, allowing for even greater effectiveness in realizing their adopted goals. In the case of the examined enterprise, the growth may lead to even broader expansion on foreign markets, primarily Norwegian and Swedish. The

company may also achieve the advantage over the incorporated enterprises through comprehensive service provided to customers, including the sales of the company's products combined with their installation. High quality of service is a guarantee of customer satisfaction. The enterprise then pursues the highest quality of products bundled with the individual treatment of every customer, aiming for good perspectives for continued cooperation. The checklist included the following threats:

- client dissatisfaction with the quality of rendered services,
- improper quality of rendered services,
- failure to meet order deadlines,
- wrong determination of client needs,
- incorrect understanding of market needs,
- incorrect methods of demand prediction,
- presence of substitutes for the offered products,
- presence of hidden defects in the supplied materials,
- supplier failure to meet technical standards,
- danger of unexpected failures of the machinery and equipment,
- low adaptability of manufacturing process,
- low profit caused by insignificant number of orders,
- material costs rise,
- changing currency exchange rates,
- changing trends,
- accidents at work,
- failures to observe the law,
- lack of adequate personnel qualifications,
- possibility of computer systems failures,
- inaccurate monitoring by control – monitoring systems.

The checklist threats were considered actual if at least 50% of respondents gave them positive marks.

The rise of the costs of materials required for the manufacturing of products offered by the company has been determined to be one of the threats impacting the functioning of supply chains, basing on the replies provided by the employees. The replies indicating the presence of the above threat have been given by 60% of respondents. Another realistic threat identified through the checklist is the changing exchange rates, which directly influence the company's profits. This threat has been pointed to also by 60% of all the questioned. Positive replies were equally frequent for the possible events such as machinery and computer system failures which may occur on equipment used by the company. Other threats were ticked by respondents less often, at frequencies below 50%.

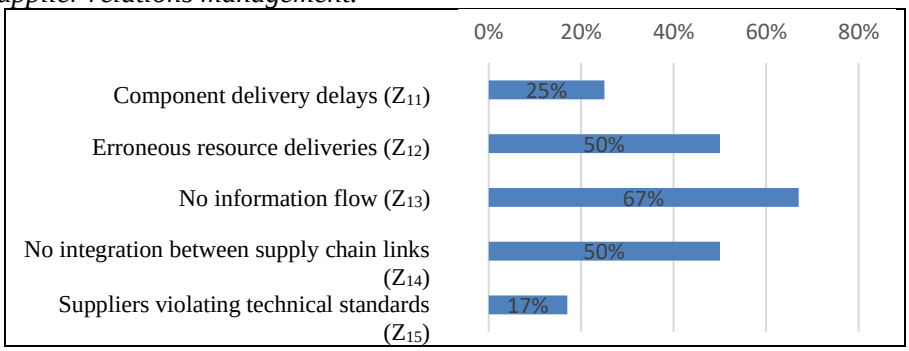
The obtained research results have been used to prepare a more detailed questionnaire to examine the threats faced by the company. Questions added to the management of demand and human resources, while other issues have been expanded. The

questionnaire has been filled by 120 respondents from various departments of a medium-size company (i.e., such which employs 50 - 249 employees). In 70% of the respondents, their replies have been obtained directly, while the remaining 30% of replies have been filled into questionnaires sent by email. The research has been carried out in the period January – April of 2017. A 100% return rate has confirmed the appropriateness of the survey format. All the questionnaires have been correctly filled out, which allowed for their use for further research.

The threats have been identified based on the number of replies by the questioned, at the same time ranking them by the frequency of their occurrence on a scale from 1 to 5. Because scale steps 4 and 5 referred to perceived threats as insignificant or non-existent, these results have been omitted in the preliminary analysis. The identified threats with their percentages of indications have been presented on bar graphs, independently from their frequencies.

The first analyzed group of threats (Z_1) is those connected with the relations with the suppliers. The threat from this group that was most often perceived by the questioned as a real-life one was the information flow failures. Also, the mistakes made in the supplies of raw materials, which may be in the scope of quality, quantity, and costs, but also in time and place of delivery as well as those referring to a lack of integration between the co-operating links in the supply chain, are equally important for the questioned. These threats have in common that information flow in the company is a crucial element of its effective functioning. The supplier's failure to maintain the technical standards was the least essential threat in the respondents' eyes. The existing threats and the percentage-wise quantities of related positive indications by the questioned are presented in Figure 2.

Figure 2. *Threats and the percentage-based numbers of their indications, in scope of supplier relations management.*

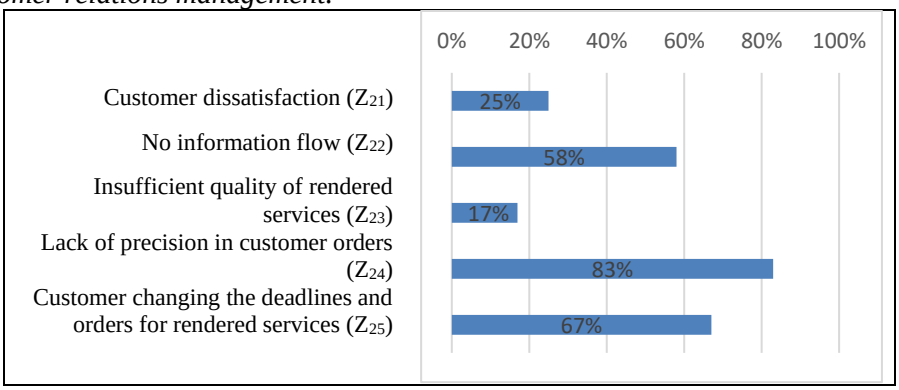


Source: *Own creation.*

As far as customer relations management is concerned, the most frequent and most significant threat turned out to be a lack of precision in the orders placed by the customers. The next most often quoted threat, having also come second in importance, were the changes introduced by customers to the deadlines and order contents

concerning rendered service. According to the respondents, the precision of the orders placed by the customers plays a significant role in ensuring the efficient functioning of the supply chain. The threat least frequently encountered by the respondents turned out to be the insufficient quality of service. The histogram presented in Figure 3 shows the quantities of indications given by the respondents concerning each error.

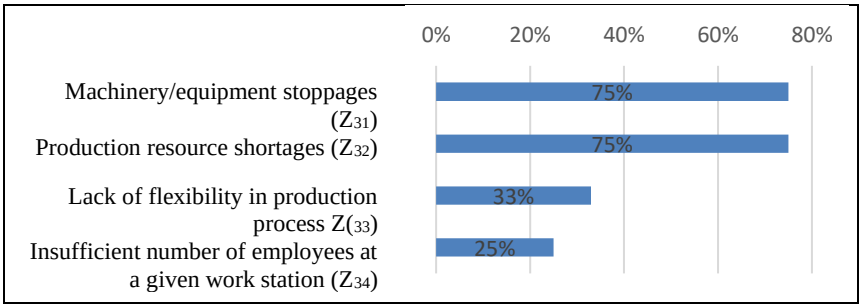
Figure 3. *Threats and the percentage-based numbers of their indications, for the customer relations management.*



Source: *Own creation.*

According to the respondents, the efficient and effective functioning of the supply chain in the examined enterprise is also influenced by the errors appearing in the manufacturing process. The most important in their eyes were the shortages of production resources and the stoppages of machinery and equipment. This is quite obvious because these shortages may cause significant delays in production and the rendering of services. According to the respondents, the lowest threat was posed by the insufficient number of employees at a given workstation. The percentage quantities of particular errors are shown in Figure 4 below.

Figure 4. *Threats and related percentage based indications, in scope of production process.*



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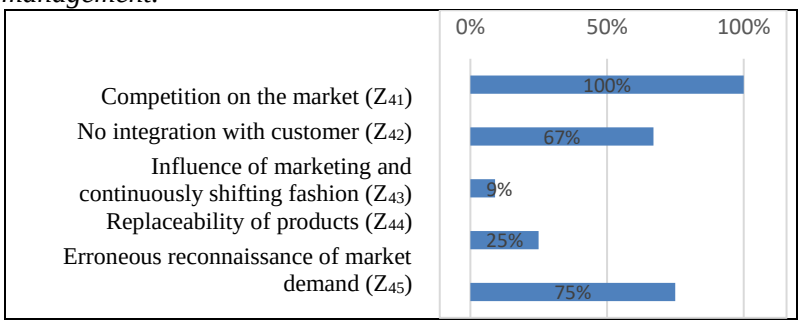
In the eyes of the questioned employees, the market competition forces are the main threat limiting the effective functioning of the supply chain at the production process

stage, with 100% of respondents indicating them as the most important and most frequent one. In the eyes of employees, the highly developed market of a given industry is the most undesirable phenomenon for the management of demand. A large part of the respondents also indicated an insufficient knowledge of the market and a lack of integration with the customer as counting among the most critical threats. The least frequent indication by the respondents referred to the influence of marketing and continuously shifting fashion. Figure 5 below illustrates the percentage-based quantities of indications given by the surveyed persons.

Figure 5. *Threats and percentage-based quantities of related indications in scope of demand management.*



Source: *Own creation.*

Financial management is one of the most important fields that impact the correct functioning of a company. The mistakes that occur in the scope of a given field of a company's business have significant importance regarding the production process conducted by the company, together with its accompanying supply chain. The threats most frequently endangering the efficient functioning of the company, according to the respondents, have been identified as a result of the conducted research.

The most frequent cause of risk in the field in question, according to the respondents, is the company's customers failing to execute the financial contracts as a result of their insolvency. The possibility of losing own financial liquidity (financial resources management) has been deemed by the respondents to be a slightly rarer threat. The bar graph (Figure 6) shows the responses to particular questions connected with the company's financial management threats. Respondents have deemed the rarest threat to the company in this field to be the rise of material costs.

Undesired random events impacting the products (e.g., their destruction or damage) are the most frequent threat in the scope of technical infrastructure management. The undesired phenomenon ranked second in frequency is the lack of outlays into the purchases of equipment used for production and distribution or their modernization. These are the most likely threats to impact the functioning of the production process and the supply chains feeding it. According to the respondents, the rarest threat is the undesired random events. Percentage-wise shares of responses are shown in Figure 7.

Figure 6. *Threats and percentage-based quantities of related indications in scope of management of finances.*

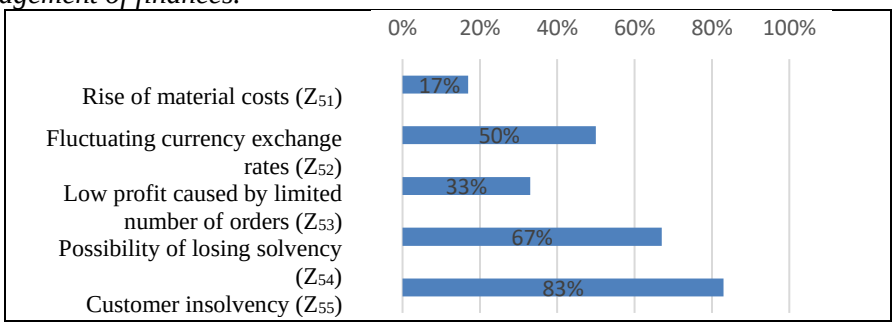


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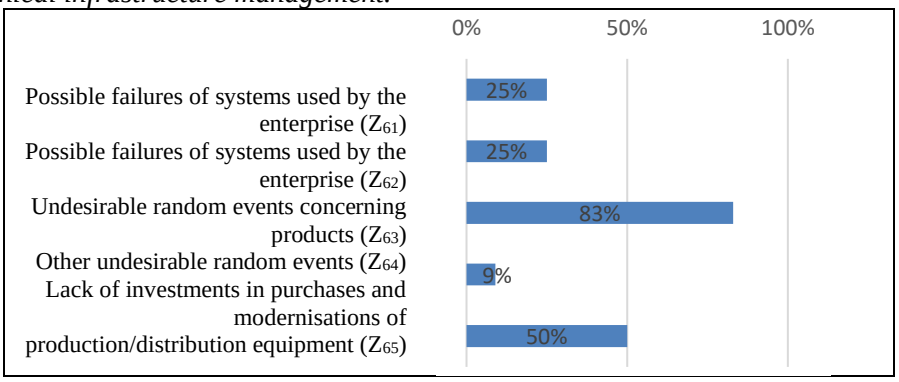
Figure 7. *Threats and percentage-based quantities of related indications in scope of technical infrastructure management.*



Source: *Own creation.*

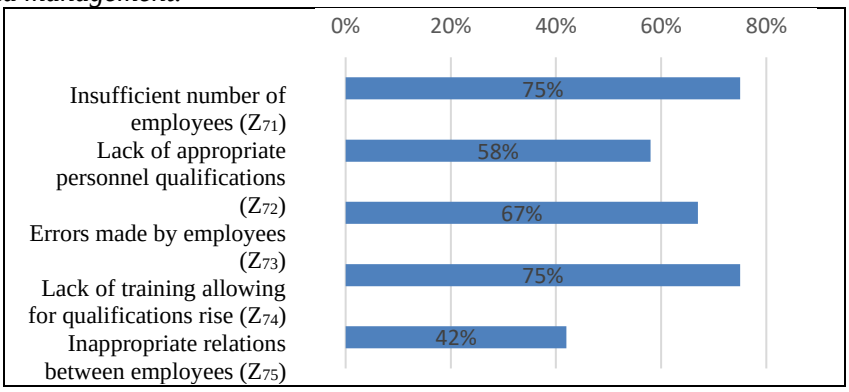
As a result of the research, it was determined that the functioning of supply chains at the production process stage is also influenced by the threats connected with the human resources management process. According to the questioned personnel, the most frequently encountered source of risk is the lack of training that would raise the qualifications of employees and a too-small number of employees.

These were the threats that received the highest number of indications. The remaining phenomena were not highlighted as much, but the differences were slight. This implies the existence of solid relations between indicated and identified threats. Inappropriate relations between the employees were not emphasized by the respondents as much, but this value is still significant compared to other investigated fields. The percentage-based analysis of the most often frequent responses is presented in Figure 8.

The mean assessments of particular threats r_lm have been developed based on questionnaire results. The lower the assessment, the higher the assessed frequency of threat occurrence. According to the respondents, Z_{41} is the most frequently encountered threat. The second position is occupied by threats (Z_{32}, Z_{71}). The

following in order are the threats Z_{24}, Z_{55}, Z_{63}. The respondents have considered the threats (Z_{43}) and (Z_{64}) to be the rarest.

Figure 8. *Threats and percentage based quantities of related indications in Scope of demand management.*



Source: *Own creation.*

According to the respondents, the most frequently occurring threats in particular groups are (Z_1 - Z_{13}, Z_2 - Z_{24}, Z_3 - Z_{32}, Z_4 - Z_{41}, Z_5 - Z_{55}, Z_6 - Z_{63}, Z_7 - Z_{71}). The mean assessment for a threat group has been determined based on equation (3). The highest value has been achieved in group 7, which means that the respondents perceive it to be the most frequently occurring ones. According to them, threats from group 6 are the rarest. A detailed ranking of threats is presented in Table 1.

Table 1. *Ranking of particular threats and their groups*

Threat groups	Threats m	Number of respondents assessing the threats R_{lm}	Mean assessment for a particular threat r_{lm}	Threat perception percentage ratio	Threat ranking	Mean assessment for a threat group r_l	Threat group ranking
Z_1	1	120	3.883	28%	16	3.51	6
	2	120	3.275	43%	12		
	3	120	2.900	53%	6		
	4	120	3.325	42%	13		
	5	120	4.167	21%	19		
Z_2	1	119	3.882	28%	15	3.33	5
	2	120	3.133	47%	10		
	3	120	4.150	21%	18		
	4	120	2.550	61%	3		
	5	120	2.925	52%	8		
Z_3	1	120	2.617	60%	4	3.23	3
	2	120	2.483	63%	2		
	3	120	3.817	30%	14		
	4	120	4.000	25%	17		
Z_4	1	120	1.633	84%	1	3.09	2
	2	120	2.942	51%	9		

	3	120	4.275	18%	20		
	4	120	4.000	25%	17		
	5	120	2.617	60%	4		
Z_5	1	120	4.150	21%	18	3.29	4
	2	91	2.912	52%	7		
	3	120	3.817	30%	14		
	4	120	2.942	51%	9		
	5	120	2.550	61%	3		
Z_6	1	119	3.882	28%	15	3.61	7
	2	120	4.000	25%	17		
	3	120	2.550	61%	3		
	4	120	4.275	18%	20		
	5	120	3.325	42%	13		
Z_7	1	120	2.483	63%	2	2.79	1
	2	96	2.740	57%	5		
	3	120	2.925	52%	8		
	4	120	2.617	60%	4		
	5	96	3.260	43%	11		

Source: *Own creation.*

By using the percentages of respondents perceiving a given threat, which were grouped into appropriate intervals, one may prepare a preliminary scale for the occurrence frequency of identified threats (Table 2).

Table 2. *Occurrence frequency scale for particular threats and their groups*

	Scale				
	Very rare	Rare	Medium frequency of occurrence	Frequent	Very frequent
Percentage of respondents	0% - 20%	21% - 40%	41% - 60%	61% - 80%	81% - 100%
Number of threats	2	11	15	5	1
Threat groups	Z_4, Z_6	$Z_1, Z_2, Z_3, Z_4, Z_5, Z_6$	$Z_1, Z_2, Z_3, Z_4, Z_5, Z_6, Z_7$	Z_2, Z_3, Z_5, Z_6, Z_7	Z_4
Threats	Z_{43}, Z_{64}	$Z_{11}, Z_{15}, Z_{21}, Z_{23}, Z_{33}, Z_{34}, Z_{44}, Z_{51}, Z_{53}, Z_{61}, Z_{62}$	$Z_{12}, Z_{13}, Z_{14}, Z_{22}, Z_{25}, Z_{31}, Z_{42}, Z_{45}, Z_{52}, Z_{54}, Z_{65}, Z_{72}, Z_{73}, Z_{74}, Z_{75}$	$Z_{24}, Z_{32}, Z_{55}, Z_{63}, Z_{71}$	Z_{41}

Source: *Own creation.*

The deepest concerns are raised by the threats perceived by nearly 80% of respondents. Even though they are three times less numerous than the threats of average frequency, they still constitute a potentially more significant source of losses for the company. Also, the numbers of threats perceived by up to abt. 50% and up to 40% of respondents cannot be passed over – there are respectively 15 and 11 such threats. On the one hand, it is advantageous for the company that its employees do notice threats, but on the other, the fact that there are so many of them is worrying.

This may point to a heightened need to analyse the threats existing in the examined company to avoid the unforeseen consequences, losses, and risks related to them.

It is worth noting that the group of threats connected with demand management (Z_4) is highly varied in the scope of employee perceptions of these threats. Some threats belonging to this group are very rarely encountered, while other ones are persistent. Group (Z_1) is the most „coherent" one, as all the threats from this group are similarly perceived – they rarely occur or at average frequency.

5. Conclusions and Recommendations

The threat identification process is a significant contributor to the smooth functioning of any company. Also, the selection of an appropriate method used for the evaluation of the dangers constituting sources of risk is equally important. A particular method should be selected from a wide range of those available to identify threats, but individually for each company, considering its characteristics and the industry sector involved. Combinations of selected methods and techniques should be used to attain a more detailed identification of threats and the resultant risk. New enterprises struggle with ever-evolving threats. Thus, it is necessary to search for modern tools that should not only contribute to risk identification but also help eliminate threats being the sources of this risk.

The selection of a specific method from among a broad range of techniques used to identify threats should be performed individually for each company, considering its characteristics and the industry of its business. To achieve a more detailed identification of threats and risks being their consequences, one should combine the selected methods and techniques.

Present-day companies struggle with ever newer threats. Therefore, it is necessary to search for modern tools that would allow for the identification of risks and the elimination of threats constituting their sources. As a result of the above, the essential task faced by today's companies is the immediate identification of threats, which would allow for their reduction or, preferably, elimination. Attention should also be turned to the fact that the increase of the number of the applied methods brings about the rise in the number of identified threats, which also allows for verifying the presence and scale of a given threat.

Several various types of threats have been found and confirmed in the research conducted in the examined company, using the survey questionnaire and the checklist. The threats are not limited to direct relations with the suppliers and the clients. Those of them impacting the proper functioning of the supply chain are also present in the processes connected with the management of finances and human resources. Also, the undesirable phenomena accompanying the production process and the technical infrastructure management have a significant influence. To a lesser or higher degree,

all the listed threats still have a limiting impact on achieving the main aims of a properly functioning supply chain.

It is worth emphasizing that the market competition forces bring about the most critical threat for the proper functioning of companies. Also, the undesired random events are essential in this regard, such as those concerning the products, client illiquidity, and in the end, the lack of precision in their orders. The conducted research has confirmed the initially put forward hypothesis concerning the applicability of a survey based on the use of an appropriate questionnaire, together with a checklist used for threat identification, to determine the occurrence frequencies and rank the threats encountered in the examined production process. It has been shown that the identified threats encountered in the various fields of company business are caused not only by employee errors or a highly developed competition in the industry but also by the causes directly independent from human beings, such as undesirable random events impacting the offered products, as well as the failures of production machinery and equipment and the computer systems.

The value of the article consists of two different aspects. Firstly, the article includes valuable guidelines for the manufacturing companies concerning the threats encountered in the supply chains. Secondly, the results of the presented research may influence the perception of actual threats by these companies, which may translate to the improvement of both their efficiency and the effectiveness of their operations.

References:

Ale, B.J.M. 2002. Risk assessment practices in The Netherlands. Safety science, 40, 105-126. doi: 10.1016/S0925-7535(01)00045-5.

Aven, T. 2007. A unified framework for risk and vulnerability analysis and management covering both safety and security. Reliability Engineering and System Safety, 92, 745-754. doi: 10.1016/j.ress.2006.03.008.

Aven, T. 2011. Selective critique of risk assessments with recommendations for improving methodology and practice. Reliability Engineering and System Safety, 96, 509-514.

Bank, J. 1992. The essence of total quality management, London, UK: Prentice Hall International Ltd.

Boehm, B. 1989. Software risk management. In: ESEC 1989. Lecture Notes in Computer Science, ed. Ghezzi, C., McDermid, J.A., 387, 1-19. Berlin, Heidelberg: Springer.

Boholm, A., Corvellec, H. 2011. A relational theory of risk. Journal of Risk Research, 14(2), 175-190. doi: 10.1080/13669877.2010.515313.

Corvellec, H. 2010.Organizational risk as it derives from what managers value: A practice-based approach to risk assessment. Journal of Contingencies and Crisis Management, 18(3), 45-54.

Ferguson, G.A., Takane, Y. 1989. Statistical analysis in psychology and education. 6th ed. New York: McGraw-Hill.

Fine, C. 1998. Clockspeed: Winning Industry Control in the Age of Temporary Advantage, New York: Perseus Publishing.

Flangan, R., Norman, G. 1993. Risk management and construction, London: Bleckwell.

Fung, I.W.H., Lo, T.Y., Tung, K.C.F. 2011. Towards a better reliability of risk assessment: development of a qualitative & quantitative risk evaluation model (Q2REM) for different trades of construction works in Hong Kong. Accident Analysis and Prevention, 48, 167-184. doi: 10.1016/j.aap.2011.05.011.

Gołembska, E. 2009. Logistyka w gospodarce światowej (Logistics in World Economy). Warsaw, Polad: Beck, C.H.

Halvorson, N., Birch, T. 2013. The trouble with history. In Australian history now, ed. Clark, A., Ashton, P., 232-250. Sydney: New South Publishing.

Hilgartner, S. 1992. The social construction of risk objects: Or, how to pry open networks of risk. In: Organizations, uncertainties, and risk, ed. Short, J.F., Clarke, L. 39-53. Boulder: Westview Press.

IEC (International Elektrotechnical Commission). 2016. Hazard and operability studies (HAZOP studies) - Application guide IEC 61882. Available from: IEC.

Kalogeraki, E.M., Apostolou, D., Polemi, N., Papastergiou. S. 2018. Knowledge management methodology for identifying threats in maritime/logistics supply chains. Knowledge Management Research & Practice, 16(4), 508-524.

Kendra, J. 2007. The reconstitution of risk objects. Journal of Risk Research 10(1), 29-49. doi: 10.1080/13669870600995931.

Lee, H., Padmanabhan, V., Whang, S. 1997. Information Distortion in a Supply Chain: The Bullwhip Effect. Management Science, 43(4), 546-558.

Logan, M.S. 2000. Using Agency Theory to Design Successful Outsourcing Relationship. International Journal of Logistics Management, 11(2), 21-32.

Lu, S., Yan, H. 2013. A comparative study of the measurements of perceived risk among contractors in China. International journal of Project Management, 31, 307-312. doi: 10.1016/j.ijproman.2012.06.001.

Manuj, I., Mentzer, J.T. 2008. Global Supply Chain Risk Management. Journal of Business Logistics, 29(1), 133-155. doi: 10.1002/j.2158-1592.2008.tb00072.x.

Maragakis, I., Clark, S., Piers, M., Prior, C.D., Tripaldi, C., Masson, M., Audard, C. 2009. Management System and Safety Culture Working Group SMS WG. Guidance on Hazards Identification. Safety, European Strategic Safety Initiative.

Mentzer, J.T. 2001. What is supply chain Management. Thousand Oaks: SAGE publications.

Mentzer, J.T., DeWitt, W., Kebler, J.S., Min, S., Nix, N.W., Smith, C.D., Zachiara, Z.G. 2001. Defining Supply Chain Management. Journal of Business Logistics, 22(2), 1-25. doi: 10.1002/j.2158-1592.2001.tb00001.x.

Mitchell, V.W. 1991. The Delphi technique: an exposition and application. Technology Analysis & Strategic Management, 3(4), 333-358.

Młyńczak, M. 2016. Risk assessment in transportation systems. Journal of KONBiN, 40, 83-100. doi.org/10.1515/jok-2016-0042.

Noordewier, T.G., John, G., Nevin, J.R. 1990. Performance Outcomes of Purchasing Arrangements in Industrial Buyer-Vendor Relationships. Journal of Marketing, 54(4), 80-93.

Okoli, C., Pawlowski, S.D. 2004. The Delphi Method as a Research Tool: An Example. Design Considerations and Applications. Information & Management, 42(1), 15-29. doi:10.1016/j.im.2003.11.002.

Pietre-Cambacedes, L., Bouissou, M. 2013. Cross-fertilization between safety and security engineering. Reliability Engineering and System Safety, 110, 110-126.

Pisz, I. 2011. Identification and risk assessment of logistics project. In: Selected logistics problems and solutions, ed. Grzybowska, K., Golińska, P., 227-242. Poznań: Poznan House of Poznan University of Technology.

PKN (Polski Komitet Normalizacyjny [Polish Committee for Standardization]). 2009. Analisys techniques for system reliability - Procedure for failure mode and effects analysis (FMEA), EN 60812:2006. Retrieved from: PKN.

PKN (Polski Komitet Normalizacyjny [Polish Committee for Standardization]). 2012. Risk management - Principles and guidelines, ISO 31000. Retrieved from: PKN.

Posadzińska, I. 2017. Purchase Marketing in the International Industrial Market: Case Studies of Construction Companies, Organization Review, 4, 67-74.

Proctor, T. 1995. The Essence of Management Creativity. London: Prentice Hall.

Pujawan, I.N., Geraldin, L.H. 2009. House of risk: a model for proactive supply chain risk management. Business Process Management Journal, 15(6), 953-967.

Raftery, J. 1994. Risk analysis in project managements, London: E & FN Spon.

Rescher, N. 1983. Risk: A philosophical introduction to the theory of risk evaluation and management. Lanham: University Press of America.

Reza, A., Azari, K., Mousavi, N., Mousavi, S.F., Hosseini, S.B. 2011. Risk assessment model selection in construction industry. Expert Systems with Applications, 38, 9105-9111.

Rosa, E. 1998. Metatheoretical foundations for post-normal risk. Journal of Risk Research, 1(1), 15-44.

Stonehouse, G., Campbell, D., Hamill, J., Purdie, T. 2004. Global and Transnational Business: Strategy and Management. 2nd ed. USA: John Wiley & Sons Ltd.

Threat. In Słownik Języka Polskiego [The Polish Language Dictionary]. 2008. Ed. Dubisz, S., 784-785, Warszawa: PWN (in Polish).

Threat. In Słownik terminów z zakresu bezpieczeństwa narodowego [The National Safety Dictionary]). 2002. Ed. Kaczmarek, J., Łepkowski, W., Zdrodowski, B., 172-177. Warszawa: AON (in Polish).

Valis, D., Koucky, M. 2009. Selected Overview of risk assessment techniques. Journal of Machine Construction and Maintenance, 4, 23-25.

Vincoli, J.W. 2014. Basic Guide to System Safety. 3rd ed. New York: Wiley

Wieteska, G. 2016. Building resilient relationships with suppliers in the B2B market. Management, 20(2), 307-321.

Wolnowska, A. 2012. Implementation of quantitative rules in company's information management. Management Systems in Production Engineering, 3(7), 21-25. http://wydawnictwo.panova.pl/pliki/08_2012/2012_8_07.pdf.

Wolnowska, A., Rawska, A. 2010. Analiza ryzyka procesu produkcyjnego przy wykorzystaniu metody [Risk analysis of the production process using FMEA method FMEA]. In: Komputerowo Zintegrowane Zarzadzanie [Computer Integrated Management], ed. Knosala, R., 2, 651-661. Opole, Poland: PTZP publishing house (in Polish). http://www.ptzp.org.pl/files/konferencje/kzz/artyk_pdf_2010/155_Wolnowska_A.pdf

Wu, X., Zhong, X., Song, S., Wu, C. 2006. Study on risk analysis of supply chain enterprises. Journal of Systems Engineering and Electronics, 17(4), 781-787.

Yang, X., Haugen, S. 2015. Classification of risk to support decision- making in hazardous processes, Safety Science, 80, 115-126.

Yildiz, A.E., Dikmen, I., Birgonu, M.T. 2014. Using expert opinion for risk assessment: a case study of a construction project utilizing a risk mapping tool. Procedia - Socialand Behavioral Sciences, 119, 519-528.