IDENTIFICATION OF DISRUPTIONS IN TRANSPORT PROCESSES

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Introduction/background: The article presents an analysis of risk factors that may cause disruptions affecting the shipping of parts and components for the automotive industry. In this regard, based on literature research, the meaning of a disruption risk and its management in transport processes are discussed. Furthermore, the role of the transport and logistics companies in the provision of services for the automotive sector is presented. In the next section, the methodology of risk factor analysis and assessment is determined and the results of studies conducted on disruptions that may have a key impact on the transport process of the analysed company are presented.

Aim of the paper: The aim of the article is to determine the influence of disruptions in the transport processes of parts and components for the automotive industry through the analysis and assessment of disruption risk factors.

Materials and methods: The tools and methods proposed to assess the risk of disruptions affecting the order execution for the transport service of parts and components for the automotive industry by the company under examination were as follows: an indicative analysis, a disruption risk assessment form, an expert judges method, PHA method and a risk matrix.

Results and conclusions: The analysis has allowed for the identification of risk factors, which, due to the potential consequences estimated by a group of experts as well as the probability of occurrence, may have a key impact on the transport process in the investigated company. Indicative analysis has shown that the timeliness of transport, which is associated with delivery time, is a major issue in a company. This formed the basis for the further analysis of process disruptions.

Keywords: transport process, disruptions, risk, indicators, disruption risk assessment form, automotive industry.

1. Introduction

Risks are present when running any type of business, but as transport businesses are responsible for both their own and others' property, they are particularly vulnerable to disruptions. The majority of companies in the logistics service provider (LSP) sector in Poland

provide their services by road transport, which is highly dependent on the actions of third parties and random events; as such, risk management in this sector is of great importance.

A major challenge for transport companies regards the services provided to businesses in the automotive industry. These services are mainly characterised by precise deliveries, the lowest possible transport costs, and short delivery times because any delay in the delivery of transported goods may disrupt the recipient's production process. Ensuring the best possible quality of transport services has an impact on customer satisfaction, which, together with the company's experience, shapes its position in the LSPs (logistics service providers) market, increasing its competitive advantage. Therefore, the proper identification of events that may disrupt the realisation of transport services and the assessment of their risk level is vital from the perspective of companies that provide transport services as it allows for planning and the implementation of preventive measures that help maintain continuity and the timeliness of transport processes.

2. The nature of the risk of disruptions in transport processes

Long-term research on risk has resulted in the emergence of a number of different concepts and theories that allow us to understand the essence of risk. In the literature, we can find many definitions of risk, ranging from the etymology of the concept itself, through the first economic theory of risk formulated in 1901 by A. Willet (Willet, 2002) – which made an attempt to distinguish risk from uncertainty – all the way to modern inquiries related to risk in the context of the process approach. The second economic approach to risk is the concept of measurable uncertainty and immeasurable uncertainty proposed by F. Knight (Knight, 2014). The definitions of risk and uncertainty he developed continue to be relevant and used in research in this field. At this point, however, it should be emphasised that the notions of risk and uncertainty are often used interchangeably, both in theory and in practice. However, they are not synonyms and therefore cannot be used to identify the same phenomena. Thus, risk can be defined as a measurable uncertainty as to whether the planned objective of the action will be achieved (Dohn, Gaschi-Uciecha, Wodarski, 2017).

Present-day supply chains are exposed to a variety of risks. The fundamental reason for this is usually a very long distance that the cargo has to cover from the manufacturer through middlemen to the final buyer. The responsibility of companies that provide transport services for both their own and others' property makes them particularly vulnerable to any kind of disruption (Cyganik, 2014). In transport processes, disruptions can be defined as unplanned events, the occurrence of which can cause undesirable delays to the delivery of goods to their destination (Kramarz, Kmiecik, 2017). They are also defined as the likelihood of the occurrence

of an undesirable event that may cause the loss of or damage to the transported cargo (Cyganik, 2014).

Risk management is often regarded as taking actions aimed at identifying, assessing, and controlling risks, as well as controlling the undertaken activities. The purpose of risk management in each company is to take action to limit and protect itself against adverse consequences (Rudzińska, Piekarski, Dudziak, 2011). Risk management is a logically arranged plan, system, or process in which successive stages can be distinguished. An example of a plan of steps in the risk management process of a company is presented in Figure 1.

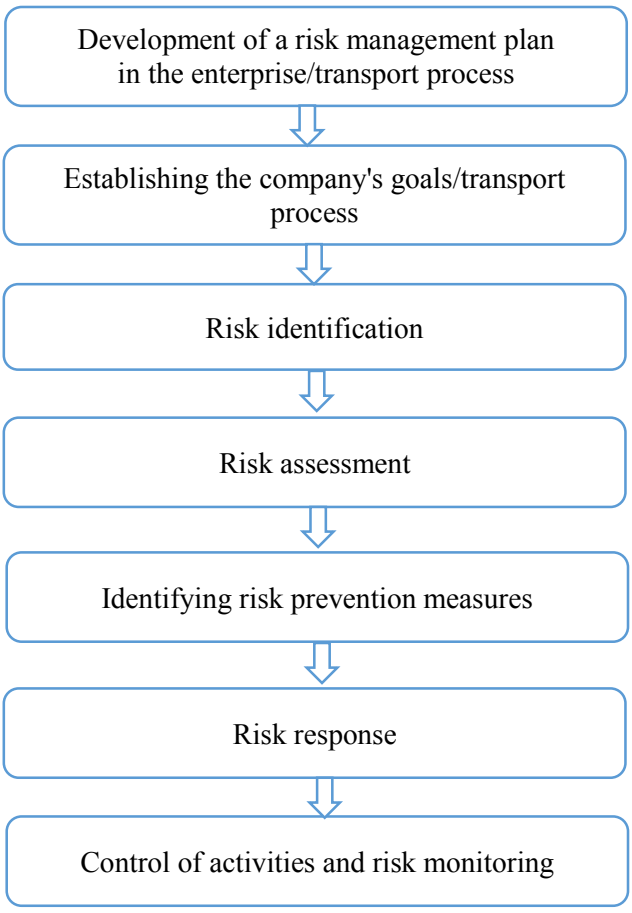

Figure 1. Stages of the risk management process in a transport company. Adapted from: Cieśla M., Turoń K., Risk management in container transport processes based on risk map and mathematical method, [in:] Jadczak R., Ledzian P. (ed.), Risk management in Logistics and Finance, Łódź 2016, p. 79-91.

The primary and key element of risk management is risk identification. An appropriate and proper identification process is crucial to properly and effectively managing risk in a company (Romanow, Stajniak, Konecka, 2017; Rudzińska, Piekarski, Dudziak, 2011). Risk identification involves activities related to the identification of occurring and probable disruptions as well as the determination, categorisation, and description of various types of risks that may jeopardise the proper implementation of the company's objectives, both during the organisation and the implementation of the defined objectives, or cause damage to or tarnish the company's reputation. The identified risks should be subjected to further analysis in order

to determine the probability with which a given risk may occur and what its consequences may be (Cieśla, Turoń, 2016).

Risk factors that occur in a company or transport process may be related to particular categories (Romanow, Stajniak, Konecka, 2017; Dohn, Gaschi-Uciecha, Wodarski, 2017), such as:

- decision errors made, for instance due to false or unreliable information,
- ignorance, carelessness, or disregard for regulations and procedures,
- human factors related to the qualification, nature, honesty, and approach to assigned professional duties,
- a technical factor,
- a random factor.

3. The role of logistics service providers (LSPs) in the automotive industry

The automotive industry is well-known for requiring a perfectly functioning organisational system, as well as a fast flow of information along the supply chain. For this reason, the industry is considered to be particularly demanding. Due to the high level of production complexity, it is important that the execution of orders is fast as well as precise. Moreover, the automotive sector is also associated with high dynamics and a diversity of orders (Trans.info, 2019).

The provision of transport and logistics services for the automotive industry is governed by its own laws. This is mainly due to the fact that the automotive sector is an international network whose customers expect a final product that will be as personalised as possible in terms of their needs and requirements. This results in the necessity to produce finished products in a large number of variants. It is also of vital importance to understand that cars consist of several thousand parts that can come from various industries, such as machinery, chemical, and electrical industries (Scandinavian Express, 2019; Trans.info, 2019). The carrier also bears a very high responsibility because any delay in the delivery of transported raw materials or semi-finished goods may disrupt the recipient's production process (Scandinavian Express, 2019).

Transport and logistics for the automotive industry demand close cooperation between the carrier, the shipper, and the logistics operator. In the case of automotive logistics, the decisive factor for cooperation with a specific carrier is the precision of transport. The transport company is obliged to take into account its system capabilities in the area of process integration with the customer as well as its readiness to report cooperation indicators based on the model adopted in the contractor's industry (Raben, 2019).

The greatest challenges in the process of servicing automotive companies are short delivery times, large fluctuations in the volume of products, keeping transport costs as low as possible,

and the need for the precise synchronisation of a number of sub-suppliers. This approach often necessitates the use of appropriate solutions, and therefore it is crucial to understand the principles of 'just-in-time' and 'just-in-sequence' when delivering components. Timely delivery dominates the workflow of production lines, especially in the automotive industry. This method means the delivery of goods and components at a precisely defined point in time when they are needed. Cooperation in such a case must be based primarily on synchronised activities and communication between the manufacturer, supplier, and logistics operator or carrier, both in the short and long term (Haber, 2017; Trans.info, 2019).

Just-in-time does not tolerate any delays as they can cause the production line to stop and result in losses. To avoid such problems, it is crucial to analyse transport and/or storage processes (Scandinavian Express, 2019).

4. Methodology for analysing and assessing disruptions

A disruption assessment analysis requires a combination of tools and methods to identify, analyse, and assess the impact level of disruptions to the transport process. The tools and methods proposed to assess the risk of disruptions affecting the order execution for the transport service of parts and components for the automotive industry by the company under examination were as follows: an indicative analysis, a disruption risk assessment form, an expert judge method, a PHA (process hazard analysis) method, and a risk matrix.

Indicators are a set of analytical tools for measuring and evaluating transport processes, and their core task is to present the actual state of the situation in an adequate and reliable way. Indicative analysis allows one to obtain information regarding the realisation of the studied transport processes, which enables the assessment of their effectiveness. Additionally, it is the basis for further analysis of disruptions affecting the activity of the analysed company (Gaschi-Uciecha, 2018). The indicators selected to assess the transport process of the analysed company are presented in Table 1.

Table 1.
Selected indicators for the assessment of the transport process

No.	Indicator	Pattern
1	Timeliness of transport	$\frac{\text{number of shipments carried out in a timely manner}}{\text{total number of shipments}} \cdot 100\%$
2	Amount of damage during transport	$\frac{\text{number of damaged transport units}}{\text{total number of units transported}} \cdot 100\%$
3	Failure of transport means	$\frac{\text{number of failures}}{\text{total number of shipments}} \cdot 100\%$

Cont. table 1.

4	Number of kilometres per transport unit	$\frac{\text{total number of kilometres}}{\text{number of transport units}}$
5	Delivery readiness	$\frac{\text{number of orders immediately carried out}}{\text{number of transports}} \cdot 100\%$

Adapted from: Gaschi-Uciecha A., Analysis and assessment of the transport process…, op.cit.

The Disruption Risk Assessment Form shown in Table 2 allows for the identification of risk factors at different stages of the transport process that may cause disruptions. Additionally, the examination form used together with the expert judge method and the PHA method makes it possible to assess the probability of risk occurrence and the potential effects of the identified factors.

Table 2.
Disruption Risk Assessment Form

Stage of the transport process	No.	Risk factor	Consequence of the risk	Likelihood of the risk occurring	Severity of the risk
–	–	–	–	–	–
–	–	–	–	–	–

The expert judge method is used to solve all kinds of organisational problems and is especially useful for analysing management processes. This method is based on a survey that includes questions and issues formulated in such a way that the expert can unequivocally determine the factor in question using a numeric scale. It is extremely important in this method that experts assess factors independently. In addition to the assessment of risk factors by the experts, it is also crucial to determine the relative validity of the assessments made by each expert. For this purpose, the expert's competence degree indicator is used, which is based on his or her self-evaluation; this in turn is based on the average of the coefficient of the expert's knowledge of the given subject and the coefficient of the argumentation's impact on his or her opinion. These coefficients range from 0 to 1, where 0 indicates that the expert does not know the problem and 1 indicates he or she has very good knowledge of the problem (Grabowska, 2015).

The PHA method is a method of initial hazard analysis that allows for qualitative risk assessment. Risk assessment using this method is about determining the probability that a specific risk may occur and the potential consequences associated with it. In order to carry out a thorough risk assessment using the PHA method, it is essential to determine the different types of probability and effects of disruptions (Cieśla, Turoń, 2016).

The effects are all the possible consequences of the disruption for the organisation. These include vehicle downtime losses, time losses, and financial losses, among other negative events. The assessment of the impact of individual risk factors is based on a five-point scale of how each affects the functioning of the surveyed organisation. On this scale, 1 indicates that

the effect of the risk is insignificant and 5 indicates it is severe. The likelihood that a risk will occur must be assessed on the basis of the occurrence frequency of the individual factors. The likelihood is assessed using a five-step scale, where 1 indicates that the likelihood of the risk occurrence is very rare or impossible and 5 indicates that it is almost certain (Cieśla, Turoń, 2016).

Once the key parameters have been estimated using the PHA method, all factors that may occur in the transport process should be summarised, taking their severity into account. The severity of a risk is the product of the probability and the potential consequences of its occurrence. Then each risk category is classified by the following risk levels (Cieśla, Turoń, 2016):

- low risk — acceptable risk — severity range from 1 to 6,
- medium risk — acceptable risk, but requiring the planning and implementation of activities mitigating this level — severity range from 8 to 12,
- high risk — unacceptable risk requiring an urgent mitigation — severity range from 15 to 25.

By determining the risk severity of particular disruption factors, it is possible to allocate them to the appropriate fields in the risk matrix presented in Table 3.

Table 3.
Risk matrix

Consequences of the risk	**Likelihood of the risk occurring**				
	Rare	Unlikely	Possible	Likely	Almost certain
Insignificant	1	2	3	4	5
Minor	2	4	6	8	10
Moderate	3	6	9	12	15
Major	4	8	12	16	20
Severe	5	10	15	20	25

Adopted from: Cieśla M., op.cit.

Assessing the risk level makes it possible to take appropriate decisions and preventive measures aimed at minimising the impact and occurrence of identified factors that cause disruptions in the examined process.

5. Analysis of disruptions in the transport processes

The indicator assessment was made for the transport process carried out by the selected company, which provides transport services for parts and elements supplied for the automotive industry. To verify the results of the indicator analysis of the transport process, the obtained

values are summarised in Table 4 together with the model indicators, established on the basis of the adopted standards in the enterprise.

Table 4.
Comparison of the indicators obtained with the benchmarks

No.	Indicator	2017		2018		Unit of Measurement
		Obtained	Benchmark	Obtained	Benchmark	
1	Timeliness of transport	94.69	min. 95	94.84	min. 95	%
2	Amount of damage in transit	0.058	max. 0.06	0.05	max. 0.05	%
3	Failure frequency of means of transport	0.162	max. 0.15	0.134	max. 0.14	%
4	Number of kilometres per means of transport	154	max. 155	158	max. 160	thousand km
5	Readiness of delivery	94.91	min. 95	95.15	min. 95	%

The conducted indicative assessment enabled us to determine the effectiveness of the transport process executed in the examined company. On the basis of the compiled results, it can be stated that process efficiency is getting better but the timeliness of transport in 2018 does not come close to meeting the requirements set by the company. However, as the studied business provides services for automotive industry companies, which expect the carriers to deliver goods exactly on time because of the planned cycle of production processes, it is necessary to determine the benchmark value of the indicator at a very high level.

Timeliness of deliveries is a key factor in ensuring that customers will continue to want to use the services of the examined company in the future. Irregularities detected in the analysed process are the basis for further research on the identification, assessment, and analysis of factors that may cause disruptions during the execution of the transport service in a given company.

On the basis of literature research, 31 potential disruption risk factors, which relate to particular stages of the transport processes, were identified. The next step was to select experts to assess the disruption risk factors. Based on a self-evaluation of experts by means of an expert's competence assessment form with respect to disruptions in the transport service process, ten expert judges with extensive knowledge on our subject (extensive experience in the logistics industry) were selected.

The selected group of expert judges assessed individual risk factors by using the PHA method with regard to a risk's potential consequences and likelihood of occurrence. Using the determined values, the severity of the risk of particular factors was calculated and is presented in Table 5.

Table 5.
Disruption Risk Assessment Form

Stage of the transport process	No.	Risk factor	Severity of the risk
Preparation of the transport offer	1	Lack of communication	6.50
	2	Non-acceptance of the offer by the customer	7.00
	3	Incorrect preparation of the offer	7.68
Acceptance and confirmation of the order	4	Information flow problems	8.00
	5	Excessive waiting time for the order to be sent	7.00
Selection of the means of transport and driver	6	Selection of the wrong means of transport and driver	7.77
	7	Lack of available means of transport and driver	8.28
Preparation of the means of transport and driver	8	Route information provided to the driver incorrectly	15.99
	9	Uneconomical route planning	6.40
	10	Mistakes connected with the preparation and handing over of the transportation documents to a driver	16.38
	11	Wrong planning of the order execution time	13.12
Loading	12	Accidents during loading	10.80
	13	Damage to the cargo	11.04
	14	Insufficient cargo securing	11.52
	15	Un-adapted cargo area	5.04
Transport	16	Accidents involving a vehicle used in transportation	15.04
	17	Breakdowns of the means of transport	8.82
	18	Adverse weather conditions	12.76
	19	Problems in communication between the forwarder and the driver	9.00
	20	Delay in the delivery of goods	21.12
	21	Necessity of detours	10.66
	22	Wrong route selection by the driver	8.41
	23	Theft of transported cargo	8.46
	24	No driving capability of the driver	6.86
	25	Infrastructure problems	7.82
Unloading	26	Accidents during unloading	10.80
	27	Damage to the cargo	11.28
	28	Un-adapted cargo area	5.04
Settlement	29	Failure to deliver an invoice	6.15
	30	Issuing of an incorrect invoice	6.60
	31	Late payment of the invoice	10.08

Based on specific values of individual risk factors' effects and their likelihood of occurrence, risk factor positions were determined using the assigned numbers in the risk matrix presented in Table 6.

Table 6.
Risk matrix of the analysed factors

Consequences of the risk	Likelihood of the risk occurring				
	Rare	Unlikely	Possible	Likely	Almost certain
Insignificant					1, 2, 5
Minor		15, 28	9		3, 4, 19
Moderate		25, 30	22	11, 18, 21	
Major	29	6, 17	31	8, 10	20
Severe	24	7, 12, 13, 14, 23, 26, 27	16		

Ten factors are assigned to the low risk category; such risks are acceptable and usually have little or no impact on the realisation of freight operations.

Another group consists of medium severity risk factors, which include 17 identified factors. The most important risk factors in this group are: poorly planned lead time, adverse weather conditions, and insufficient cargo securing during loading. The factors assigned to this group are considered acceptable; however, they require constant control as well as the systematic planning and implementation of actions that reduce their severity.

In the transport process, unacceptable risk group factors can result in major disruptions. Based on the assessed severity of the risk, four factors were categorised to this group, including: delays in the delivery of goods, mistakes connected with the preparation and handing over of the transportation documents to a driver, errors in the provision of route information to the driver, and accidents involving a vehicle used in transportation.

The factor severity analysis for particular stages of the examined transport process allows us to observe that the activities connected with transport as well as the preparation of the means of transport and the driver are exposed to the highest risks. Moreover, due to the susceptibility to tolerable risk, attention should be paid to activities related to loading, unloading, and the settlement of transport services with the customer.

The most essential risk factors include four unacceptable factors and three key acceptable factors, which are: incorrect planning of the order execution time, adverse weather conditions, and insufficient cargo securing; the potential causes and consequences of their occurrences were identified. As such, we are able to state that the analysed risk factors are mainly related to human errors, errors resulting from insufficient information, the carelessness or ignorance of employees, and random events. The consequences include, first and foremost, delays in order execution and financial losses; the latter may be caused by damage to the transported cargo or contractual penalties imposed by automotive industry customers to minimise losses resulting from production line downtime.

The identified causes for the key factors allowed us to come up with preventive measures to better detect emerging disruptions and help avoid them. The proposed actions include, among others: additional manager supervision over the transport process; training in safe driving and the optimisation of transport processes; more accurate analysis of the transport route and more frequent contact with the driver; language courses; changing the mobile network operator or replacing communication equipment with newer models; obeying road traffic rules and regulations; and increasing the frequency of rolling stock inspections.

Conclusion

This article presents literature and empirical research related to the impact of disruptions on the transport processes of parts and components supplied to automotive companies. The conducted research has allowed us to state that disruptions have a significant influence on the transportation process. Their proper identification, analysis, and evaluation has allowed us to determine actions aimed at limiting the impact of risk on the realisation of the examined process.

Indicative analysis has shown that the timeliness of transport, which is associated with delivery time, is a major issue in a company. This formed the basis for the further analysis of process disruptions. The assessment of identified potential risk factors by expert judges allowed us to determine their severity, and thus determine which factors may have a key impact on the transport process under examination. Based on the identified causes of the most critical factors, precautionary actions were determined to increase the detectability of disruptions occurring in the process and, thus, reduce their negative impact on the process.

The measures identified may contribute to improving the efficiency of the transport service execution process and therefore the quality of the services offered by the company. It is especially relevant in the case of transport services rendered for the automotive industry because any delay in the delivery of transported semi-finished goods may disrupt a customer's production process and result in losses.

However, periodic audits of risk management principles should be carried out, and the compliance of this process with accepted standards should be established. It is worth remembering that the functioning of an enterprise is dynamic. Therefore, it is necessary to identify changes that take place within the enterprise and its environment and make appropriate adjustments to the overall risk management system.

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