LogForum

> Scientific Journal of Logistics <

2020, 16 (4), 573-592

http://doi.org/10.17270/J.LOG.2020.518

http://www.logforum.net p-ISSN 1895-2038 e-ISSN 1734-459X

ORIGINAL PAPER

EXCLUSIONARY CONSTRAINTS IN TRANSPORT – RESULTS OF QUANTITATIVE RESEARCH

Marcin Anholcer[1], Arkadiusz Kawa[2]

1) Poznań University of Economics and Business, Poznań, **Poland**, 2) Łukasiewicz Research Network, Institute of Logistics and Warehousing, Poznań, **Poland**

ABSTRACT. **Background**: Among all the processes in the supply chain, transport is one of the most complex and most expensive. While planning the transportation process, one needs to consider various factors, among others the exclusionary constraints imposed on selected suppliers, products or mean of transport. Although several papers can be found where the authors discuss the problem of exclusionary constraints, it is very difficult to find one concerning the empirical research in this area. Our work tries to fill this gap. The main goal and contribution of this article is the analysis of significance and importance of various exclusions in transport present in the real life.
Methods: We present the results of a quantitative research performed on a random sample of 300 logistics services providers in Poland, concerning the exclusionary constraints in transportation.
Results: The research confirmes that the exclusion factors are an important part of activity of the companies transporting goods. Although the distributions of the frequencies are different, depending on the factor, one may observe that every factor was noticed by a significant fraction of companies. The analysis of the potential dependencies between the variables show that the importance and frequency of the factors is rather independent from the company's features. Our study contributes to the theories and practices of logistics enterprises.
Conclusions: This study extends earlier research on exclusionary constraints with using empirical studies. In the future work we will use the results of the quantitative research to develop mathematical models of the transportation problems and we want to prepare more effective methods of planning the deliveries.

Key words: transportation, exclusionary constraints, quantitative research, logistics.

INTRODUCTION

Supply chain configuration consists of building a structure in an enterprise network, within which a flow of things and information takes place. Such a structure is made of individual actors (a producer, an assembler, a distributor, a retailer, etc.). A supply chain may embrace all flows starting from the purchase of raw materials and finishing with the delivery to the final customer.

One of the challenges related with the supply chains is price pressure which forces supply chain leaders into constant efforts to decrease product prices, even when the competitive strategy is primarily focused on such characteristics as quality or delivery time. Globalization and internationalization of enterprises have also contributed to the fact that a large number of companies produce or commission production in various countries around the world [Anholcer, Kawa 2012].

What is closely connected with the flow of goods among the nodes of an enterprise network is transport, which is considered one of the most important elements of a logistic system and requires careful planning and control.

Transportation costs can be a significant part of a company's overall logistics spending

Citation: *Anholcer M., Kawa A.,2020. Exclusionary constraints in transport – results of quantitative research. LogForum 16 (4), 573-592, http://doi.org/10.17270/J.LOG.2020.518*
Received: 09.07.2020, Accepted: 28.08.2020, on-line: 18.09.2020.

[Murray 2014]. According to various estimates, transportation constitutes one-third of the logistics costs [see e.g. Tseng et al. 2005]. All the costs are transferred to the customer by increasing prices. This shows why decreasing transportation costs is one of the companies' major targets. Various transportation strategies may be applied by management to improve the performance [Murray 2014]. The issue of transportation cost optimization is treated as one of the most difficult and most complex problems which transport enterprises deal with.

In many cases it is necessary to impose some exclusionary constraints on the transportation process. In particular, it can be the case when some types of goods cannot be transported by the same mean of transport (like livestock and frozen fruits and vegetables). Another situation where such constraints have to be imposed is when some suppliers do not want their products to be delivered to the same customer (e.g. because of some reasons concerning marketing strategy of the company).

Various transportation and, more generally, network problems with exclusionary constraints were studied e.g. by Cao [1992], Cao and Uebe [1995], Darmann et al. [2011], Glover et al. [1978], Goossens and Spieksma [2009], Klingman and Russel [1975], Öncan, Zhang and Punnen [2013], Pferschy and Schauer [2013], Sun [2002], Thompson and Setbi [1986], Vancroonenburg et al. [2014], Zhang et al. [2011]. All the mentioned papers represent, however a theoretic approach: the authors consider models and algorithms, but do not analyze the real life data. We decided to fill this gap. For that reason we performed a quantitative research, presented in this article.

Based on several articles and market reports we distinguished several factors that can imply the necessity of exclusions. It turned out that sample possible causes of exclusions may be: sensitivity for humidity [Kurmanov et al. 2015, Brenner et al. 2014], sensitivity for temperature [Kurmanov et al. 2015, Blake et al. 2010, Butzke et al. 2012, Brenner et al. 2014, Lu et al. 2013], sensitivity for light [Blake et al. 2010], over-sized loads [Goldstein 2010], high-value goods [Goldstein 2010], duration of transportation [Lu et al. 2013] and chosen types of transported goods, like perishable products [Lu et al. 2013], dangerous products [Muncke et al. 2017] or livestock [Broom 2008].

Based on this knowledge, we performed a qualitative research: Focus Group Interview (FGI) and Individual In-Depth Interview (IDI) in order to prepare a longer list of possible causes [see Anholcer, Kawa 2015, Anholcer, Kawa 2017]. The main goal of the present article was to perform a research among the logistics companies in order to find out which causes of exclusions are the most significant and the most frequent in real life.

EMPIRICAL RESEARCH DESCRIPTION

In order to collect the empirical data, Polish logistics firms were asked to fill a questionnaire. The questions concerned the exclusionary constraints (in the context of products), and possible losses in transportation, as well as in storage. Most of them were closed. More specifically, the respondents were allowed to choose one out of 5 answers (1 meaning "not significant" or something similar, and 5 – "very significant", or similar). In addition, several questions about the firm were posed, e.g. about size, employment, exact kind of performed activity (transportation / storage / logistics etc.). The research was performed with the use of the Computer-Assisted Web Interview (CAWI) and Computer-Assisted Telephone Interview (CATI). The objective of the research was to analyze the significance and frequency of various possible causes of exclusions in transportation. The collection method was direct structured individual interview using questionnaires, performed among the respondents being managers responsible for transportation. General population consisted of Polish companies involved in logistic operations and in order to choose the final group of respondents, we used random sampling with sample size equal to 300. The questionnaire was first tested in a pilot designed for 7 respondents, chosen from among the representatives of the logistics

services industry, experts and researchers operating in the area of logistics [Kawa and Anholcer 2018].

According to Eurostat [2016] approximatively 140 thousand transport and warehousing companies were operating in Poland in 2014. After removing firms involved in pipeline and passenger transport, which are not part of logistics services industry, the number of firms in our target population tops 94 000. In order to perform random sampling, we collected the data about the companies using the Regon database hold by the Central Statistical Office in Poland, as well as commercial databases (in order to get the contact information). Initially, about 23 thousand managers obtained the survey and 58 questionnaires returned. Then out of about 30 thousand persons 248 were interviewed by telephone. After excluding few questionnaires with incomplete information and errors, 300 of them were qualified for further analyzes. These gives the measurement error of 5.6%, assuming the confidence level of 95%. Also according to literature, 300 observations are enough for concluding about the population of about 94 000 [Bazarnik et al. 1992].

Table 1. Sample characteristics

Characteristics	Share in the sample
Employment	
0-9 employees	49.7%
10-49 employees	36.7%
50+ employees	11.7%
N/A	2.0%
Legal form	
Sole-trader	54.3%
Limited liability company	25.3%
Civil law partnership	7.7%
Others	10.7%
N/A	2.0%
Serviced industries	
Construction	41.7%
Food	29.0%
Chemical	15.3%
Furniture	15.3%
Logistic	14.0%
Agricultural	13.7%
Paper	13.3%
Electric	13.0%
Textile	8.0%
Medical	6.3%
Telecommunications	4.0%
Financial	1.3%

Source: own computations

The basic sample statistics have been presented in Table 1. The respondents who completed the questionnaire represented usually micro (49.7%) and small (36.7%) enterprises having usually the legal form of sole-traders (54.3%), limited liability companies (25.3%) and civil law partnership (7.7%) The majority of the surveyed companies provided services for customers from the construction (41,7%) and food (29%) industry.

In this article we focus on two groups of questions, concerning the exclusionary constraints in transportation. Question 2 was: "Below some causes are listed, because of which it is impossible to transport selected goods jointly; please describe their significance for your company, by choosing one of the numbers from 1 (completely not significant) to 5 (very significant)". This question consisted of 17 sub-questions corresponding with selected possible reasons of exclusions. These were:

p2.1. Sensitivity for duration of transport.
p2.2. Sensitivity for transportation conditions (fragile goods).
p2.3. Sensitivity for temperature.
p2.4. Sensitivity for humidity.
p2.5. Sensitivity for light.
p2.6. Sensitivity for fragrances.
p2.7. High-value goods.
p2.8. Perishable goods.
p2.9. Dangerous product (e.g. ADR).
p2.10. Livestock.
p2.11. Competitive goods (products of competitive companies).
p2.12. Loads of above-standard sizes.
p2.13. Time windows of deliveries.
p2.14. Exclusive transport contract.
p2.15. Large distances between supply and destination points.
p2.16. Legal restrictions (e.g. summer and weekend prohibitions).
p2.17. Others.

Similarly, the question 3 was "please describe the frequency of the following causes of exclusions in your company, by choosing one of the numbers from 1 (does not occur at all) to 5 (very often)". It also consisted of 17 sub-questions, corresponding with the questions p2.1-p2.17, this time numbered by p3.1-p3.17, respectively. In the following

section we presented the results of quantitative research performed on the described questions.

EMPIRICAL RESEARCH RESULTS

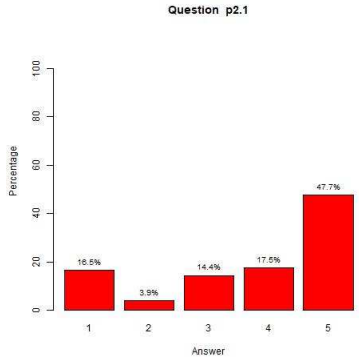
Let us start with the basic statistics of the questions they are collected in table 2. Although the answers are not numeric, the mean and median give some insight into which causes are significant or frequent and which are not. As we can see, most of the respondents answered almost all the questions, the only exceptions are questions p2.17 and p3.17 (about the other possible causes of exclusions). This means that the list of possible causes of exclusions prepared by the authors was rather complete and it omitted only few possible causes.

Table 2. Basic statistics

Question	#Answers	Mean	Median	Question	#Answers	Mean	Median
p2.1	285 (95.00%)	3.761	4	p3.1	282 (94.00%)	2.89	3
p2.2	286 (95.33%)	3.416	4	p3.2	284 (94.67%)	2.669	3
p2.3	284 (94.67%)	2.863	3	p3.3	284 (94.67%)	2.391	2
p2.4	285 (95.00%)	2.432	2	p3.4	284 (94.67%)	1.979	1
p2.5	283 (94.33%)	1.968	1	p3.5	283 (94.33%)	1.597	1
p2.6	284 (94.67%)	2.511	2	p3.6	283 (94.33%)	1.975	1
p2.7	286 (95.33%)	3.476	4	p3.7	283 (94.33%)	2.661	3
p2.8	282 (94.00%)	2.681	2	p3.8	283 (94.33%)	2.014	1
p2.9	283 (94.33%)	2.58	1	p3.9	282 (94.00%)	2.018	1
p2.10	280 (93.33%)	1.893	1	p3.10	278 (92.67%)	1.45	1
p2.11	279 (93.00%)	2.315	2	p3.11	280 (93.33%)	2.193	2
p2.12	283 (94.33%)	2.364	1	p3.12	283 (94.33%)	1.933	1
p2.13	285 (95.00%)	3.488	4	p3.13	283 (94.33%)	3.074	3
p2.14	281 (93.67%)	3.142	3	p3.14	285 (95.00%)	2.418	2
p2.15	284 (94.67%)	3.468	4	p3.15	282 (94.00%)	3.028	3
p2.16	286 (95.33%)	3.455	4	p3.16	286 (95.33%)	2.664	3
p2.17	41 (13.67%)	2.488	1	p3.17	46 (15.33%)	2.261	1

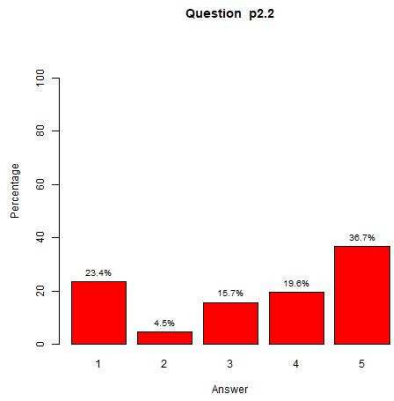
Source: own computations

Now, let us present the analysis of the answers' frequencies. The results are presented on figures 1–34.



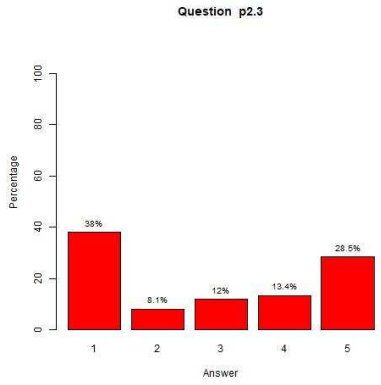
Source: own computations

Fig. 1. Frequencies of answers for question p2.1 – significance of the factor: Sensitivity for duration of transport.



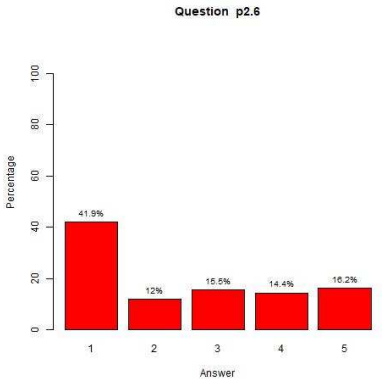
Source: own computations

Fig. 2. Frequencies of answers for question p2.2 – significance of the factor: Sensitivity for transportation conditions (fragile goods)



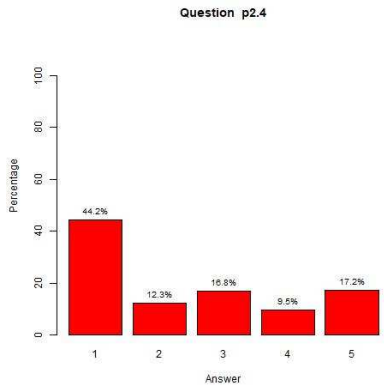
Source: own computations

Fig. 3. Frequencies of answers for question p2.3 – significance of the factor: Sensitivity for temperature



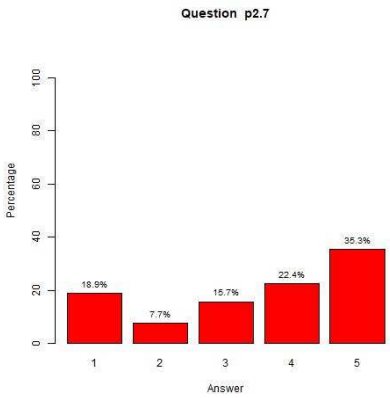
Source: own computations

Fig. 6. Frequencies of answers for question p2.6 – significance of the factor: Sensitivity for fragrances



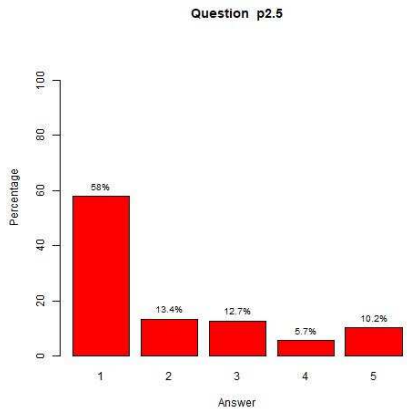
Source: own computations

Fig. 4. Frequencies of answers for question p2.4 – significance of the factor: Sensitivity for humidity



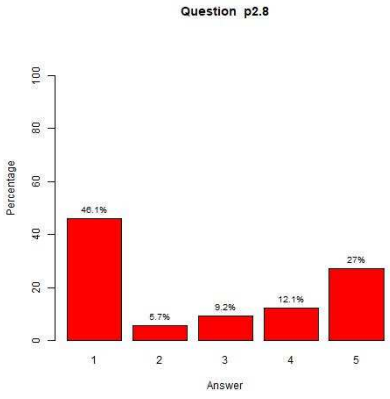
Source: own computations

Fig. 7. Frequencies of answers for question p2.7 – significance of the factor: High-value goods



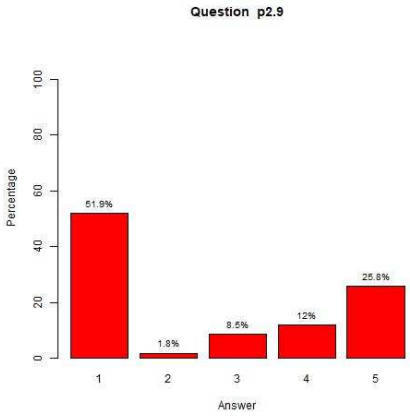
Source: own computations

Fig. 5. Frequencies of answers for question p2.5 – significance of the factor: Sensitivity for light



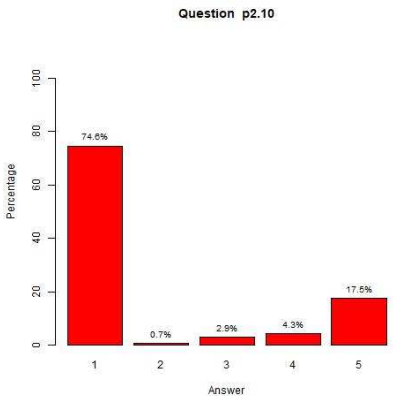
Source: own computations

Fig. 8. Frequencies of answers for question p2.8 – significance of the factor: Perishable goods



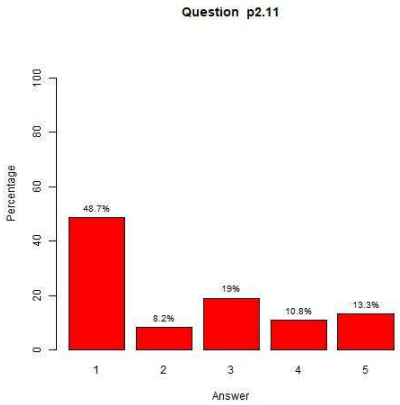
Source: own computations

Fig. 9. Frequencies of answers for question p2.9 – significance of the factor: Dangerous product (e.g. ADR)



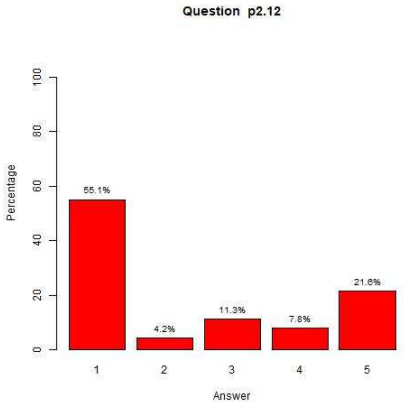
Source: own computations

Fig. 10. Frequencies of answers for question p2.10 – significance of the factor: Livestock



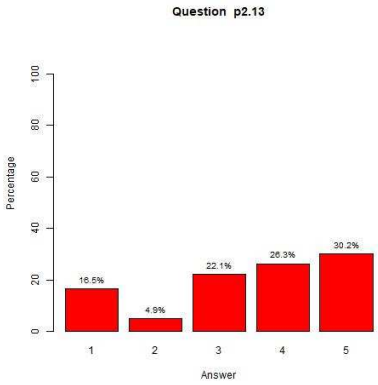
Source: own computations

Fig. 11. Frequencies of answers for question p2.11 – significance of the factor: Competitive goods (products of competitive companies)



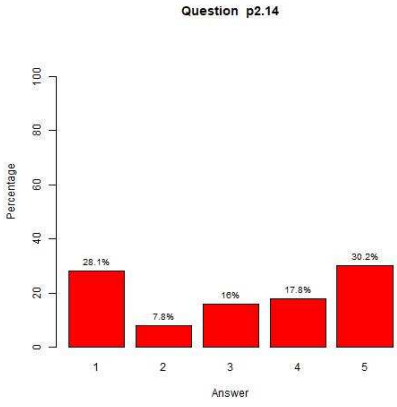
Source: own computations

Fig. 12. Frequencies of answers for question p2.12 – significance of the factor: Loads of above-standard sizes



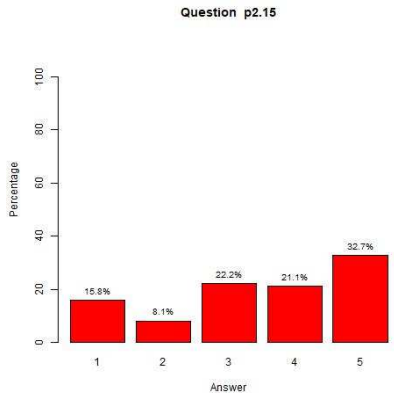
Source: own computations

Fig. 13. Frequencies of answers for question p2.13 – significance of the factor: Time windows of deliveries



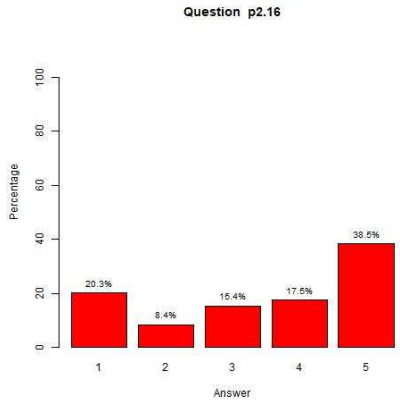
Source: own computations

Fig. 14. Frequencies of answers for question p2.14 – significance of the factor: Exclusive transport contract



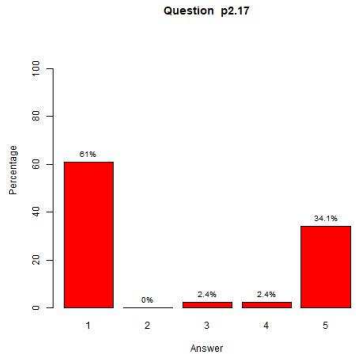
Source: own computations

Fig. 15. Frequencies of answers for question p2.15 – significance of the factor: Large distances between supply and destination points



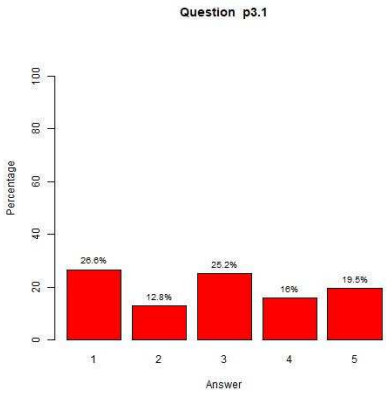
Source: own computations

Fig. 16. Frequencies of answers for question p2.16 – significance of the factor: Legal restrictions (e.g. summer and weekend prohibitions)



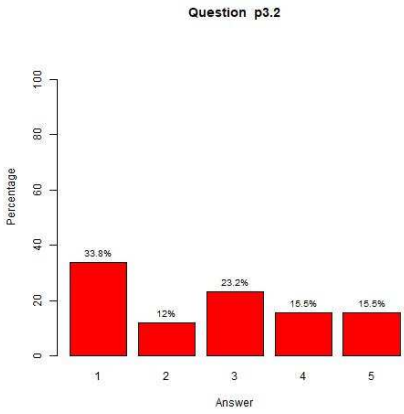
Source: own computations

Fig. 17. Frequencies of answers for question p2.17 – significance of the factor: Others



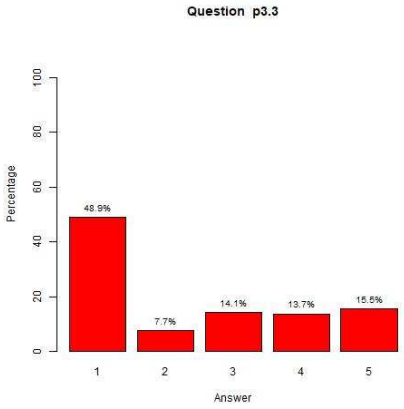
Source: own computations

Fig. 18. Frequencies of answers for question p3.1 – frequency of the factor: Sensitivity for duration of transport



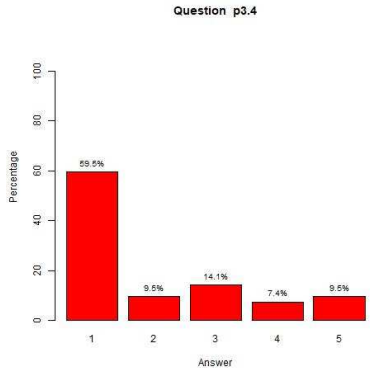
Source: own computations

Fig. 19. Frequencies of answers for question p3.2 – frequency of the factor: Sensitivity for transportation conditions (fragile goods)



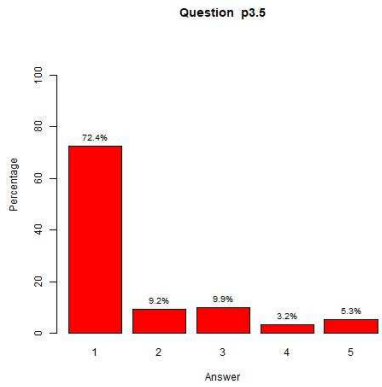
Source: own computations

Fig. 20. Frequencies of answers for question p3.3 – frequency of the factor: Sensitivity for temperature



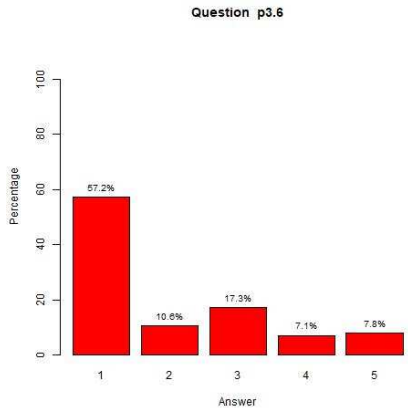
Source: own computations

Fig. 21. Frequencies of answers for question p3.4 – frequency of the factor: Sensitivity for humidity



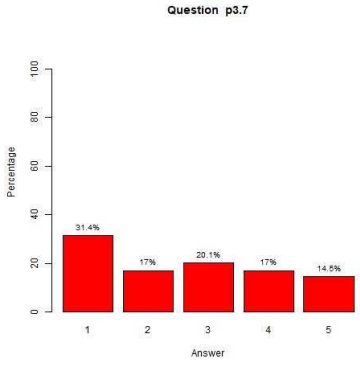
Source: own computations

Fig. 22. Frequencies of answers for question p3.5 – frequency of the factor: Sensitivity for light



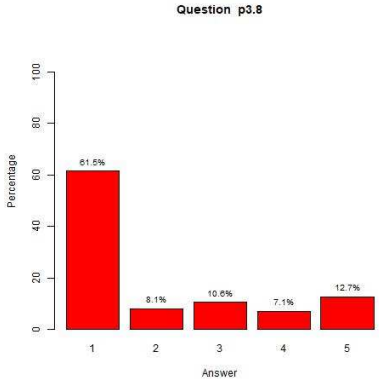
Source: own computations

Fig. 23. Frequencies of answers for question p3.6 – frequency of the factor: Sensitivity for fragrances



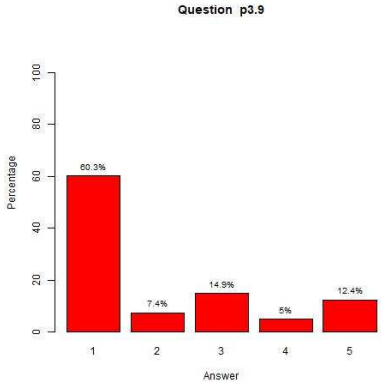
Source: own computations

Fig. 24. Frequencies of answers for question p3.7 – frequency of the factor: High-value goods



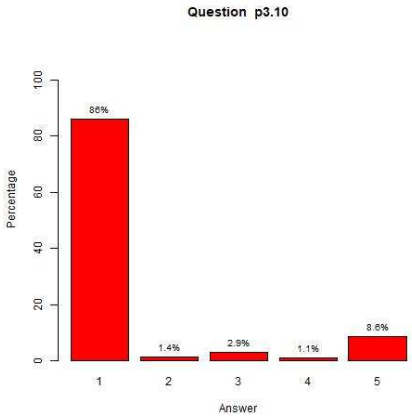
Source: own computations

Fig. 25. Frequencies of answers for question p3.8 – frequency of the factor: Perishable goods



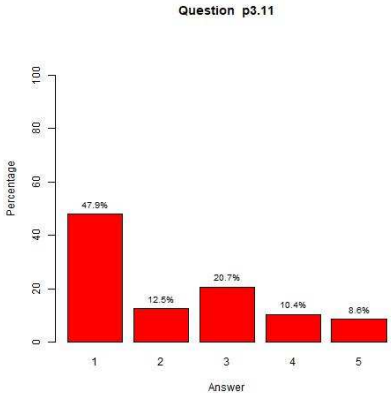
Source: own computations

Fig. 26. Frequencies of answers for question p3.9 – frequency of the factor: Dangerous product (e.g. ADR)



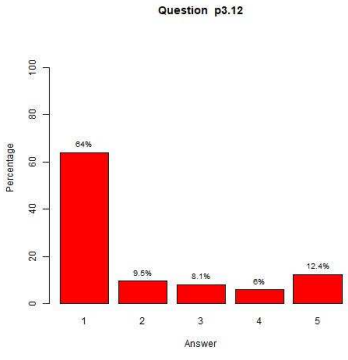
Source: own computations

Fig. 27. Frequencies of answers for question p3.10 – frequency of the factor: Livestock



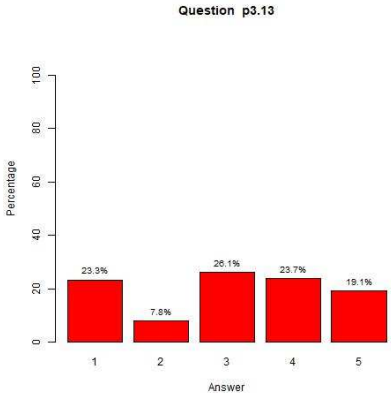
Source: own computations

Fig. 28. Frequencies of answers for question p3.11 – frequency of the factor: Competitive goods (products of competitive companies)



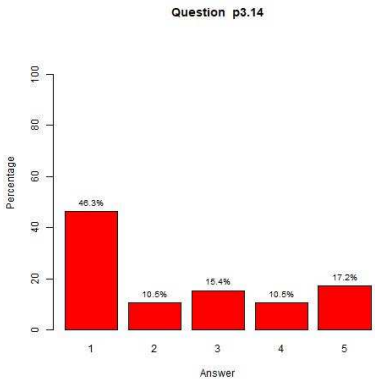
Source: own computations

Fig. 29. Frequencies of answers for question p3.12 – frequency of the factor: Loads of above-standard sizes



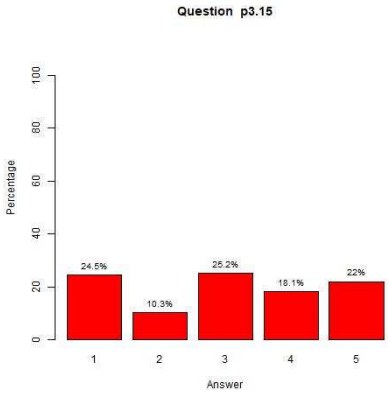
Source: own computations

Fig. 30. Frequencies of answers for question p3.13 – frequency of the factor: Time windows of deliveries



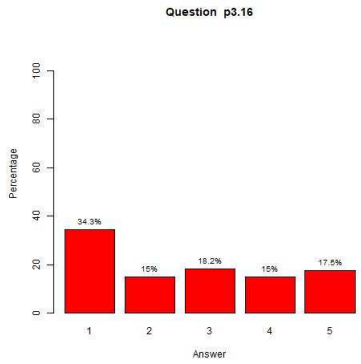
Source: own computations

Fig. 31. Frequencies of answers for question p3.14 – frequency of the factor: Exclusive transport contract



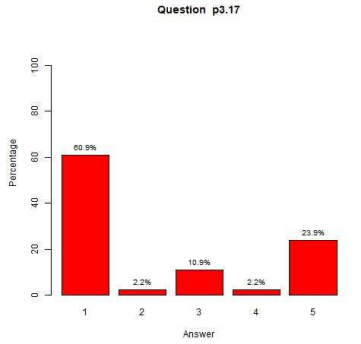
Source: own computations

Fig. 32. Frequencies of answers for question p3.15 – frequency of the factor: Large distances between supply and destination points



Source: own computations

Fig. 33. Frequencies of answers for question p3.16 – frequency of the factor: Legal restrictions (e.g. summer and weekend prohibitions)



Source: own computations

Fig. 34. Frequencies of answers for question p3.17 – frequency of the factor: Others

As we can see, in the case of first three factors (sensitivity for duration of transport, transportation conditions and temperature), the distribution of answers is very similar: for relatively many respondents the chosen factors were either very important or completely not significant. Moreover, only in the case of sensitivity for temperature, "not significant" was the most common answer. In two remaining cases it was the second answer.

The situation with the next three factors is different than before: many respondents marked the sensitivity for humidity, sensitivity for light and sensitivity for fragrances as completely not significant (over 44%, 56% and almost 42%, respectively). The other answers gained similar numbers of answers (between 10% and 20%, with few exceptions).

In the case of high-value goods, one may observe that relatively many firms (over 35%) consider this factor as very significant. The distribution of answers is very similar to the ones of the answers to questions p2.1-p2.3.

As shown on figures 8-12, many respondents (usually more than a half) consider as completely not significant factors the perishable or dangerous products, livestock, over-sized commodities and the situation when the competitive good are supposed to be transported. What is worth mentioning, if someone considers some of the factors as significant, then in most cases it is considered as very important. This makes the distributions of the mentioned answers a little bit similar to the distributions of the answers to questions p2.1-p2.3.

This similarity is much more visible in the case of the answers to questions p.13-p.16. In fact, two extremal answers (1 and 5) were chosen the most frequently, but the distribution is much flatter in the case of time windows, exclusive transport contracts, long distances and legal restrictions.

The last distribution is very different from others. If the respondent answered to the question p2.17, they either described other (not listed above) factors as completely not important or very significant. One should expect such distribution of answers: if someone gives an example of new factor, not given before, it usually means that this factor is very important to them.

The list of potential other factors may be interesting. The respondents had opportunity to give some examples in a separate, open question. Unfortunately, only few of them decided to give some examples (we managed to collect only 14 answers and most of them were very similar to the pre-defined factors. Among others, the following factors were listed: transport price, weight of commodity, the spatial distribution of commodities and weather (unfortunately we do not have more detailed explanations for these factors).

Let us switch now to the questions about the frequencies of various exclusion factors.

As we can see, in case of duration and fragility, the distributions are rather flat, although the most common answer is "never".

The figures 20 and 21 show that the sensitivity for temperature and humidity does not occur as the reason of exclusions in about half of the companies. The other answers were rather evenly distributed.

This situation is also visible in figures 22 and 23. Most firms did not notice any occurrence of the sensitivity for fragrances or light that would cause any exclusions.

The high value of goods as a case of exclusions is an exception – still "never" is the most common answer, but in this case almost 70% of firms met this problem and the distribution of the answers from 2 to 5 is very flat.

In the case of five next factors, presented on figures 25-29 (perishables, dangerous, competitive or over-sized goods and livestock), the distributions look like before: no occurrence in most firms (or at least 47,9%) and very few of them describe this factor as "very often".

Time windows seem to be much more important factor: almost 80% of companies met this problem and almost 70% gave the answers between 3 and 5. Exclusive contracts (figure 31) were in turn not present in over 45% of companies.

Large distances and legal restrictions were visible in over 75% and over 65% of firms, respectively. The distributions of the answers 2-5 could be considered as flat again.

Finally, as in the case of significance, also the frequency of the factor "other" is either completely not present in the companies (over 60% of the answers) or is very high (almost 24%). Also, in this case, the respondents were able to give some specific examples of the other factors. Unfortunately, this time they did not give any specific examples.

In the remainder of our research, we focused on the possible dependencies between answers to various questions. For that reason, we prepared the contingency tables with the joint distribution of the answers to the questions p2.1-p2.17, p3.1-p3.17 and the questions about the company. The latter ones described, among others, company's branch of activity (distribution, trade, production, transportation, shipping, logistics), type of deliveries (from groupage to full truck load), range (from local to worldwide), comparison of financial performance and resources of the company and main competitors, branches of the customers, region of Poland, where the main office of the company is registered, number of employees and legal form of the company. For each case where it was possible, the χ^2 independence test was performed at the significance level 0.05 i.e., we rejected the hypothesis about the variables' independence when the ¬p–value was less than 0.05.

In the case of dependency between exclusion factors and company's features, we decided to present the results of the test only in the cases when the null hypothesis was rejected (i.e., we can assume that the variables are dependent). The results are presented in tables 3-9.

Table 3. The results of χ^2 test: question m1 (main field of activity: distribution, trade, production, transportation, shipping, logistics, other)

Q1	Q2	Chi-sq	df	p-val
m1	p2.10	116.961	28	0.000
m1	p2.12	44.285	28	0.026
m1	p3.8	45.958	28	0.018
m1	p3.9	51.167	28	0.005
m1	p3.12	43.529	28	0.031

Source: own computations

As we can see in table 3, only in case of two exclusion factors, their significance may be considered as depending on the kind of firm's activity. These are: livestock (p2.10) and over-sized loads (p2.12). If we consider the occurrence of the factors, it depends on the firm's branch in three cases. These time these are: perishable (p3.8) and dangerous (p3.9) products and over-sized loads (p3.12). As we can see, in general the exclusions caused by the loads of above-standard size strongly depend on the firm's area of activity.

Table 4. he results of χ^2 test: questions m2.1 (frequency of groupage loads), m2.2 (frequency of partial loads), m2.3 (frequency of full-truck loads)

Q1	Q2	Chi-sq	df	p-val
m2.1	p2.5	31.681	20	0.047
m2.1	p2.6	32.540	20	0.038
m2.1	p2.7	38.750	20	0.007
m2.1	p3.3	36.479	20	0.014
m2.1	p3.4	37.030	20	0.012
m2.1	p3.5	40.947	20	0.004
m2.1	p3.7	33.546	20	0.029
m2.1	p3.9	34.113	20	0.025
m2.1	p3.12	31.873	20	0.045
m2.2	p2.1	34.867	20	0.021
m2.2	p2.4	37.336	20	0.011
m2.2	p2.7	34.566	20	0.023
m2.2	p2.8	34.486	20	0.023
m2.2	p2.9	39.419	20	0.006
m2.2	p2.14	45.752	20	0.001
m2.2	p3.4	35.025	20	0.020
m2.2	p3.5	41.968	20	0.003
m2.2	p3.7	41.324	20	0.003
m2.2	p3.13	32.690	20	0.036
m2.2	p3.14	36.087	20	0.015
m2.3	p2.1	33.804	20	0.027
m2.3	p2.7	35.898	20	0.016
m2.3	p2.8	40.259	20	0.005
m2.3	p2.14	44.347	20	0.001
m2.3	p2.16	33.777	20	0.028
m2.3	p3.8	37.520	20	0.010

Source: own computations

Let us consider the kind of loads that firm delivers (table 4). In case of groupage loads, their frequency had influence on the importance of the factors such as sensitivity for light (p2.5) and fragrances (p2.6), and high-value goods (p2.7). It has also influence on the occurrence of the factors such as fragility on temperature (p3.3), humidity (p3.4) and light (p3.5), high-value goods (p3.7), dangerous (p3.9) and over-sized (p3.12) loads. The frequency of partial loads influences the significance of sensitivity for duration (p2.1) and humidity (p2.4), high-value (p2.7), perishable (p2.8) and dangerous (p2.9) products, and exclusive contracts (p2.14). It corresponds also with the frequency of the occurrence of the factors like sensitivity for humidity (p3.4) and light (p3.5), high-value goods (p3.7), time windows (p3.13) and exclusive contracts (p3.14). Finally, the frequency of full-truck loads has influence on the significance of sensitivity for duration (p2.1), high-value (p2.7) and perishable (p2.8) goods, exclusive contracts (p2.14) and legal restrictions (p2.16). Only the frequency of the occurrence of perishable products (p3.8) depends on the frequency of full-truck loads.

Now let us analyze the relation between the range of deliveries and the occurrence of the exclusion factors (table 5).

Table 5. The results of χ^2 test: questions m3.1 (frequency of local deliveries), m3.2 (frequency of regional deliveries), m3.3 (frequency of countrywide deliveries), m3.4 (international/worldwide deliveries)

Q1	Q2	Chi-sq	df	p-val
m3.1	p2.7	49.683	20	0.000
m3.1	p3.2	34.299	20	0.024
m3.2	p2.1	39.415	20	0.006
m3.2	p2.5	33.083	20	0.033
m3.2	p2.15	34.576	20	0.022
m3.2	p3.16	41.149	20	0.004
m3.3	p2.6	37.232	20	0.011
m3.3	p3.5	31.793	20	0.046
m3.3	p3.7	37.080	20	0.011
m3.3	p3.11	33.314	20	0.031
m3.4	p2.2	32.661	20	0.037
m3.4	p2.3	31.696	20	0.047
m3.4	p2.6	37.955	20	0.009
m3.4	p2.8	34.319	20	0.024
m3.4	p2.9	31.680	20	0.047
m3.4	p2.13	34.746	20	0.021
m3.4	p2.14	37.107	20	0.011
m3.4	p3.2	65.948	20	0.000
m3.4	p3.3	37.737	20	0.010
m3.4	p3.6	47.213	20	0.001
m3.4	p3.9	40.348	20	0.005
m3.4	p3.13	32.940	20	0.034

Source: own computations

The factors that depend on the frequency of local deliveries are high-valued goods (significance – p2.7) and fragility of commodities (frequency – p3.2). The frequency of regional deliveries influences the factors like: sensitivity for duration (importance – p2.1), sensitivity for light (importance – p2.5), distances from supply and destination points (importance – p2.15) and legal restrictions (frequency – p3.16). Countrywide deliveries influence the following exclusion factors: sensitivity for light (frequency – p3.5) and fragrances (importance – p2.6), high-value goods (frequency – p3.7) and competitive goods (frequency – p3.11). As we can see, the biggest influence on both importance and occurrence of the exclusion factors has the frequency of operating on international market. To be more specific, it influences the fragility of products (importance and frequency – p2.2 and p3.2), sensitivity for temperature (importance and frequency – p2.3 and p3.3), sensitivity for fragrances (importance and frequency – p2.6 and p3.6), perishable products (importance – p2.8),

dangerous products (importance and frequency – p2.9 and p3.9), time windows (importance and frequency – p2.13 and p3.13) and exclusive contracts (importance – p2.14).

The questions m4 (average distance to customers) and m5 (number of customers) were open questions, skipped them in this analysis. Another question was about the comparison of the company's economic parameters to the parameters of the competitors (table 6). The respondents were asked to choose a number between 1 and 5 (1 – much worse, 5 – much better).

Table 6. The results of χ^2 test: questions m6.1 (market share: 1 – much worse that competitors' shares, 5 – much better), m6.2 (sales income), m6.3 (profit), m6.4 (ROI).

Q1	Q2	Chi-sq	df	p-val
m6.1	p3.7	36.795	20	0.012
m6.1	p3.9	37.230	20	0.011
m6.2	p3.7	36.701	20	0.013
m6.2	p3.9	39.230	20	0.006
m6.2	p3.10	31.435	20	0.050
m6.2	p3.12	32.225	20	0.041
m6.2	p3.14	34.093	20	0.026
m6.3	p3.8	32.975	20	0.034
m6.3	p3.9	35.360	20	0.018
m6.3	p3.10	33.457	20	0.030
m6.4	p2.2	33.242	20	0.032
m6.4	p2.10	38.371	20	0.008
m6.4	p2.15	32.125	20	0.042
m6.4	p2.16	35.197	20	0.019
m6.4	p3.5	32.548	20	0.038
m6.4	p3.8	42.174	20	0.003
m6.4	p3.9	38.640	20	0.007
m6.4	p3.15	32.915	20	0.034

Source: own computations

As we can see, the evaluation of the market share was connected with the exclusion factors like high-valued and dangerous products (in both cases some differences in frequency encountered – p3.7 and p3.9). Same connection was found in the context of the evaluation of sales income. Moreover, the latter one influenced also the frequencies of occurrence of factors like livestock (p3.10), oversized loads (p3.12) and exclusive contracts (p3.14). The evaluation of profit had in turn influence on the frequency of perishable (p3.8) and dangerous (p3.9) products and livestock (p3.10). The evaluation of ROI was the only one that differentiated somehow also the importance of the exclusion factors. To be more specific, it was related to fragility (importance – p2.2), sensitivity for light (frequency – p3.5), perishable goods (frequency – p3.8), dangerous products (frequency – p3.9), livestock (importance – p2.10), distance from supply and destination points (importance and frequency – p2.15 and p3.15) and legal restrictions (importance – p2.16).

Similarly, the respondents compared also the resources of the firm to the resources of the competitors (1 – much worse, 5 – much better). The results of tests are presented in table 7.

As we can see, the evaluation of know-how was related to the exclusion factors like sensitivity for duration (frequency – p3.1), fragility (importance and frequency – p2.2 and p3.2), perishable goods (importance – p2.8), dangerous products (frequency – p3.9) and distance from supply and destination points (importance – p2.16).

The organizational issues were related to sensitivity for duration (frequency – p3.1), fragility (frequency – p3.2), sensitivity for fragrances (importance – p2.6), high-valued goods (frequency – p3.7) and dangerous products (frequency – p3.9).

Management methods corresponded with fragility (frequency – p3.2), sensitivity for light (frequency – p3.5), high-value goods (frequency – p3.7) and perishable goods (importance – p2.8).

The evaluation of technology was connected with fragility (frequency – p3.2), high-value goods (frequency – p3.7) and perishable goods (importance – p2.8).

The experience in turn correlated with fragility (frequency – p3.2), perishable goods (importance – p2.8), dangerous and competitive products (frequency – p3.9 and p3.11).

The perception of brand correlated with duration (frequency – p3.1), fragility (frequency – p3.2), sensitivity for light (importance – p2.5), perishable goods (importance – p2.8), dangerous products (frequency – p3.9) and time windows (frequency – p3.13).

Table 7. The results of χ^2 test: questions m7.1 (know-how: 1 – much worse that competitors' know-how, 5 – much better), m7.2 (operations organization), m7.3 (management methods), m7.4 (technology), m7.5 (experience), m7.6 (brand), m7.7 (relations)

Q1	Q2	Chi-sq	df	p-val
m7.1	p2.2	31.670	20	0.047
m7.1	p2.8	37.511	20	0.010
m7.1	p2.15	37.609	20	0.010
m7.1	p3.1	53.088	20	0.000
m7.1	p3.2	38.585	20	0.008
m7.1	p3.9	32.972	20	0.034
m7.2	p2.6	31.901	20	0.044
m7.2	p3.1	41.096	20	0.004
m7.2	p3.2	43.783	20	0.002
m7.2	p3.7	37.752	20	0.009
m7.2	p3.9	37.185	20	0.011
m7.3	p2.8	33.210	20	0.032
m7.3	p3.2	33.289	20	0.031
m7.3	p3.5	33.282	20	0.031
m7.3	p3.7	41.002	20	0.004
m7.4	p2.8	39.709	20	0.005
m7.4	p3.2	39.178	20	0.006
m7.4	p3.7	31.632	20	0.047
m7.5	p2.8	34.721	20	0.022
m7.5	p3.2	37.001	20	0.012
m7.5	p3.9	32.881	20	0.035
m7.5	p3.11	31.493	20	0.049
m7.6	p2.5	32.896	20	0.035
m7.6	p2.8	37.436	20	0.010
m7.6	p3.1	31.916	20	0.044
m7.6	p3.2	36.038	20	0.015
m7.6	p3.9	35.899	20	0.016
m7.6	p3.13	31.959	20	0.044
m7.7	p2.8	37.722	20	0.010
m7.7	p2.10	36.746	20	0.013
m7.7	p2.14	36.070	20	0.015
m7.7	p3.2	34.536	20	0.023
m7.7	p3.5	39.774	20	0.005
m7.7	p3.7	32.299	20	0.040
m7.7	p3.8	32.374	20	0.039
m7.7	p3.13	37.464	20	0.010

Source: own computations

Finally, the perception of firm's relations was related to fragility (frequency – p3.2), sensitivity for light (frequency – p3.5), high-value goods (frequency – p3.7), perishable goods (importance and frequency – p2.8 and p3.8), livestock (importance – p2.10), time windows (frequency – p3.13) and exclusive contracts (importance – p2.14).

The analysis of the possible influence of the branch of economy in which the company operates was presented in tables 8a and 8b. Multiple choices were possible. First observation is that the questions m8.4 (textile industry), m8.8 (telecommunication), m8.11 (finance) and m8.12 (logistics) do not appear in the table. This means, that the occurrence and significance of the discussed exclusion factors are independent from operating (or not) in the four branches of economy listed above.

Operating (or not) in the food industry had influence on fragility (importance – p2.2), sensitivity for temperature (importance and frequency – p2.3 and p3.3), sensitivity for humidity (frequency – p3.4), sensitivity for fragrances (importance and frequency – p2.6 and p3.6), perishable products (importance and frequency – p2.8 and p3.8) and legal restrictions (importance and frequency – p2.16 and p3.16)

Presence at the energy market influenced only the importance and frequency of occurrence of high-value commodities (p2.7 and p3.7).

Being involved in the construction industry had influence on the exposition on factors like fragility (importance – p2.2), sensitivity for temperature (frequency – p3.3), high-value commodities (frequency – p3.7), perishable products (importance and frequency – p2.8 and p3.8), competitive products (frequency – p3.11), oversized loads (importance – p2.12), time windows (frequency – p3.13), distance from supply and destination points (frequency – p3.15) and legal restrictions (importance – p2.16).

Operating in paper industry influenced the occurrence of perishable products (importance – p2.8), livestock (frequency – p3.10) and exclusive contracts (importance – p2.14).

Activity in chemical industry correlated with the factors like fragility (importance – p2.2), sensitivity for temperature (frequency – p3.3), sensitivity for humidity (importance and frequency – p2.4 and p3.4), sensitivity for fragrances (frequency – p3.6), dangerous products (importance and frequency – p2.9 and p3.9) and the frequency of occurrence of oversized loads and restrictions on time windows (p3.12 and p3.13).

Operating (or not) in agriculture had influence on sensitivity for duration (frequency – p3.1), sensitivity for temperature (importance – p2.3), sensitivity for humidity (frequency – p3.4), sensitivity for light (frequency – p3.5),

sensitivity for fragrances (frequency – p3.6) and perishable products (frequency – p3.8).

Table 8a. The results of χ^2 test: questions m8.1 (food industry: yes/no), m8.2 (energy: yes/no), m8.3 (construction: yes/no), m8.5 (paper industry: yes/no), m8.6 (chemical industry: yes/no), m8.7 (agriculture: yes/no), m8.9 (health: yes/no)

Q1	Q2	Chi-sq	df	p-val
m8.1	p2.2	20.772	4	0.000
m8.1	p2.3	26.972	4	0.000
m8.1	p2.6	19.892	4	0.001
m8.1	p2.8	24.867	4	0.000
m8.1	p2.16	12.760	4	0.013
m8.1	p3.3	31.163	4	0.000
m8.1	p3.4	10.943	4	0.027
m8.1	p3.6	29.671	4	0.000
m8.1	p3.8	38.458	4	0.000
m8.1	p3.16	16.202	4	0.003
m8.2	p2.7	13.671	4	0.008
m8.2	p3.7	26.418	4	0.000
m8.3	p2.2	11.897	4	0.018
m8.3	p2.8	13.580	4	0.009
m8.3	p2.12	13.670	4	0.008
m8.3	p2.16	9.562	4	0.048
m8.3	p3.3	9.505	4	0.050
m8.3	p3.7	9.526	4	0.049
m8.3	p3.8	11.739	4	0.019
m8.3	p3.11	9.612	4	0.047
m8.3	p3.13	11.262	4	0.024
m8.3	p3.15	10.545	4	0.032
m8.5	p2.8	9.720	4	0.045
m8.5	p2.14	10.772	4	0.029
m8.5	p3.10	12.316	4	0.015
m8.6	p2.2	13.513	4	0.009
m8.6	p2.4	13.029	4	0.011
m8.6	p2.9	16.202	4	0.003
m8.6	p3.3	12.299	4	0.015
m8.6	p3.4	11.916	4	0.018
m8.6	p3.6	13.339	4	0.010
m8.6	p3.9	18.210	4	0.001
m8.6	p3.12	18.489	4	0.001
m8.6	p3.13	12.011	4	0.017
m8.7	p2.3	10.054	4	0.040
m8.7	p3.1	9.818	4	0.044
m8.7	p3.4	10.517	4	0.033
m8.7	p3.5	14.904	4	0.005
m8.7	p3.6	13.734	4	0.008
m8.7	p3.8	15.578	4	0.004
m8.9	p2.5	23.183	4	0.000
m8.9	p3.2	18.236	4	0.001
m8.9	p3.4	10.621	4	0.031
m8.9	p3.8	12.407	4	0.015

Source: own computations

Table 8b. The results of χ^2 test: questions m8.10 (furniture industry: yes/no) and. m8.13 (other: yes/no)

Q1	Q2	Chi-sq	df	p-val
m8.10	p2.5	9.801	4	0.044
m8.10	p2.9	12.863	4	0.012
m8.10	p2.12	11.225	4	0.024
m8.10	p3.2	11.500	4	0.021
m8.10	p3.9	11.185	4	0.025
m8.10	p3.16	11.730	4	0.019
m8.13	p3.13	10.058	4	0.039

Source: own computations

Presence in the health industry influenced fragility (frequency – p3.2), sensitivity for humidity (frequency – p3.4), sensitivity for light (importance – p2.5) and the occurrence of perishable goods (frequency – p3.8).

Operating in furniture industry correlated with fragility (frequency – p3.2), sensitivity for light (importance – p2.5), occurrence of dangerous products (importance and frequency – p2.9 and p3.9) or oversized loads (importance – p2.12) and legal restrictions (frequency – p3.16).

Other industries do not influence the discussed factors. The only exception, where a relation was found, is the frequency of the occurrence of time windows (p3.13).

The region of Poland (m9), in which the firm has its headquarters, had no influence on the answers to any of the questions about the significance (p2.1-p2.17) or frequency of occurrence (p3.1-p3.17) of any of the discussed factors of exclusions. Same with the legal form of the enterprise (m11). Thus, the last analyzed group of possible dependencies were those concerning the company's size, measured with the size of the crew (table 9).

Table 9. The results of χ^2 test: question m10 (how many employees has the company: 0-9, 10-49, 50-249, 250-999, 1000-4999, 5000 and more)

Q1	Q2	Chi-sq	df	p-val
m10	p2.2	42.345	20	0.002
m10	p2.5	33.213	20	0.032
m10	p2.6	36.850	20	0.012
m10	p2.8	37.919	20	0.009
m10	p2.13	38.666	20	0.007
m10	p3.2	50.112	20	0.000
m10	p3.3	41.948	20	0.003
m10	p3.5	36.641	20	0.013
m10	p3.6	39.004	20	0.007
m10	p3.7	33.180	20	0.032
m10	p3.8	34.439	20	0.023
m10	p3.9	58.251	20	0.000
m10	p3.12	39.937	20	0.005
m10	p3.13	32.842	20	0.035
m10	p3.16	39.459	20	0.006

Source: own computations

The number of employees correlated with fragility of transported goods (importance and frequency – p2.2 and p3.2), sensitivity for temperature (frequency – p3.3), sensitivity for light (importance and frequency – p2.5 and p3.5), sensitivity for fragrances (importance

and frequency – p2.6 and p3.6), occurrence of high-value products (frequency – p3.7), perishable goods (importance and frequency – p2.8 and p3.8) or dangerous products (frequency – p3.9), oversized loads (frequency – p3.12), time windows (importance and frequency – p2.13 and p3.13) and legal restrictions (frequency – p3.16).

Just to reassume this part of our analysis, let us note that the importance and significance of the exclusion factors rather rarely relies on company's features – usually various properties were correlated with only few factors. The extremal cases, like some kinds of industry, location and the legal form of the company do not influence neither the importance nor the occurrence of the factors at all i.e., their distribution does not depend of those features of the company.

Let us end this section with the analysis of the results of the independence tests for the questions about importance (p2.1-p2.17) or frequency of occurrence (p3.1-p3.17) of the exclusion factors. This time, because of the number of dependencies, we presented only the ¬p–values of the tests for all the pairs: among p2.1-p2.17 (table 10), between p2.1-p2.17 and p3.1-p3.17 (table 11) and among p3.1-p3.17 (table 12).

As we can see, in almost all the cases we must reject the independence hypothesis, which means that the importance and frequencies of occurrence of various exclusion factors are dependent. There are, of course, some exceptions (marked in red). One may observe that they are usually connected with question p2.17 or p3.17 ("other factors"). The remaining results show that the frequency and importance of various factors are related to each other. A very important information is that all the values on the diagonal of the table 11 are 0.000 (i.e., they are less than 0.0005). This means that in case of every exclusion factor, its importance is related with its occurrence.

Table 10. The results of χ^2 test: questions about the significance of factors (p2.1-p2.17) vs. themselves

p-val	p2.1	p2.2	p2.3	p2.4	p2.5	p2.6	p2.7	p2.8	p2.9	p2.10	p2.11	p2.12	p2.13	p2.14	p2.15	p2.16	p2.17
p2.1	0.000	0.000	0.000	0.001	0.041	0.000	0.000	0.000	0.003	0.006	0.005	0.006	0.000	0.000	0.000	0.000	0.114
p2.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.029	0.000	0.000	0.002	0.000	0.283
p2.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.051	0.000	0.002	0.005	0.026	0.002	0.250
p2.4	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.003	0.004	0.009	0.001	0.001	0.000	0.663
p2.5	0.041	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.306	0.009	0.028	0.002	0.602
p2.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.047	0.002	0.000	0.017	0.000	0.288
p2.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.001	0.000	0.229
p2.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.006	0.000	0.000	0.000	0.010	0.000	0.403
p2.9	0.003	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.268	0.000	NA
p2.10	0.006	0.000	0.000	0.001	0.000	0.000	0.001	0.000	0.000	0.000	0.004	0.000	0.011	0.006	0.174	0.000	NA
p2.11	0.005	0.000	0.051	0.003	0.000	0.000	0.000	0.006	0.000	0.004	0.000	0.023	0.000	0.000	0.000	0.001	0.753
p2.12	0.006	0.029	0.000	0.004	0.000	0.047	0.000	0.000	0.000	0.000	0.023	0.000	0.001	0.391	0.104	0.000	0.109
p2.13	0.000	0.000	0.002	0.009	0.306	0.002	0.000	0.000	0.000	0.011	0.000	0.001	0.000	0.000	0.000	0.000	0.707
p2.14	0.000	0.000	0.005	0.001	0.009	0.000	0.000	0.000	0.000	0.006	0.000	0.391	0.000	0.000	0.000	0.000	0.094
p2.15	0.000	0.002	0.026	0.001	0.028	0.017	0.001	0.010	0.268	0.174	0.000	0.104	0.000	0.000	0.000	0.000	0.009
p2.16	0.000	0.000	0.002	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.041
p2.17	0.114	0.283	0.25	0.663	0.602	0.288	0.229	0.403	NA	NA	0.753	0.109	0.707	0.094	0.009	0.041	0.000

Source: own computations

Table 11. The results of χ^2 test: questions about the significance of factors (p2.1-p2.17) vs. questions about the frequency of factors (p3.1-p3.17)

p-val	p3.1	p3.2	p3.3	p3.4	p3.5	p3.6	p3.7	p3.8	p3.9	p3.10	p3.11	p3.12	p3.13	p3.14	p3.15	p3.16	p3.17
p2.1	0.000	0.062	0.029	0.308	0.256	0.074	0.007	0.000	0.029	0.001	0.002	0.531	0.000	0.000	0.002	0.014	0.617
p2.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.016	0.000	0.000	0.017	0.004	0.000	0.053	0.001	0.648
p2.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.001	0.009	0.055	0.000	0.115	0.322	0.205
p2.4	0.015	0.000	0.000	0.000	0.000	0.000	0.055	0.000	0.031	0.001	0.024	0.025	0.310	0.024	0.109	0.037	0.259
p2.5	0.038	0.000	0.000	0.000	0.000	0.000	0.011	0.000	0.000	0.205	0.017	0.110	0.013	0.107	0.545	0.125	0.018
p2.6	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.022	0.120	0.326	0.181	0.001	0.737	0.000	0.103
p2.7	0.000	0.000	0.088	0.003	0.000	0.001	0.000	0.000	0.000	0.014	0.000	0.000	0.008	0.009	0.039	0.001	0.156
p2.8	0.015	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.003	0.012	0.000	0.000	0.000	0.436
p2.9	0.217	0.000	0.001	0.002	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.052	0.017	0.033	0.036	NA
p2.10	0.138	0.062	0.009	0.002	0.002	0.000	0.542	0.000	0.000	0.000	0.000	0.000	0.096	0.020	0.053	0.377	NA
p2.11	0.000	0.002	0.176	0.013	0.006	0.001	0.001	0.641	0.020	0.106	0.000	0.073	0.000	0.000	0.000	0.002	0.809
p2.12	0.092	0.154	0.002	0.260	0.002	0.024	0.000	0.000	0.000	0.000	0.156	0.000	0.249	0.004	0.265	0.001	0.399
p2.13	0.003	0.001	0.035	0.170	0.071	0.012	0.002	0.001	0.020	0.482	0.492	0.013	0.000	0.000	0.000	0.000	0.622
p2.14	0.001	0.000	0.001	0.004	0.018	0.000	0.000	0.000	0.000	0.051	0.000	0.316	0.000	0.000	0.000	0.000	0.172
p2.15	0.000	0.006	0.189	0.042	0.031	0.311	0.063	0.016	0.014	0.427	0.024	0.083	0.000	0.000	0.000	0.000	0.456
p2.16	0.056	0.000	0.003	0.000	0.001	0.000	0.001	0.000	0.052	0.015	0.003	0.009	0.013	0.000	0.000	0.000	0.140
p2.17	0.800	0.442	0.200	0.906	NA	0.797	0.848	0.509	0.271	NA	0.928	0.761	0.319	0.070	0.137	0.011	0.000

Source: own computations

Table 12. The results of χ^2 test: questions about the frequency of factors (p3.1-p3.17) vs. themselves

p-val	p3.1	p3.2	p3.3	p3.4	p3.5	p3.6	p3.7	p3.8	p3.9	p3.10	p3.11	p3.12	p3.13	p3.14	p3.15	p3.16	p3.17
p3.1	0.000	0.000	0.000	0.000	0.018	0.000	0.000	0.000	0.007	0.028	0.000	0.285	0.000	0.000	0.000	0.000	0.421
p3.2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.018	0.000	0.006	0.000	0.000	0.000	0.000	0.089
p3.3	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.017	0.000	0.000	0.000	0.000	0.000	0.285
p3.4	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.719
p3.5	0.018	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.003	NA
p3.6	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.002	0.000	0.000	0.000	0.000	0.001	0.087
p3.7	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.000	0.974
p3.8	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.000	0.000	0.121
p3.9	0.007	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.001	0.613
p3.10	0.028	0.018	0.000	0.000	0.000	0.000	0.012	0.000	0.000	0.000	0.000	0.000	0.111	0.000	0.003	0.059	NA
p3.11	0.000	0.000	0.017	0.000	0.000	0.002	0.000	0.000	0.000	0.000	0.000	0.073	0.000	0.000	0.000	0.000	0.841
p3.12	0.285	0.006	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.073	0.000	0.016	0.258	0.118	0.000	0.562
p3.13	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.002	0.000	0.111	0.000	0.016	0.000	0.000	0.000	0.000	0.041
p3.14	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.258	0.000	0.000	0.000	0.000	0.866
p3.15	0.000	0.000	0.000	0.000	0.000	0.001	0.000	0.000	0.000	0.003	0.000	0.118	0.000	0.000	0.000	0.000	0.150
p3.16	0.000	0.000	0.000	0.000	0.003	0.000	0.000	0.000	0.001	0.059	0.000	0.000	0.000	0.000	0.000	0.000	0.001
p3.17	0.421	0.089	0.285	0.719	NA	0.087	0.974	0.121	0.613	NA	0.841	0.562	0.041	0.866	0.150	0.001	0.000

Source: own computations

CONCLUSIONS

The research described in this article confirms that the exclusion factors are an important part of activity of the companies transporting goods. Although the distributions of the frequencies are different, depending on the factor, one may observe that every factor was noticed by a significant fraction of companies. This confirms also that the list of factors, prepared based upon the qualitative research [Anholcer, Kawa 2017], properly reflects the real situation.

The analysis of the potential dependencies between the variables show that the importance and occurrence of the factors is rather independent from the company's features. There are, however, some exceptions (usually between 5 and 10 factors per each feature). There are, however, also the features (like location of the headquarters and legal form) which have no influence on any of the exclusion factors.

This means that one should study all the existing dependencies – e.g. operating in some markets clearly increases or decreases the exposition on some exclusion factors (which cause, in turn, additional costs).

What is also interesting – the occurrence and importance of various factors are dependent (with few exceptions). It means that when being subject to some exclusion, one should expect that soon also other exclusions would appear.

Of course, we plan further research in this area, mostly based upon further exploration of the data collected with the questionnaire. First, we will use the results of the quantitative research to develop mathematical models of the transportation problems. We also collected data about the losses and defects that may occur during transportation or storage and we are in train of analyzing them. Finally, taking into account the results of the analyses, we plan to prepare more effective methods of planning the deliveries.

The limitation of the methodological nature of this study is the essence of a quantitative research, especially data collected with the questionnaire. This method is burdened with the risk of free interpretation of phenomena and concepts by both the respondents and the researchers, their subjectivity, variability of the examined environment, and evaluation.

ACKNOWLEDGMENTS AND FUNDING SOURCE DECLARATION

The publication was financed from the funds of the National Science Center granted on the basis of decision number DEC-2014/13/B/HS4/01552.

REFERENCES

Anholcer M., Kawa A., 2012. Optimization of Supply Chain via Reduction of Complaints Ratio. In: Jezic G., Kusek M., Ngoc-Thanh Nguyen N.-T., Robert J., Howlett R.J., Lakhmi C., Jain L.C. (eds.), Agent and Multi-Agent Systems. Technologies and Applications. Lecture Notes in Computer Science, 2012, 7327/2012. http://doi.org/10.1007/978-3-642-30947-2_67

Anholcer M., Kawa A., 2017. Identyfikacja ograniczeń wykluczających w transporcie – wyniki badań przeprowadzonych metodą jakościową. Gospodarka Materiałowa i Logistyka 06/2017, 18–24. [Identification of Exclusionary Constraints in Transport - Research Results Conducted by Qualitative Method]

Anholcer, M., Kawa, A., 2015. Optimization of transportation decisions under exclusionary side constraints in food supply chain. In: Bruzzone A., Longo F., Mercadé-Prieto R., Vignali G. (eds.): Proceedings of the International Food Operations and Processing Simulation Workshop, DIME UNIVERSITA DI GENOVA, Genova, 28-33.

Bazarnik, J., Grabiński, T., Kąciak, E., Mynarski, S., Sagan A., 1992. Badania Marketingowe. Metody i Oprogramowanie Komputerowe [Marketing research. Computer methods and software]., Canadian Consortium of Management Schools, Warszawa – Kraków: Akademia Ekonomiczna w Krakowie

Blake A., Kotseridis Y., Brindle I.D., Inglis, D., Pickering, G.J., 2010. Effect of light and temperature on 3-alkyl-2-methoxypyrazine concentration and other impact odorants of Riesling and Cabernet Franc wine during bottle aging. Food Chemistry, 119 (3), 935–944. http://doi.org/10.1016/j.foodchem.2009.07.052

Brenner V., Hülsmann M., Cordes-Berszinn P., 2014. Improving Flexibility in Autonomous Cooperating Food Chains. In: Nandakumar M., Jharkharia S., Nair A. (eds) Organisational Flexibility and Competitiveness. Flexible Systems Management. Springer, New Delhi, http://doi.org/10.1007/978-81-322-1668-1_20

Broom D.M., 2008. The welfare of livestock during road transport. In: M. Appleby, V. Cussen, L. Garcés, L. Lambert and J. Turner (Editors) Long Distance Transport and the Welfare of Farm Animals 157-181. Wallingford: CABI.

Butzke C.E., Vogt E.E., Chacon-Rodriguez L.C., 2012. Effects of heat exposure on wine quality during transport and storage. Journal of Wine Research, 23 (1), 15–25. http://doi.org/10.1080/09571264.2011.646254

Cao B., 1992. Transportation problem with nonlinear side constraints a branch and bound approach. Mathematical Methods of Operations Research (ZOR) 36, 185–197. http://doi.org/10.1007/BF01417216

Cao B., Uebe G., 1995. Solving transportation problems with nonlinear side constraints with tabu search. Computers & Operations Research 22, 593–603. http://doi.org/10.1016/0305-0548(94)00055-D

Darmann A., Pferschy U., Schauer J., Woeginger G.J., 2011. Paths, trees and matchings under disjunctive constraints. Discrete Appl Math 159 (16):1726–1735. http://doi.org/10.1016/j.dam.2010.12.016

Eurostat 2016. Transportation and storage statistics – NACE Rev. 2, http://ec.europa.eu/eurostat/statistics-explained/.

Glover F., Karney D., Klingman D., Russel R., 1978. Solving singly constrained transshipment problems, Transportation Science 12, 277–297. http://doi.org/10.1287/trsc.12.4.277

Goldstein S., 2010. Pallet firms push global ops. Packaging News, (February), 32–33.

Goossens D., Spieksma F.C.R., 2009. The transportation problem with exclusionary side constraints. 4OR, A Quarterly Journal of Operations Research, 7, 51–60. http://doi.org/10.1007/s10288-007-0067-z

Kawa A., Anholcer M., 2018. Exclusionary constraints in storage: an empirical study of logistics service providers. Logforum 14 (3), 4. http://doi.org/10.17270/J.LOG.2018.283

Klingman D., Russel R., 1975. Solving constrained transportation problems. Operations Research , 23, 1, 91-10, Published by: INFORMS https://www.jstor.org/stable/169788

Kurmanov N., Tolysbayev B., Abilmazhinov Y., 2015. The limiting storage life of perishables during joint transportation, CBU International Conference Proceedings, Prague, 3, 499–505. http://doi.org/10.12955/cbup.v3.644

Lu L., Zheng W., Lv Z., Tang Y., 2013. Development and application of time-temperature indicators used on food during the cold chain logistics. Packaging Technology and Science, 26, 1, 80–90. http://doi.org/10.1002/pts.2009

Muncke J., Backhaus T., Geueke B., Maffini M.V., Martin O.V., Myers J.P., Scheringer M., 2017. Scientific challenges in the risk assessment of food contact materials. Environmental Health Perspectives, 125 (9). http://doi.org/10.1289/EHP644

Murray M., 2014. Reducing Transportation Costs, http://logistics.about.com/od/forsmallbusinesses/a/Reducing-Transportation-Costs.htm (access: 10.06.2014).

Öncan T., Zhang R., Punnen A.P., 2013. The minimum cost perfect matching problem with conflict pair constraints, Computers & Operations Research, 40, 4, April 2013, 920–930. https://doi.org/10.1016/j.cor.2012.10.022

Pferschy U., Schauer J., 2013. The maximum flow problem with disjunctive constraints. Journal of Combinatorial Optimization, 26, 109–119. http://doi.org/10.1007/s10878-011-9438-7

Sun M., 2002. The transportation problem with exclusionary side constraints and two branch-and-bound algorithms. European Journal of Operational Research, 140, 629–647. http://doi.org/10.1016/S0377-2217(01)00239-9

Thompson G.L., Setbi A.P., 1986. Solution of constrained generalized transportation problems using the pivot and probe algorithm. Computer and Operations Research, 13:1- 9. http://doi.org/10.1016/0305-0548(86)90059-6

Tseng Y., Yue W.L., Taylor M.A.P., 2005. The role of transportation in logistics chain. Proceedings of the Eastern Asia Society for Transportation Studies, 5, 1657–1672.

Vancroonenburg W., Della Croce F., Goossens D., Spieksma F.C.R., 2014. The Red–Blue transportation problem, European Journal of Operational Research 237, 814–823. http://doi.org/10.1016/j.ejor.2014.02.055

Zhang R., Kabadi S.N., Punnen A.P. (2011), The minimum spanning tree problem with conflict constraints and its variations. Discrete Optim 8(2):191–205. http://doi.org/10.1016/j.disopt.2010.08.001

OGRANICZENIA WYKLUCZAJĄCE W TRANSPORCIE - WYNIKI BADAŃ METODĄ ILOŚCIOWĄ

STRESZCZENIE. **Wstęp:** Spośród wszystkich procesów w łańcuchu dostaw, transport jest jednym z najbardziej złożonych i najdroższych. Planując proces transportu, należy wziąć pod uwagę różne czynniki, m.in. ograniczenia wykluczające nałożone na wybranych dostawców, produkty czy środki transportu. Chociaż są artykuły, w których autorzy omawiają problem ograniczeń wykluczających, to nie ma tych dotyczących badań empirycznych. Nasza praca stara się wypełnić tę lukę. Głównym celem tego artykułu jest analiza znaczenia i wagi różnych wykluczeń w transporcie obecnych w praktyce gospodarczej.
Metody: Przedstawiamy wyniki badania metodą ilościową przeprowadzonego na losowej próbie 300 dostawców usług logistycznych w Polsce, dotyczącego ograniczeń wykluczających w transporcie.
Wyniki: Badania potwierdzają, że warunki wykluczające stanowią ważną część działalności firm zajmujących się transportem towarów. Chociaż rozkłady częstości są różne, w zależności od czynnika, można zauważyć, że każdy został

zauważony przez znaczną część respondentów. Analiza potencjalnych zależności pomiędzy zmiennymi pokazuje, że znaczenie i częstotliwość czynników jest raczej niezależna od cech przedsiębiorstwa. Nasze badanie stanowi wkład w teorię i praktykę przedsiębiorstw logistycznych.
Wnioski: Badanie to stanowi rozszerzenie wcześniejszych badań nad ograniczeniami wykluczającymi z wykorzystaniem badań empirycznych. W przyszłych pracach wykorzystamy wyniki badań ilościowych do opracowania modeli matematycznych problemów transportowych i chcemy przygotować bardziej efektywne metody planowania dostaw.

Słowa kluczowe: transport, ograniczenia wykluczające, badania metodą ilościową, logistyka.

Marcin Anholcer ORCID ID: https://orcid.org/0000-0001-7322-7095
Poznań University of Economics and Business
Department of Operations Research
al. Niepodległości 10, 61-875 Poznań, **Poland**
e-mail: m.anholcer@ue.poznan.pl

Arkadiusz Kawa ORCID ID: https://orcid.org/0000-0003-0697-8838
Łukasiewicz Research Network – Institute of Logistics and Warehousing
Ul. Estkowskiego 6, 61-755 Poznań, **Poland**
e-mail: arkadiusza.kawa@ilim.lukasiewicz.gov.pl