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STATISTICAL ANALYSIS AND PREDICTION OF THE PRODUCT COMPLAINTS

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Abstract: The article presents the results of the analysis of cardboard packaging complaints based on selected quality tools and statistical tools for the purpose of a rough assessment of the effectiveness of corrective and preventive actions taken by the surveyed company and for predictive purposes. The analysis was performed in terms of two research periods - 1 year and quarters, and from the point of view of total complaints and external - customer complaints. Data on the number of products complained of as well as financial losses incurred by the company on this account were analysed. The article presents the potential of both classic quality tools and statistical tools for the purposes of in-depth analysis of complaints data and for predictive purposes and subsequent risk analysis. The critical complaint was indicated - complaint code 403 - overprint. The number of complained products to be expected in the next quarter of the new year was determined. The article shows that the corrective and preventive actions taken by the company have not yet brought the expected result in the form of reducing the number of products complained by customers during the quarters surveyed.
Keywords: quality management, cardboard packaging, complaints, quality tools, statistical analysis, prediction

1. INTRODUCTION

The quality of the product delivered to the market is one of the most important factors influencing the company's competitiveness in the market (Ingaldi, 2021). One of the methods of assessing the quality level of products is by relating it to the quantity of non-compliant products produced in the production process and/or the number of products complained about by customers (Pacana and Czerwińska, 2020). The occurrence of non-conformities in the manufactured product causes, it does not meet customer expectations and excessive production costs arise (Potkány et al., 2021). Due to the low quality of products, enterprises also often incur high costs of warranty repairs. It is also associated with customer dissatisfaction, which translates into lower

future sales (Krynke, Mielczarek, Kiriliuk, 2021). In order to increase customer satisfaction, production companies try to detect any non-conformities of products during the production process. This reduces the costs associated with possible complaints or returns (Schiffauerova and Thomson, 2006). The number of non-conforming products or products complained about gives information about the current quality level (Webber, Wallace, 2012) and can be treated as a reflection of the effectiveness of corrective and preventive actions in relation to the identified quality problems (Performance Review Institute ed., 2006). Effective corrective and preventive actions aimed at finding the right root cause of quality problems, their proper implementation should bring benefits in the form of a reduction in the number of complaint events, and the number of products complained about by customers in the end (Tashi, Mbuya, Gangadharappa, 2016). Companies strive to ensure a low risk of non-conformance in the production process, which includes high efficiency of their detection (Hamrol, Kujawińska, Bożek, 2020), a low chance of their occurrence in the process taking into account the significance of a given non-conformance for customer and for the next steps in the process (Hamrol, 2005). Undoubtedly, each non-conformance is associated with costs for the company, which are the greater the non-conformance is later detected in the production process, and the largest is when the non-conforming product reaches the customer (Ji, Ameri, Cho, 2021). Therefore, companies should, in order to increase the effectiveness and efficiency of their production processes, carry out an in-depth analysis of cases of identified non-conformities of products.

When conducting product non-conformities analyses, classic quality tools are often used, such as the Ishikawa diagram, Pareto-Lorenz diagram, or attribute control cards (Tarí and Sabater, 2004). Most of the quality tools use data, which makes the analysis more reliable (Pavletic, Sokovic, Paliska, 2008), and allows for better management and improvement of the process. Having data on the number and types of non-conformities or non-conforming products, more or less advanced statistical procedures can be applied to them in order to discover additional relationships that can be used for improvement purposes (Makarov, 2015). In-depth analysis of non-conformities data can steer corrective actions back on track. Anticipating the number of incidents of non-conformities helps management be better prepared for the future by identifying the most likely scenario. It is better to know the future in a few percent than to know only the past in 100%. Predicting the number and types of non-conformities is an important element of the risk analysis and enables anticipatory improvement actions to be taken.

2. METHODOLODGY

The aim of the article is to statistically analyse complaints of cardboard packaging in the surveyed company in the research period of 1 year, and then in the sub-periods of this period - quarters, and to predict the number of products complained by customers for one subsequent sub-period ahead. Complaints in the examined enterprise are divided into internal and external. Internal complaints are those detected internally by the quality control services and employees assigned to control tasks. In turn, external complaints are complaints submitted by customers. Both types of complaints result in certain financial losses for the company, but the losses caused

by external complaints are more serious. Internal and external complaints together constitute total complaints. The research undertaken in the article concerns two issues regarding complaints: the number of complained products (in pieces) in the analysed periods and financial losses incurred by the company in connection with complaints. The research period in the analysis was 1 year, which was then divided into quarters. The object of the research is the producer of corrugated cardboard packaging. The company produces packaging from 3 and 5-layer cardboard on grey, white, and white papers coated based mainly on recycled papers. The company's main customers are the largest companies in the food, fruit and vegetable, household chemicals, and alcohol industries.

The purpose of this article is to answer the following questions:

1. Which of the total reasons for the complaint of corrugated boards are critical in terms of the number of products complained about and critical in terms of the related financial losses?
2. Which of the total reasons for the complaint of corrugated boards are critical in terms of the number of products complained about and in terms of financial losses together?
3. Which reasons for the total complaint of corrugated boards are unusual in terms of the number of products complained about and in terms of financial losses related to them?
4. Which reasons for external complaints of corrugated boards are unusual in terms of the number of products complained about in individual quarters of the year?
5. What is the relationship between the numbers of products complained by customers for particular reasons in the quarters of the year under review?
6. Is there a significant difference between the numbers of products complained by customers for various reasons for the compared quarters of the year? If so, which year's quarters are different, and what is the difference?
7. Does the data on the number of products complained by customers in the following year's quarters show a trend? If so, in what direction?
8. What is the forecast regarding the number of products complained by customers for the next quarter of the new year?

In order to answer the question (1), quality tools were used - a Pareto-Lorenz diagram and a matrix data analysis diagram. The Pareto-Lorenz diagram is a classic quality tool used to validate factors based on data such as the number of occurrences for a given period. The Pareto-Lorenz diagram makes it possible to separate factors the important from the less important (Stasiak-Betlejewska and Czajkowska, 2017). The Pareto-Lorenz diagram was used in order to validate the reasons for complaints due to the number of complained products and the financial losses they generate. It allowed identifying the reasons for the complaints that were critical in terms of the criteria under consideration.

In order to answer the question (2), a matrix data analysis diagram was used. Matrix data analysis is a new quality tool for identifying and reading the occurrence of a specific factor depending on two or more variables. It allows looking at a large amount of data. The matrix data analysis was used to look for the relationship between the share of the number of products complained and the share of financial losses on this

account, and to indicate the cause of the complaint which is critical due to these two criteria jointly (Mizuno, 1988, Nayatani, Eiga, Futami, 2006, Andrássyová et al., 2013). In order to obtain answers to questions (3) and (4), a box and whisker plot in the version of the median-quartile-range was used. The box-whisker plot is one of the statistical tools of quality management methods used to present the distribution of a statistical feature based on the calculated descriptive statistics. In the case of a median-quartile-range chart, these are descriptive statistics like median, quartiles, and range. It allows you to identify atypical values in the data set, that is, values that differ significantly from the rest. Atypical values are defined as outliers or extreme values depending on the met inequality and marked differently in the box and whisker plot. Outliers appear in the box plot when the inequality is met: upper outlier value: subject's result ≥ Q1−1.5 ∗ IQR; lower outlier value: subject's result ≤ Q3 + 1.5 ∗ IQR. The extreme values appear in the box plot when the inequality is satisfied: upper extreme value: subject's result ≥ Q3 + IQR * 3; lower extreme value: subject's result ≤ Q1 - IQR * 3 (where: IQR = Q3 − Q1, Q1 - first quartile, Q3 - third quartile). Outliers are usually marked on a box plot with a "circle", while extreme values with a "star" (Marmolejo-Ramos and Tian, 2010).

In order to answer the question (5), a picture graph of the Chernoff faces type (Chernoff, 1973) was used. In this chart, the quarters of the year will be visualized by 4 faces in such a way that the relative values of the number of products complained by customers for each complaint cause in those quarters will be represented by a different size or position of different elements of the human face. Chernoff's faces will reveal hidden patterns of interrelationships between the number of products complained for individual reasons for complaints in the quarters under investigation, which are difficult to detect in any other way.

In order to answer the questions (6), the non-parametric Friedmann ANOVA test (Friedman repeated measures analysis of variance by ranks) will be used. This test is used when the measurements of the tested variable are made several times (k> = 2) under different conditions (Więckowska, 2021). The hypotheses verified in the research are: H0: there is no significant difference between the number of products complained by customers for the compared quarters, H1: the difference in the number of products complained by customers between at least two quarters is significant.

In order to answer the question (6), the Page trend test (Daniel, 1990, Więckowska, 2021) and the Neumann Q test (Neumann Trend Test) (Tóth, 2010) were used. It was verified whether the corrective and preventive actions taken by the company's management in relation to the total complaints had an impact on the reduction of the number of items of products complained by customers in subsequent quarters of the year. The Page test for ordered alternatives and Neumann's Q test will indicate the existence (or absence) of a significant trend in the subsequent quarters of the year in terms of the number of products complained by customers. Test Page for trend is a repeated measure trend test (Daniel, 1990). Neumann's Q test examines a series of values ordered over time in terms of trend and is especially useful for trend analysis with a small amount of data (≥ 4) (Tóth G., 2010).

In order to answer the question (7), the Excel program was used, the scatter plot type built into the program with straight lines and markers, and the function of adding trend lines based on the plotted data. The type of linear trend was used. A simple regression

form has been added that has been plotted on the scatter plot. The fit of the regression model to the data was determined by calculating the convergence coefficient R squared.
Statistica 13.3, PQStat 1.8, and Excel programs were used as a statistical data analysis tools.

3. RESULTS AND DISCUSSION

The reasons for complaints about cardboard packaging in the surveyed company for a period of 1 year were analysed, depending on the place of their detection: within the company (internal complaints) and at the customer (external complaints). The list of detected complaints (Table 1) indicates 35 different reasons not related only to production, but also arising in other departments of the company, and resulting from reasons not related to production. The list of complaint codes for cardboard packaging, their reasons together with a detailed description is presented in Table 1.

Table 1
Reasons for complaints about cardboard packaging, their description and codes

Code	Short description	A detailed description of the error
101	Raw material quality	The quality of the raw material influencing the processes related to its processing
102	Tools	Tools missing or damaged
201	Packaging molding / construction	Improper packaging formation, poor design
301	Creases	No creases or improper placement of creases, weak creases
302	Lack of paper on the edge	There is no paper on the edge of the sheet
303	Sheet format	Wrong sheet format
304	The quality of the cardboard surface	Uneven surface, paper wrinkles, grater, kinks between wave crests, blisters
305	The quality of cardboard gluing	Inadequate sticking of cardboard, delamination
306	Cardboard curve	Curvature, warping of cardboard
401	Punching elements	Rotary die cutter missing or misplaced, frayed edges and gaps, flat die punch defects
402	Gluing packages	Improper gluing of the packaging
403	Overprint	Improper print, smudged print, underprints; wrong color
404	Product marking	Product marking not in accordance with the customer's requirements
405	Packing	Packaging not in accordance with the customer's requirements, bad strapping, lack of foil, Pallets not in accordance with the production order, etc.
406	Cracking	Cardboard cracking on creases or during cutting
407	Size of the package	Incorrect packaging dimensions
408	Crushed cardboard	Incorrect waveform, damage during production
409	Wrong layout on the sheet	Wrong arrangement of the print or pattern on the sheet in relation to the print, reverse wave direction

410	Quantity	Quantitative defect
411	Tape	Bad placement, bad incision
412	Palette	Wrong size pallets, damaged pallets, wrong number of pallets on delivery note, etc.
413	Machinery	Technical condition of machines
414	Barcode	Code unreadable, unprinted on the bar code
501	Spoilage on the Magazine of Finished Products (MFP)	Unable to find goods on MFP
502	Spoilage after inventory	No goods after inventory at MFP
503	Wrong: delivery / documents	Incorrect delivery documents or delivery errors
504	Damage	Damage during storage or transport, getting wet
505	Spoilage on PR	Unable to find goods on PR
701	Incorrect data in CPMS	Incorrect data entered into CPMS, incorrect quantities
702	Communication	Bad flow of information, lack of information, false information, no contact
703	Confused batch	Confused papers
704	Price	Price inconsistent with the commercial offer
705	Cooperation	The complaint is recognized for the good of cooperation with the client
900	Other complaints	
901	Tests	Product development, first launch

An analysis of internal and external complaints (in total) over a period of 1 year was performed, first, using the classic quality tool - the Pareto-Lorenz diagram. Both data on the number of complained products (quantitative approach) and data on the value of complaints (cost approach) were analysed. The Pareto-Lorenz diagram made it possible to separate the reasons for complaints in total, important from less important, and to indicate those reasons that should be addressed in the first place due to their high frequency of occurrences in the audited year and generated financial losses for the company.

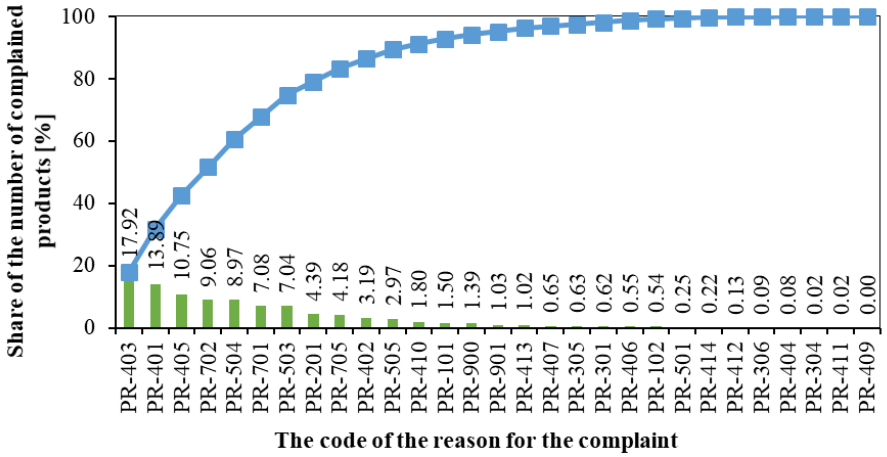

Fig. 1. Pareto-Lorenz diagram for identifying the critical complaints causes of cardboard packaging in terms of frequency of occurrence during the year

The reasons for the total complaints about the largest number of defective products generated are those marked with codes 403, 401 and 405. These reasons generate 42.55% of all quality problems. These are the reasons closely related to the production that appear during the production of products.
The financial losses incurred in connection with total complaints were analysed using the Pareto-Lorenz diagram (Fig. 2).

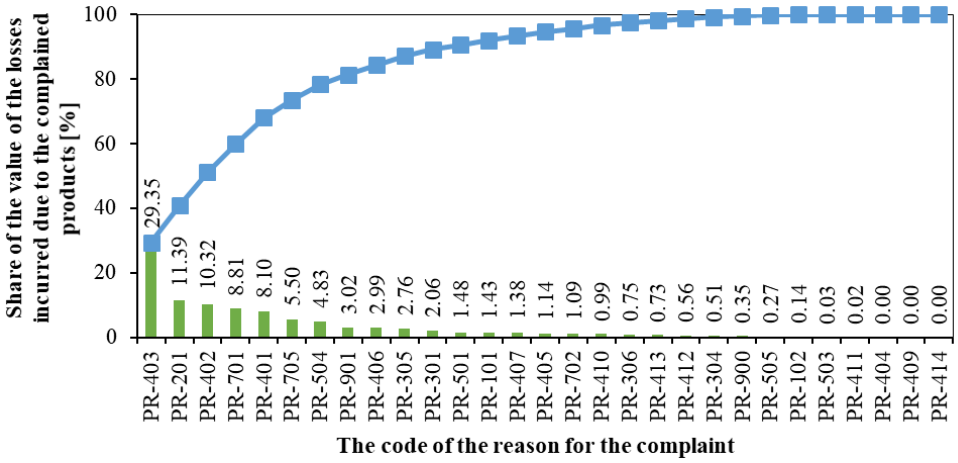

Fig. 2. Pareto-Lorenz Lorenz diagram for identifying the critical complaints causes of cardboard packaging in terms in terms of financial losses incurred by the company during the year

As the diagram shows, the key reasons for complaints in general, which generate the highest costs, are those marked with the codes 403, 201 and 402. The first three reasons for complaints generate 51.05% of financial losses due to complaints for the examined company. The dominant cause of complaints, both in terms of the frequency of occurrences and in terms of the value of the loss suffered by the examined company, is the one related to improper printing (improper print, smudged print, no print, wrong colour).
In order to jointly evaluate the complaint in terms of the number of products complained of and the losses incurred by the company under investigation, an additional matrix data analysis diagram was created (Fig. 3).

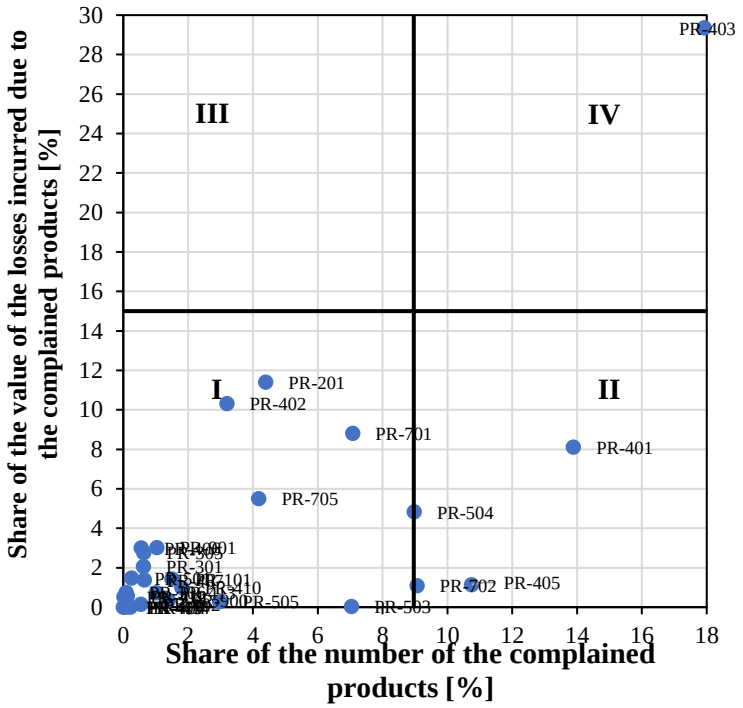

Fig. 3. A matrix data analysis diagram for the analysis of the relationship between the share and costs of the complaints reasons in total on an annual basis

The individual quarters of the diagram have been assigned the following meaning: quarter I: reasons for the complaint - trivial (rarely occurring and do not result in significant costs), quarter II: reasons for the complaint - burdensome (not expensive, but visible, because they often occur), quarter III: reasons for the complaint - expensive (rarely occur, but result in significant costs), quarter IV: critical reasons for complaints (they often arise and result in significant costs). The following reasons for complaints were included in the individual quarters of the matrix data analysis diagram (Table 2).

Table 2
Classification of the reasons for complaints with regard to the frequency of occurrence and total costs based on a matrix diagram

A quadrant of a matrix diagram	III: Complaints reasons which are costly	IV: Complaints reasons which are critical
Complaints reason code	-	PR-403
A quadrant of a matrix diagram	I: Complaints reasons which are trivial	II: Complaints reasons which are inconvenient
Complaints reason code	PR-101, PR-102, PR-201, PR-301, PR-304, PR-305, PR-306, PR-402, PR-404, PR-406, PR-407, PR-409, PR-410, PR-411, PR-412, PR-413, PR-414, PR-501, PR-503, PR-504, PR-505, PR-702, PR-705, PR-900, PR-901	PR-401, PR-405, PR-701

In quarter IV there was only one reason for the complaint - code 403, i.e. overprint. This reason should be considered - according to the adopted criteria - as critical and the company should pay attention to its minimization in the first place.
To determine whether the recorded values of the number of products complained of and the related financial losses are atypical, a matrix diagram in the version of the box and whisker plot was used (Fig. 4).

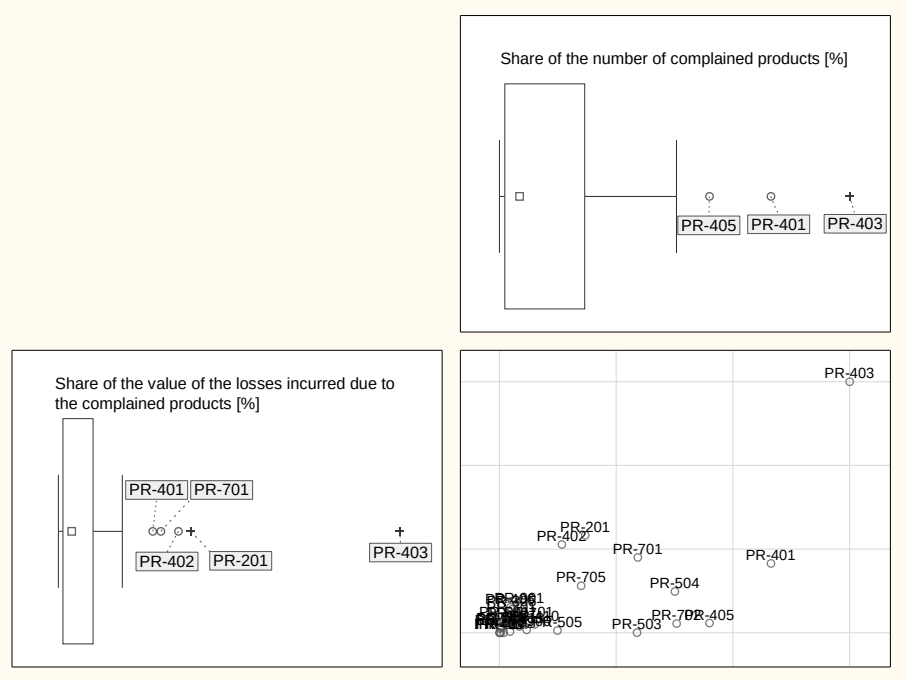

Fig. 4. Matrix diagram of the box and whisker plot type for identifying outliers of reasons for complaints due to the frequency of occurrences and generated financial losses

As shown in Fig. 4, the unusual values of losses due to complaints concerned the causes of complaints code 401, 402, and 701, while extreme complaints code 403. On the other hand, non-standard values of the share of the number of products complained about related to complaints code 401 and 405, extreme ones - complaints with code 403.
An analysis of the frequency of occurrences of the number of products complained of by the customer with a breakdown into individual quarters of the year was performed in order to identify unusual and extreme cases of the number of products complained about in individual quarters of the year. For this purpose, a box and whisker plot was used (Fig. 5).

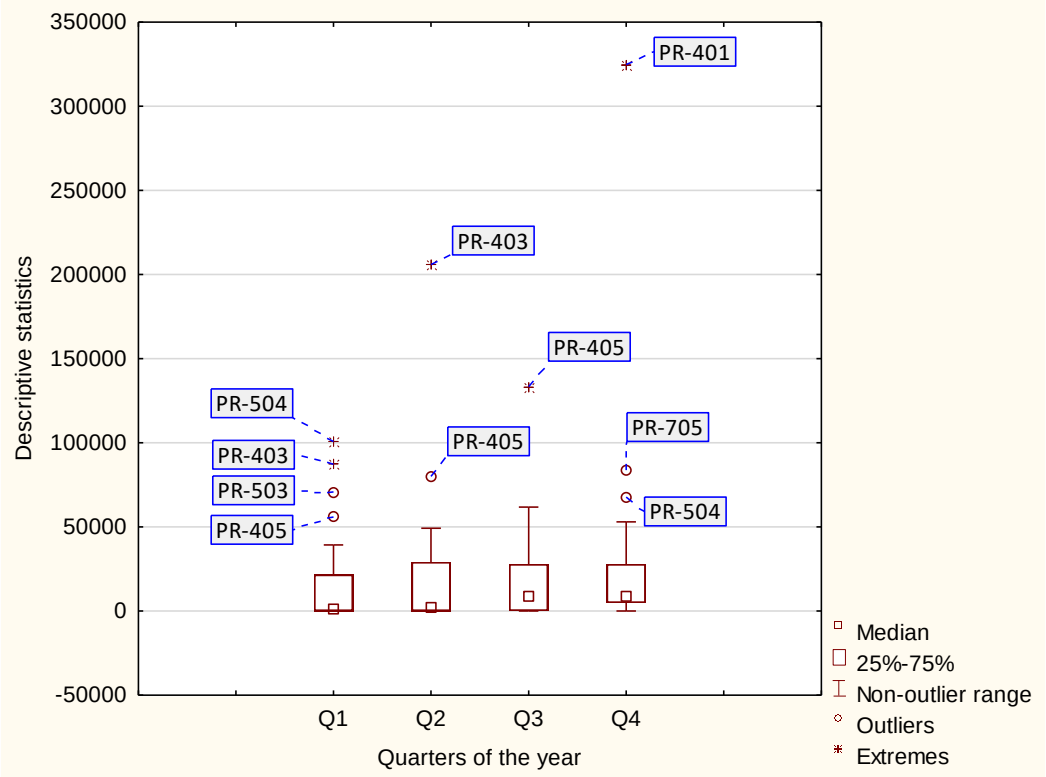

Fig. 5. A box and whisker plots for identifying the outlier of the complaints reasons in terms of the number of complained products by the customer in each quarter of the year

In the first quarter of the year, the reasons for the customer's complaint code such as 405 and 503 should be indicated as unusual values of the occurrences, and the extreme ones - 403 and 504 as the extreme ones. In the second quarter of the year, the customer's complaint with the code 405 should be considered as the unusual value of the occurrences, and the customer complaint code 403 as extreme - 403. In the third quarter of the year there is one extreme value of the customer's complaint - code 405, while in the fourth quarter of the year there were two unusual values for the number of occurrences of customer complaints with the code - 504 and 705, and one extreme, but with a significant degree of extreme - 401. From the analysis of the box and whisker plot in individual quarters of the analysed year, they stood out in terms of the number of products complained by customers, in particular the reasons for complaints with the code 504 (damage), 403 (overprint) and 405 (packaging) and 401 (punching elements).

In terms of the number of products complained by the customer, the fourth quarter was characterized by the highest relative volatility (coefficient of variation), followed by the second quarter, and the lowest quarter for the third quarter (Table 3).

Table 3
Basic descriptive statistics for the analysis of the number of complained products by the customer in each quarter of the year

Quarter of the year	Mean	Median	Lower Quartile	Upper Quartile	Range	Quartile range	St. Dev.	Coefficient of variation
Q1	19417.0	974.0	0.0	21665.0	100730.0	21665.0	31072.9	160.0
Q2	23564.6	1780.0	0.0	29221.0	205957.8	29221.0	46406.7	196.9
Q3	21742.5	9000.0	140.0	27924.0	133366.0	27784.0	31777.6	146.2
Q4	32148.3	9295.0	4862.0	27948.0	324820.0	23086.0	69134.4	215.0

Chernoff's faces were used (Fig. 6) to present a multidimensional presentation of the number of products complained by the customer in the individual quarters of the surveyed year. Chernoff's faces made it possible to indicate the extreme values of the number of occurrences of individual reasons for complaints in the quarters under study. The analysis is supplemented by a heat map (Table 4) showing the range of the value of the number of products complained about in three perspectives using colours (from green to red): by reasons for complaints, by individual quarters, and by reasons for complaints and individual quarters in total (cross-sectional approach).

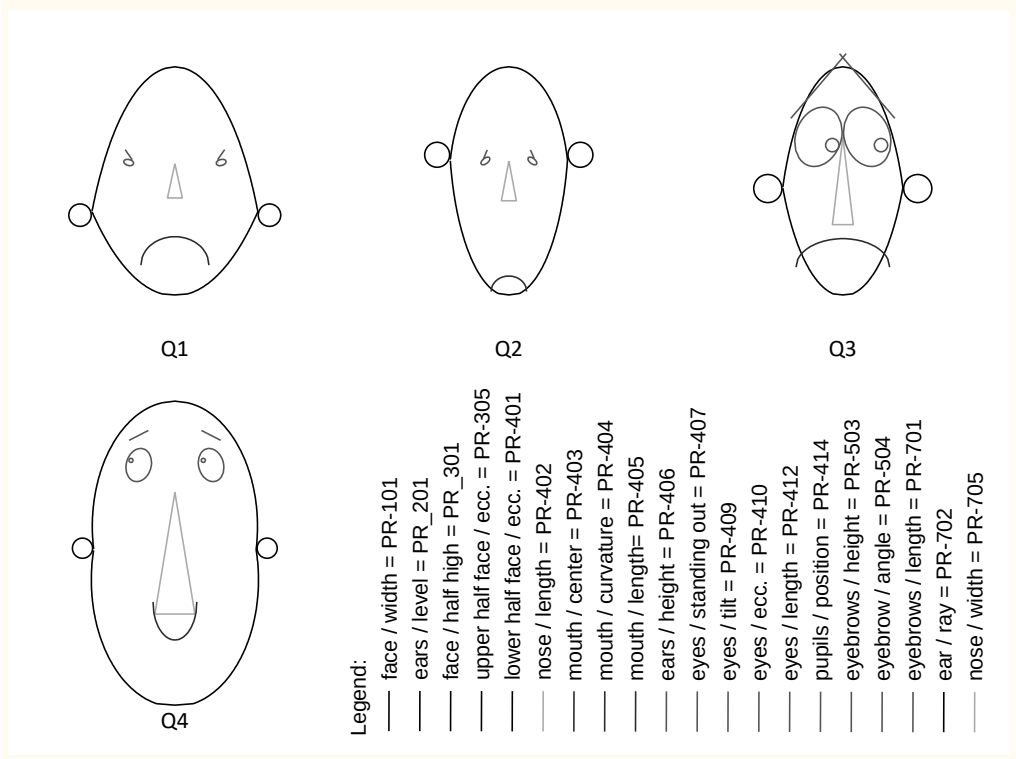

Fig. 6. Chernoff's faces for a multidimensional analysis of the number of products complained by the customer due to individual reasons for complaints in the quarters of the year under study

The analysis shows that each of the quarters analysed differs in terms of the number of products complained about due to the reasons considered. Each face is different, and specific in terms of shape and facial expressions. There is no similarity in the number of products complained by customers for particular reasons in the subsequent quarters of the year. This was also confirmed by the heat map, which shows random colours by quarter.

Table 4
Heat map for the analysis of the number of occurrences of complained products by customers according to three approaches: reasons for complaints, quarters of the year, reasons for complaints & quarters of the year together

Complaints reason code	According to the complaints reasons				According to quarters of the year				Cross-sectional approach			
	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4	Q1	Q2	Q3	Q4
PR-101												
PR-201												
PR-301												
PR-305												
PR-401												
PR-402												
PR-403												
PR-404												
PR-405												
PR-406												
PR-407												
PR-409												
PR-410												
PR-412												
PR-414												
PR-503												
PR-504												
PR-701												
PR-702												
PR-705												
PR-900												
PR-901												

In the last stage of the analysis, an answer to the question was products complained by customers for various reasons for the compared quarters of the year. For this purpose, the non-parametric Friedman ANOVA test was used.
Comparing the p-value of the Friedman's test with the significance level $\alpha = 0.05$, it should be stated that the number of products complained by customers for various reasons does not differ significantly in each quarter of the year.

The expected result of continuous corrective and preventive actions implemented by the company in relation to complaints should be a decrease in the number of their occurrences over the following quarters of the year. The answer to this question was obtained (is there a given trend in the number of products complained in subsequent quarters) using the Page test for the ordered alternatives. The results in this regard are presented in Table 5.

Table 5
The results of the ANOVA Friedman test and the trend test

Friedman ANOVA, trend test	
Analysed variables	Q1;Q2;Q3;Q4
Number of unspecified	0
Number of missing data	0
Significance level	0.05
Accept missing data (Durbin/Skillings-Mack)	Yes
C	550
A	653
T1 statistic Friedman	3.276699
Degrees of freedom	3
p-value	0.350899
T2 statistic Iman-Davenport	1.097051
Degrees of freedom	3 / 63
p-value	0.357041
Skillings-Mack statistic	3.068182
Degrees of freedom	3
p-value	0.381232
Page test for trend	
The ordinal number for [Q1]	1
The ordinal number for [Q2]	2
The ordinal number for [Q3]	3
The ordinal number for [Q4]	4
L statistic	571.5
Z statistic	1.58788
One sided p-value	0.056157
Two sided p-value	0.112313

As shown in Table 5, there is no such trend in the number of products complained in subsequent quarters of the year. Comparing the one-sided value of $p = 0.056157$ with the significance level of $\alpha = 0.05$, it should be stated that the measures taken so far to reduce the number of customer complaints have not yet brought the expected downward trend in the number of products complained.

Another trend test, Neumann's Q trend test, was also used to assess whether the data on the number of products complained by the customer in the following quarters show a trend. The value of the Q test statistic in the considered example is greater than the critical value ($1.39 > 0.80$), which allows for the null hypothesis of no trend at the significance level of 0.05. Data from the analysed quarters of the year regarding the number of products complained by the customer do not show a significant trend.

Prediction were made regarding the number of products complained of by the customer for one period ahead (for the next quarter of the new year) based on the analysis of data on the number of items complained of for the quarters 1-4 of the analysed year (Fig. 7).

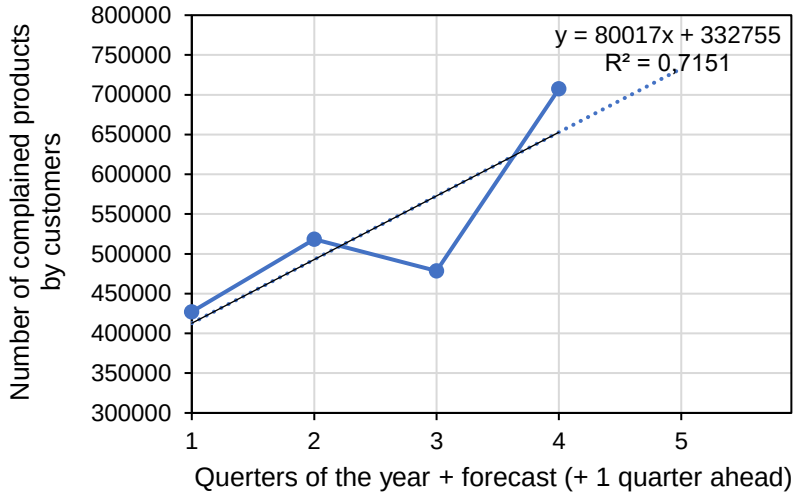

Fig. 7. The trend line for the number of complained products for Q1-Q4 of the current year with a forecast for 1 period ahead (i.e. for the first quarter of the new year)

The derived regression line has the form y = 80017x + 332755 products complained for the "5" quarter, i.e. for the first quarter of the new year. If nothing changes, you should expect approx. 732,840 items of products complained in the next, first quarter of the new year. The coefficient of convergence R square equal to 71% means a relatively good fit of the model - 71% of the variability of the explained variable is explained by the variability of the explanatory variable.

In order for the "black" scenario in the form of increasing the number of products complained in the following quarters to prove to be incorrect, the company must take more effective corrective and preventive actions in relation to the identified causes of the complaint. It is important each time to find the fundamental (root) cause of complaints from customers, which is a necessary condition to take appropriate corrective and preventive actions, bringing the intended effect in the form of reducing the number of products complained in the future. It is important to properly use the 8D methodology or the A3 report for effective complaint analysis. It is also important to use the FMEA method effectively to minimize the risk of all causes of complaints, especially those critical in terms of frequency and costs.

4. CONCLUSION

The aim of the article was a statistical analysis of complaints regarding cardboard packaging recorded within 1 year in order to roughly assess the effectiveness of corrective and preventive actions taken in the analysed company. The analysis was also performed for the purposes of prediction, predicting the number of products complained by customers for the next period under study, i.e. the quarter of the new year. The results were presented both in annual and quarterly terms. The quality tools based on numerical data were used: the Pareto-Lorenz diagram and matrix data

analysis diagram to indicate critical inconsistencies in terms of the number of items complained about and financial losses incurred by the examined company. Appropriate statistical procedures were also used to in-depth the analyses performed and to obtain answers to the research questions posed.

The following conclusions should be drawn from the analyses performed:

- a critical complaint about cardboard packaging, both in terms of the number of complained products and due to financial losses in the analysed period, is a complaint with code 403 - overprint,
- atypical values of financial losses incurred due to complaints were related to the causes of complaints code 401, 402 and 701, while the extreme ones products complained was related to the complaint code 403,
- in terms of the number of products complained about by the customer, the fourth quarter was characterized by the highest relative volatility, and the third quarter the lowest,
- each of the quarters was characterized by at least one unusual or extreme case of the number of products complained for a given reason, there is generally no stability of results in this respect in terms of the quarters surveyed,
- the total number of products complained by customers for various reasons does not differ significantly in each quarter of the year,
- the number of products complained by customers in the following quarters shows a trend that resembles a growing trend, however, the indicated trend is not statistically significant,
- if nothing changes (keeping the ceteris paribus principle, i.e. in the absence of influence or variability of third factors), in the next, first quarter of the new year, should expect approx. 732,840 items of complained products.

The article shows that despite the corrective and preventive actions taken by the company with regard to internal and external complaints, the share of the latter did not decrease in the following quarters of the year, and even increased in the last quarter of the year. A recommendation for the company is to implement corrective and preventive actions faster and to verify the effectiveness of such actions. Reliable performance of the FMEA analysis in the scope of non-compliance risk assessment in the production process should also help to implement appropriate corrective, preventive, and improvement actions, but mainly protect the process against non-conformances. A statistical analysis has been carried out revealed the potential hidden in the data on cardboard packaging complaints, which potential should be used to reduce the number of internal and external non-conformities, increase the effectiveness of quality control processes, and generally to improve the quality of production processes and to reduce manufacturing costs.

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