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The Use of Clustering in Analysis of Business Lines in the Insurance Industry in Conditions of Crisis: The Case of Lloyd's of London

Bożena Frączek , Zuzanna Roch 

ABSTRACT

In an era of the overlapping effects of the Covid pandemic and the conflict in Ukraine, it is worth taking a closer look at the markets that focus on risk management, that is, the insurance market, in terms of its further organization and development. The aim of the paper is to examine how the crises related to the Covid-19 pandemic and the conflict in Ukraine have affected insurance business lines (using a case study of Lloyd's). The study's use of clustering (Ward's method) for insurance business lines at Lloyd's, and its analysis within dynamically changing conditions, is expected to achieve preliminary classifications and insights for further more advanced research, resulting in more effective insurance activities. The impact of the discussed crises on cluster formation is significant. The study is divided into three main periods of analysis: the pre-Covid-19 period, the Covid-19 period and the Covid-19 recovery period (which occurred at the same time as the deepening of the conflict in Ukraine). Clustering highlighted the impact that the described crises have had on the performance of individual lines of business. In addition, it also turned out the division into clusters for insurance and reinsurance is not uniform. The exceptions are the years 2021 and 2022, in which clusters are formed identically for insurance and reinsurance. The results of the research highlight the necessity for further exploration of the study area in order to ensure the best possible further sustainable development of the insurance industry, and to better prepare it for any inconveniences or crises that may affect it.

KEY WORDS:

insurance, reinsurance, Covid-19, conflict in Ukraine, cluster analysis.

JEL Classification: G22.

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1. Introduction

Nowadays, it can be clearly seen that each of the currently functioning segments of the financial market has its own characteristic features, thanks to which many different types can be distinguished. Notwithstanding, it is worth taking a closer look at the markets that focus on risk management, that is, the insurance market, which in the times of the global Covid-19 pandemic and the ongoing conflict in Ukraine have experienced a variety of factors that have significantly

(or not) changed their performance, as well as the perception of the further organization of the business.

The insurance industry, like the other financial sectors, has not escaped the impact of the above-mentioned crisis events, however, it responded to the pandemic and the conflict in Ukraine very rapidly. On the one hand, the insurance industry has had to face a number of challenges and will continue to do so, but on the other hand there are many new opportunities in the medium to long term for the industry.

The literature contains many studies on various

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aspects of the functioning of the insurance market in the face of the Covid-19 pandemic and the conflict in Ukraine. The Covid-19 crisis accelerated the need for digital transformation in insurance companies in order to maintain the current status quo or to be even more customer-oriented, as well as improving their offers and increasing operational efficiency. This is worth to underline that the previous research (before pandemic) often was focused on dissimilar aspects of insurance market, like market transparency and disclosure requirements, ways of regulatory intervention, insurance market discipline, etc. (Eling & Schmit, 2012). The latest research (after pandemic) and its results have focused on presenting and assessing the digitalization processes taking place in the insurance sector in the face of the crisis caused by the Covid-19 pandemic. For example, it has been indicated that in the aftermath of the epidemic, the use of new technologies and of digitalization has had a great impact on customer expectations (Pauch & Bera, 2022). Despite the crucial need for digitalization, PwC points out that in times of economic slowdown, insurers must prioritize cost management and adapt their cost structure so as to remain competitive in a shrinking market. The key is to focus on maintaining stability while preparing for future challenges with resilience. Simplifying the range of insurance products offered can be a beneficial starting point, as catering to individual customer needs with customized policies may not be practical, especially in the digital era (Adams, 2020). At this point, it should be emphasized that all innovations introduced by the insurance industry are accompanied by the need for workforce training, as well as the costs that the described innovations entail. What is more, before the pandemic, the insurance industry had been relatively hesitant compared to other industries in adopting remote working and working-from-home arrangements. However, when the crisis hit and carriers were compelled to implement remote working policies, new challenges surfaced. Working professionals, particularly those who were also parents dealing with at-home schooling, experienced increased pressure and often found themselves contemplating leaving the workforce (Adams, 2020). Other research in this area has touched on the problem of the insurability of pandemic risk in specific insurance business lines, for example, the commercial insurance

market. Analysis of the private insurance market for pandemic risks shows that it is unlikely that the insurance industry alone will be able to provide sufficient coverage for business interruption losses such as those that occurred during the Covid-19 crisis (Gründl et al., 2021). Another aspect identified with regard to the same business line was also the risk and the likelihood of potential consequences of the Covid-19 pandemic in the medium- and long-term horizon. It has been shown that changes in the commercial insurance market dominated the losses incurred in the aftermath of the pandemic (Przybytniowski et al., 2022).

Much less research has so far been conducted in the area of the impact of the conflict in Ukraine on the insurance market - mainly due to the relatively short time since the beginning of the conflict. Meanwhile, it should be underlined that the conflict in Ukraine came at a difficult moment for the world economy due to the ongoing recovery from the pandemic-induced recession (World Bank, 2022), and had a direct tangible impact on world trade and investment. Undoubtedly, this situation had a direct and indirect impact on the insurance market and its further development. These include the many significant restrictions included in the sanctions packages and their impact on limiting the insurance market, for example, air and car transport (Arvis et al., 2022). In addition, the geopolitical risk, which surged in many countries, has raised the insurance premiums that firms need to pay (higher insurance costs) to cover the risk of future production disruptions in a foreign country that could be caused by economic sanctions or the outbreak of a conflict (Ruta, 2022).

However, it should be highlighted at this point that after the annexation of Crimea and Sevastopol, the Russian Federation forced inhabitants to leave the occupied territories. One study published in May 2022 claimed that this caused a reduction in insurance premium payments due to the withdrawal of capital by those migrating. It was also mentioned that the presence of significant corruption and political instability in Ukraine is the primary cause of inflation, which obstructs progress in the insurance system (Yavorska et al., 2022). The Food and Agriculture Organization of the United Nations (FAO) released an information note in which it indicated that the rise in insurance premiums or the absence of war coverage in insurance

agreements for ships traveling to the Black Sea has worsened the already high expenses associated with maritime transportation (FAO, 2022). This might be perceived as a sign for the insurance industry to re-think insurance product coverage in the future. What is more, certain sectors such as aviation, marine, energy and cybersecurity have been significantly impacted by the Russia-Ukraine conflict, and have witnessed a rise in insurance premiums. In response, some insurers are contemplating introducing endorsements or policy modifications that could potentially impact coverage of future losses (Kopit, 2022).

The conditions in which the modern world is functioning due to the Covid-19 pandemic and the conflict in Ukraine require research in many economic and financial areas to be updated, including the insurance market. This research aims to analyse the impact of Covid-19 and the conflict in Ukraine on specific insurance business lines.

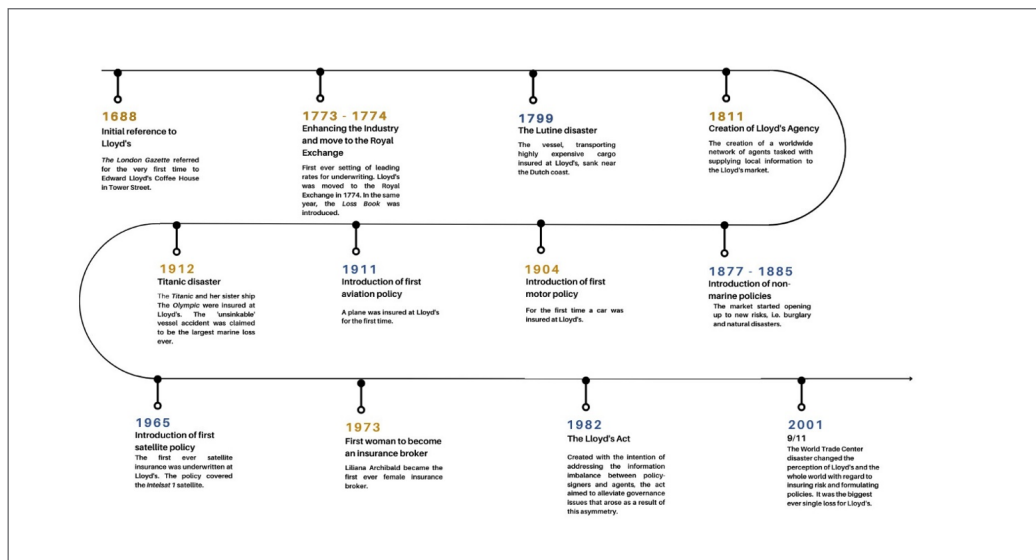
It should be mentioned that no research focused on insurance business lines in the context of the impact of crisis situations on each of these lines has been reported in the literature. Meanwhile, it is probable that

different crisis situations do not affect different areas of insurance in the same way. Therefore, exploratory research was planned so as to isolate clusters in the group of insurance business lines based on a case study of Lloyd's of London (Lloyd's), and to check whether the crises related to the Covid-19 pandemic and the conflict in Ukraine affect these clusters.

Lloyd's is undeniably one of the largest insurance markets in the world, and in many places, regions and countries has a pivotal role in economic growth (James, 2007). It owes its position as a renowned and long-standing insurance and reinsurance marketplace based in London thanks to independent reinsurance firms that operate and compete with one another on the marketplace. However, these firms also collaborate by collectively assuming the large risks they reinsure (Smets et al, 2014). However, it is worth noting here that Lloyd's contributed to a large extent to the sustainable development of the insurance industry at the turn of the century, not only in the UK but also on the global market.

The development of Lloyd's (Allen, 1980; Lloyd's, 2019; Pearson, 2002) through the lens of the most im-

Figure 1
Timeline of Selected Events in the History of Lloyd's of London



portant events is presented in Figure 1.

One of the most important and quite recent regulations introduced by Lloyd's was the Lloyd's Act issued in 1982. The Act required the publication of syndicate accounts, the standardisation of reporting practices, an auditor's 'true and fair' report and a statement of 'Disclosures of interests' (Gwilliam et al., 2012). The main purpose of the Act was to address the information imbalance between the parties signing policies.

Over time, the insurance industry experienced substantial growth in the complexity of the information it utilized. The role of Lloyd's of London today is to promote the adoption of insurance, strengthening the resilience of local communities and contributing to global economic development. Lloyd's is supported by a wide range of global resources and a capital framework designed to ensure financial stability. In other words, as the world's leading insurance market, it serves as the 'guardian' of the market.

The unconventional history, scope of activity, openness to innovations and, above all, pioneering approach to addressing risks in the insurance industry, are just a few reasons why many researchers have shown a keen interest in the phenomenon of the legendary Lloyd's of London. In such an active and constantly developing environment, it is worth paying attention to the conditions that have enabled and continue to enable this development.

The investigation by this study of the clustering of insurance business lines conducted at Lloyd's and its analysis within dynamically changing conditions may lead to useful classifications and conclusions, and may provide a starting point for further more advanced research resulting in more effective insurance activities. The study, with its particular emphasis on global crises that have recently taken place or are still ongoing, may at a later stage help to identify the path which the insurance industry can follow in order to mitigate the risks and threats of crises.

2. Method

With respect to the above-mentioned insights, the objective of the paper is to examine how the crises related to the Covid-19 pandemic and the conflict in Ukraine have affected insurance business lines (based on a case study of Lloyds). In order to achieve the objective, the following research questions were formulated:

RQ1. Is it possible to specify clusters of specific business lines (Property, Casualty, Marine, Aviation, Transport, Energy and Life) that have different levels of main indicators describing their activity (Table 1), and if so, how many clusters may be specified (separately for insurance and reinsurance)?

RQ2. Are the clusters resulting from the cluster analysis different or similar in specified subperiods of 2019-2022? (the pre-Covid-19 period, the Covid-19 period and the Covid-19 recovery period – which occurred at the same time as the deepening of the conflict in Ukraine).

RQ3. Are the clusters resulting from the cluster analysis different or similar for insurance and reinsurance?

The research is exploratory; therefore, no research hypotheses have been formulated.

For the purposes of the study, the essence of insurance and reinsurance at Lloyd's should be clarified.

Starting with insurance, the literature provides a wide variety of multiple definitions. However, what all of them have in common is that the main purpose of insurance is to transfer risk from the policyholder to the insurance company. In the case of any loss covered by the policy, the insurer agrees to compensate for these losses by offering financial benefits and/or providing related services appropriate to the risk (Commission on Insurance Terminology of the American Risk and Insurance Association, 1965).

While insurance consists mainly of transferring risk, the most common characteristic of reinsurance is the insurance of insurance. This arrangement is not directly related to the insured individual or the policyholder. Instead, it serves as a way for insurance companies to transfer a portion of their risk and financial liability to another company (Darul, 1994). In the reinsurance market, the main players are insurance companies that engage in the trade of risk as their primary commodity. The objective of the transactions conducted by these companies is to redistribute the risk they have assumed through direct underwriting for the general public. Companies that benefit from this redistribution of risk are willing to provide monetary compensation to other companies in exchange (Borch, 1962).

With regard to the market discussed in the study, Lloyd's is the 7th largest reinsurer on the international market according to AM Best Ranking of Top 50 Global

Reinsurers - 2022. However, it is important to mention that the premiums for specific groups in the ranking might incorporate premiums from Lloyd's Syndicates (AM Best, 2022).

It should also be emphasized that Lloyd's itself is neither an insurer nor a reinsurer. It is not possible to purchase a policy directly from the corporation.

According to Lloyd's of London's main areas of activity, the business lines reported are presented in Table 1.

The Lloyd's data used in the research takes into account a division into insurance and reinsurance (as presented in Table 1) and refers to the period from 2019 to 2022. The data presented in Table 2 presents

Table 1

Division of Insurance and Reinsurance business lines reported at Lloyd's of London for the years 2019-2022

Insurance	
Property	The term Property in the insurance industry is a general term encompassing fire insurance, business interruption insurance, burglary insurance, fidelity guarantee insurance, natural perils and other related lines of coverage (Swiss Re, 2023) of Non-Life Risk.
Casualty	Casualty insurance can be defined as a great variety of insurance products, mostly engaging products related to the general liability and professional liability. To be more precise, Casualty is not directly associated with life insurance or property insurance. Mostly, it encompasses insurance types such as auto insurance, burglary and theft insurance or workers' compensation, etc. (Rejda & McNamara, 2014). At Lloyd's, this business line encompasses a diverse range of sectors, with the most prominent ones being general liability and professional liability.
Marine, Aviation and Transport	<p>Starting in 2019, Lloyd's decided to change the rules of reporting and since then has reported a merged account for the Marine, Aviation and Transport business lines. This occurred despite the fact that these lines were in previous years performing according to expectations.</p> <p>Marine – contracts tailored under marine insurance are agreements in which the insurer commits to compensating the insured, based on the agreed terms and extent, for losses that occur as a result of a marine adventure, encompassing the losses associated with maritime activities (Hodges, 2012). In the case of Lloyd's market, marine insurance is closely associated with the establishment of the marketplace, since its roots go back to the times when ship owners met in the then popular coffee shop belonging to Edward Lloyd located near the River Thames. Lloyd initiated the practice of leasing out 'boxes' or in other words tables, where enterprising individuals saw the opportunity to offer insurance products to ship owners as a safeguard in case their vessels failed to return (Lloyd's, 2019). Nowadays, Lloyd's of London is considered to be a pioneer and a leading figure in the industry (Lloyd's, 2017), with major areas of the business focusing on cargo, hull, species, fine art and the previously mentioned marine liability.</p> <p>Aviation - there are four main broad categories of aviation insurance, coverage is available to protect airplanes, seaplanes, amphibians and flying boats from loss. This insurance stands out from the other insurance categories due to several unique characteristics. Among these are three major factors, including the limited range of insurable risks, the relatively small size of the insurance sector, and the industry's vulnerability to catastrophic events (Flouris, Hayes, Pukthuanthong, & Walker, 2009). The Lloyd's Aviation business line incorporates the airline, aerospace, general aviation, space and war sectors (especially affected since the start of the conflict in Ukraine). What is more, Lloyd's is widely regarded as the most esteemed institution for aviation insurance globally (El-Kasaby, Tarry, & Vlasek, 2003).</p> <p>Transport –transportation insurance mostly covers the risks connected with the process of the shipment of goods. These products are at risk of being damaged or lost during transportation due to various perils (Rejda & McNamara, 2014). Lloyd's has a dedicated account for marine risks, so the transport business line specifically provides coverage for land transportation.</p>

Table 1*Division of Insurance and Reinsurance business lines reported at Lloyd's of London for the years 2019-2022 (Continued)*

Insurance	
Energy	The scope of coverage of energy insurance usually focuses on the upstream, oil and petrochemical, chemical, power generation and/or renewables, and mining sectors. The products are used for protecting against a large variety of exposure, namely, business interruption (and the subsequent financial losses), damage on site, machinery repair, off-shore damage (for example in the case of oil rigs), etc. For Lloyd's, the Energy line of business encompasses property and liability, both onshore and offshore, and offers liability products that span a broad spectrum, from construction and exploration to production, refining and distribution (Lloyd's, 2022).
Life	The life insurance industry can be divided into two branches. First – life insurance itself, which aims to offer coverage against two primary risks: untimely death and longevity. Second – accident and health insurance, whose main goal is to cover all losses caused by sickness and/or injury that affect the insured person's life (Błach, et al., 2014).
Reinsurance	
Property	As above. Property represents the biggest sector in reinsurance in the analysed period.
Casualty	As above.
Specialty*	The definition of the specialty business line may vary in different markets, companies or even reinsurers. The first distinguishing feature of specialty lines is that it is a type of non-life risk that has nothing to do with property or casualty. In other words, it is a type of risk coverage that requires against extra unique and/or extraordinary occurrences. It consists of: Marine, Aviation, Transport, Energy and Life (in the case of the analysed data). According to Lloyd's 2022 Annual report, the London Market Data Council reached a consensus on the extent and methodology of the Core Data Record and Market Reform Contract, aiming to establish standardized data usage across the London market. This initiative represents a pioneering effort in the realm of specialty (re)insurance (Lloyd's, 2022).

Note: For the analysed period, Lloyd's reported a specialty line only for Reinsurance. In Insurance, in 2019 Lloyd's introduced a change in reporting standards, and started to present its accounts for Marine, Aviation and Transport as a combined one, rather than separately as it was in previous years.

Table 2*Definitions and Reasons for the Use of the Analysed Indicators Describing Activities of Business Lines*

Indicator	Description
Gross written premium (GWP)	This shows the performance and development of the company. It refers to the overall value of premiums from insurance or reinsurance that have been recorded by the insurer during the year (Łyskawa, Kędra, Kląpkiv i Kląpkiv, 2019). Gross written premiums encompass the difference between the estimated premium documented in prior periods and the actual income received. These premiums are reported before deducting commissions, but after accounting for taxes, duties levied on premiums, and other similar deductions (Lloyd's, 2022).
Net earned premium	This refers to the amount that the insurer has actually generated in a year, taking into account the prospective experience rating, premium discounts and retrospective rating adjustments (Dongsae, 1988).
Net incurred claims	Expenses that are incurred are recognized as opposite to expenses that are paid (Dongsae, 1988). The incurred claims for the year comprise payments made, as well as changes in the provisions for outstanding claims. This includes provisions for claims that have been incurred but not yet reported, as well as associated expenses. Moreover, it also contains already reported but not yet settled claims. Additionally, any other adjustments to claims from previous years are taken into account (Lloyd's, 2022).

Table 2*Definitions and Reasons for the Use of the Analysed Indicators Describing Activities of Business Lines (Continued)*

Indicator	Description
Net operating expenses	Expenses that encompass total costs related to the functioning of the corporation. As can be found in Lloyd's of London's Annual Reports, net operating expenses are composed of administrative expenses, reinsurance commissions and profit participation, acquisition costs and deferred acquisition costs (Lloyd's, 2022).
Under-writing result	This is a metric used to assess market results originating from insurance business activities. It is an indicator of the level of the insurer's underwriting endeavours over the year. It represents the net earned premiums after subtracting reinsurance, as well as the net operating expenses and net claims incurred after accounting for reinsurance (Lloyd's, 2017).
Combined ratio (CR)*	As well as the underwriting result, the combined ratio is a metric used as a measure of the insurer's underwriting performance over the year. It corresponds to the proportion of net operating expenses and net claims incurred after considering reinsurance and the previous year's releases in relation to the net earned premium after deducting reinsurance (Lloyd's, 2017). The rationale behind using CR is that it evaluates the percentage of every premium dollar utilized for covering losses and expenses. In empirical studies, researchers typically favour the combined ratio over, for instance, the profit ratio since the former is occasionally negative (Cummins & Nye, 1980). In other words, it also functions as a means of comparing the market with its counterparts.

Note: As the Combined Ratio is a product of the summation of Net Operating Expenses and Net Claims Incurred divided by Net Earned Premium, it was intentionally omitted in later analysis. This decision was made due to the fact that while it serves as a ratio for assessing the profitability of specific business lines, it does not represent actual outcomes.

definitions and justification for the use of the analysed performance indicators.

The research used cluster analysis, more specifically Ward's method. Separate analyses were carried out for insurance and reinsurance, and for each year in the period 2019 - 2022.

The objective of cluster analysis is to uncover natural groupings or types so as to initiate further/subsequent stages of the research in question. This is therefore an appropriate method within exploratory research. Cluster analysis has a heuristic nature, which encourages the further exploration of data (Dubes & Jain, 1980). Cluster analysis is a popular technique within statistical data analysis that sorts observations into similar clusters and thus helps to uncover group structures in the data (Ketchen & Shook, 1996). The applied Ward's method is a widely-available and popular hierarchical clustering technique (Bratchell, 1989), forming a tree-like structure that divides the

dataset into smaller subsets (Frączek, 2022). It groups objects using rules, so that in the same group ('cluster') there are objects relatively more similar to each other than to those in other groups. In the insurance industry (in an actuarial setting) it is usually used in applications such as insurance product marketing, as well as variable annuity valuation and ratemaking (Hu & O'Hagan, 2020). For the purposes of this article, cluster analysis will be used to divide the Lloyd's business lines into a number of homogeneous groups/clusters, taking into account the parameters listed in Table 2. The usage of cluster analysis in analysis of particular business lines (for insurance and reinsurance) may help in finding and understanding basic similarities and differences between particular business lines (and their change over time due to crises), and/or to find relationships and regularities between business lines within insurance and reinsurance. It should be underlined that the research is exploratory, and social

science exploration is a broad-ranging, purposive, prearranged undertaking designed for the discovery of generalizations leading to a description and understanding of a given area (Stebbins, 2001).

3. Research Procedure and Results

The empirical analysis was conducted in two steps.

The first step was the adjustment of the data gathered from Lloyd’s of London financial reports, acquired from the Lloyd’s of London official website. The original annual results used in the research contained data such as Gross Written Premium (GWP), Net Earned Premium (NEP), Net Incurred Claims (NIC), Net Operating Expenses (NOE) und Underwriting Result (UR) for 2019, 2020, 2021 and 2022 related to the following specific business lines:

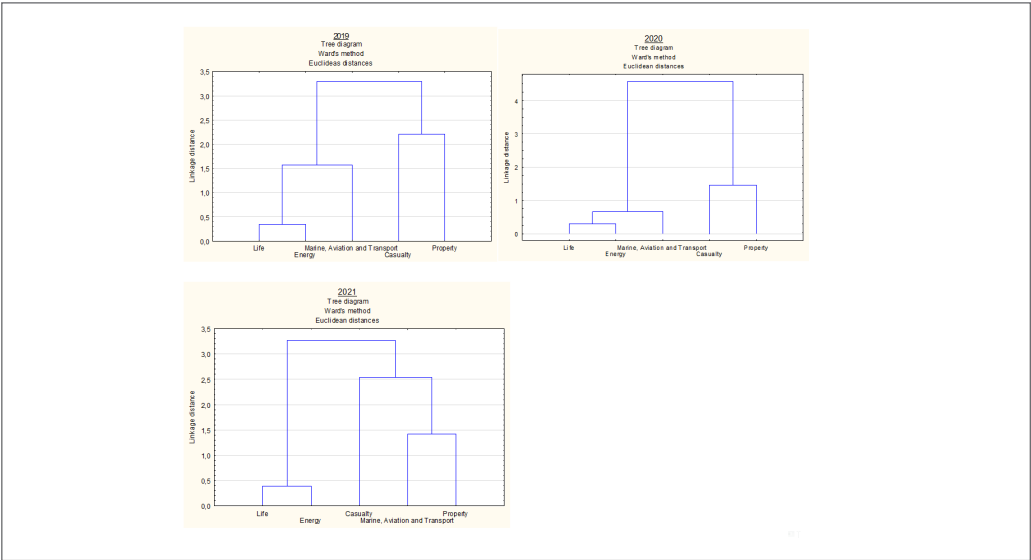
- Property, Casualty, Marine, Aviation, Transport, Energy, and Life - for insurance;
- Property, Casualty and Specialty (as the total

result for Marine, Aviation, Transport, Energy, and Life) - for reinsurance

This resulted in an additional research thread which explored whether there is any justification for combining Marine, Aviation, Transport, Energy, and Life in the case of insurance. The concept of combining the Marine, Aviation, Transport, Energy and Life business lines (and create the Specialty business line) in the case of insurance allows for creation of the same categories of business lines for insurance and reinsurance, namely, Property, Casualty and Specialty – necessary for further analysis. For this purpose, cluster analysis was carried out for insurance, taking into account all the business lines (Property, Casualty, Marine, Aviation, Transport, Energy and Life) for 2019, 2020 and 2021 (in 2022 there was a strong significant correlation between the gross written premium and underwriting result) – Fig.2.

At this point, it should be mentioned that as part of every cluster analysis conducted in this

Figure 2
Hierarchical Cluster Analysis for Insurance in Lloyds in 2019, 2020 and 2021



Note: Linkage method - Ward's method. Euclidean distance of Property, Casualty, Marine, Energy, Aviation, Life business lines

research, the linearity and correlation between the variables were checked, as well as the standardization of the data. Standardization involves rescaling the data values so that they all have the same mean and standard deviation: a mean of 0 and a standard deviation of 1. After correlation analysis, it turned out that only the gross written premium (GW) and underwriting result (UR) may be taken into account in further analysis as the others do not show statistically significant (at $p < 0.05$) strong correlation relationships (i.e., taking into account the strength of the relationship above 0.75).

Fig. 2 presents the results of cluster analysis of origi-

nal business lines with the use of two parameters: gross written premium (GW) and underwriting result (UR):

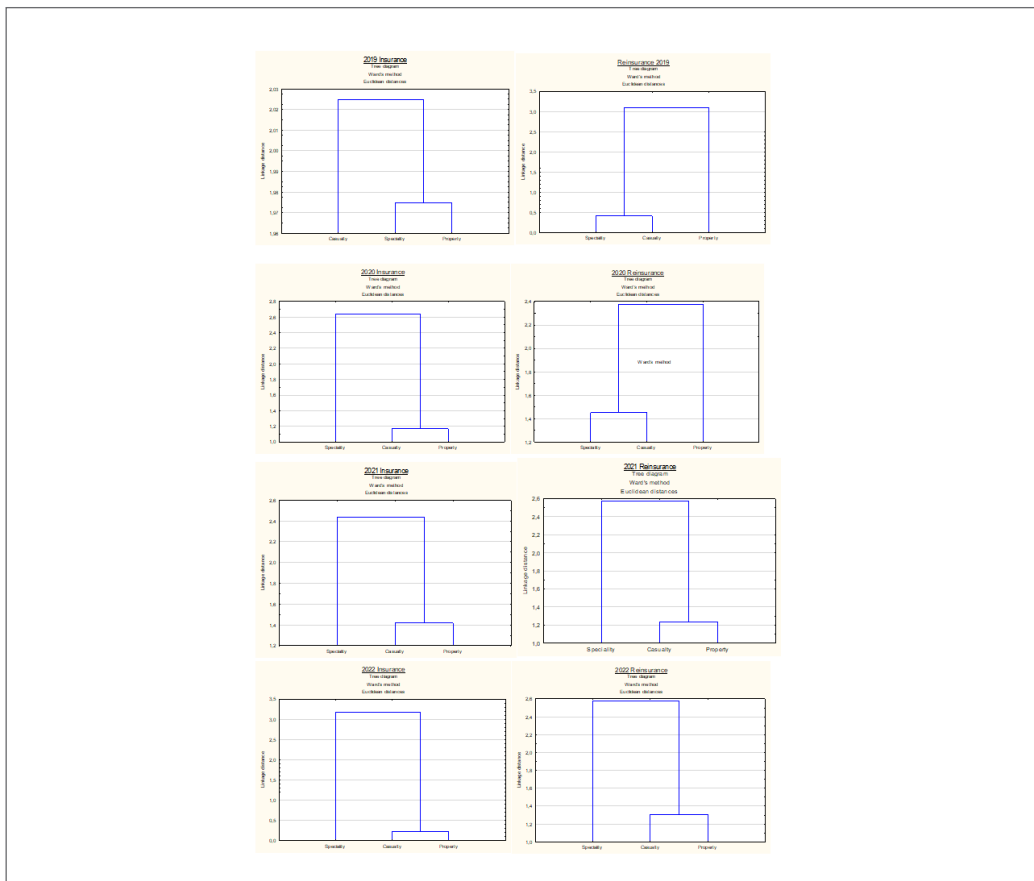
- Property, Casualty, Marine, Aviation, Transport, Energy and Life - for insurance;
- Property, Casualty and Specialty - for reinsurance

It turned out that in 2019 and 2020, the areas Marine, Aviation, Transport, Energy and Life were fully distinguished in the cluster analysis and in 2021 - partially. Therefore, in the further analysis, three specific business lines were considered: Specialty, Property and Casualty – for both areas: insurance and reinsurance.

In the second step, a separate cluster analysis using

Figure 3

Hierarchical Cluster Analysis for Insurance and Reinsurance in Lloyd's in 2019, 2020, 2021 and 2022



Note: Linkage method - Ward's method. Euclidean distance of Property, Casualty and Specialty business lines

Table 3
Basic Descriptive Statistics of the Variables for the Business Lines

Variables	Valid N	Mean	Median	Min	Max	SD	CV
Insurance 2019							
Gross written premium	3	5675,000	6793,000	3417,000	6815,000	1955,516	34,458
Underwriting result	3	-183,000	-171,000	-390,000	12,000	201,268	-109,983
Reinsurance 2019							
Gross written premium	3	3806,000	2960,000	2053,000	6405,000	2296,032	60,3266
Underwriting result	3	-144,667	-94,000	-258,000	-82,000	98,333	-67,9720
Insurance 2020							
Gross written premium	3	7529,000	9067,000	4293,00	9227,000	2803,600	37,237
Underwriting result	3	-827,000	-688,000	-2104,00	311,000	1213,485	-146,733
Reinsurance 2020							
Gross written premium	3	4053,000	3321,000	2211,000	6627,000	2297,201	56,679
Underwriting result	3	-218,667	-288,000	-441,000	73,000	263,921	-120,696
Insurance 2021							
Gross written premium	3	8055,333	9587,000	4219,000	10360,00	3344,768	41,52240
Underwriting result	3	263,667	336,000	-17,000	472,00	252,397	95,72586
Reinsurance 2021							
Gross written premium	3	4779,000	4440,000	2512,000	7385,000	2454,124	51,35224
Underwriting result	3	163,000	99,000	54,000	336,000	151,502	92,94630
Insurance 2022							
Gross written premium	3	10148,33	12045,00	5413,000	12987,00	4127,878	40,67543
Underwriting result	3	483,33	536,00	376,000	538,00	92,959	19,23285
Reinsurance 2022							
Gross written premium	3	5121,667	4818,000	2802,000	7745,000	2485,452	48,52819
Underwriting result	3	212,000	247,000	67,000	322,000	131,053	61,81765

Ward’s method was carried out for insurance and reinsurance in the areas of Specialty, Property and Casualty for 2019, 2020, 2021 and 2022. As in the first step, two parameters were distinguished (GW and UR) for the Specialty, Property and Casualty business lines as not showing statistically significant (at $p < 0.05$) strong correlation relationships (i.e., taking into account the strength of the relationship above 0.75). Basic descriptive statistics of the variables taken into account in further analysis are presented in Table 3. The results of the cluster analysis are presented in Figure 3.

The graphic presentation of the cluster analysis in Figure 3 allows for comparison of the primary results of cluster analysis for Lloyd’s specific business lines in insurance and reinsurance.

In order to discuss these preliminary results, it is

necessary to look at more detailed characteristics of the individual clusters identified. Table 4 presents the relevant characteristics of each cluster identified in the analysis for insurance and reinsurance respectively.

The graphic presentation of the cluster analysis in Figure 3 allows for comparison of the primary results of cluster analysis for Lloyd’s specific business lines in insurance and reinsurance.

In order to discuss these preliminary results, it is necessary to look at more detailed characteristics of the individual clusters identified. Table 4 presents the relevant characteristics of each cluster identified in the analysis for insurance and reinsurance respectively.

The results for 2019 are visible in Table 4 and Figure 3. As can be seen, the Insurance results have been grouped for Casualty in one cluster while Specialty

Table 4

Division of Clusters for Insurance and Reinsurance in Lloyd's in 2019, 2020, 2021 and 2022. Values for GWP and UR in £ m

Insurance		Reinsurance	
Gross Written Premium (GWP); Underwriting Result (UR)		Gross Written Premium (GWP); Underwriting Result (UR)	
Cluster 1	Cluster 2	Cluster 1	Cluster 2
2019			
Casualty (6793; 390)	Specialty (3417; -171) Property (6815; 12)	Specialty (2053; -82) Casualty (2960; -94)	Property (6405; -258)
2020			
Specialty (4293; 311)	Casualty (9067; -688) Property (9227; -2104)	Specialty (2211; 73) Casualty (3321; -288)	Property (6627; -441)
2021			
Specialty (4219; 472)	Casualty (10360; -17) Property (9587; 336)	Specialty (2512; 336)	Casualty (4440; 99) Property (7385; 54)
2022			
Specialty (5413; 376)	Casualty (12987; 536) Property (12045; 538)	Specialty (2802; 67)	Casualty (4818; 322) Property (7745; 247)

and Property are in another. To start with, all insurance lines reported by Lloyd's experienced minor improvement in terms of Gross Written Premium when compared to previous years. The rise in figures among Casualty lines was of particular note because of minor restrictions that were connected to the upswing in prices in the reported year, which had been withheld for the previous couple of years. The probable cause for this was that policies focusing on cyber protection continued to develop, as did professional lines. It should also be mentioned that Lloyd's reported that the niche and heavy industrial lines experienced a heightened focus on underwriting, encompassing not only pricing but also evaluations of program structure and policy terms (Lloyd's, 2019). The second cluster in 2019 encompasses the Property and Specialty lines, both of which reported a strong Gross Written Premium in 2019, notably for Specialty. In 2019, Property and Specialty both experienced losses connected with the natural catastrophes that took place in the second half of 2019. From the perspective of Underwriting Results, the Casualty line generated a negative value of £390m. The Property and Specialty lines reported as follows: a positive result (£12m), and a negative result (£171m) that was the first negative figure for a few

years.

In terms of Reinsurance in 2019, the clusters were formed as follows: Specialty together with Casualty, and Property as a separate one. The large difference between the clusters can be clearly seen on the graph below. The categorisation of Specialty and Casualty together may be justified by the fact that in 2019, the Casualty treaty market initiated a reduction in capacity and successfully achieved price strengthening for a wide range of business lines. Also, a slight rise in prices was reported for Specialty, which was caused by major losses and other challenges that occurred in the reported year. In other words, the Gross Written Premium for both of the lines increased in analysed year. Moreover, both lines experienced concerns and challenges related to their respective areas. The Casualty line was faced with emerging trends such as social inflation and increased uncertainty, while the Specialty line suffered losses due to catastrophic events, as well as exposure to natural disasters. Regarding both of the lines, Lloyd's emphasized the importance of oversight and monitoring in following years (Lloyd's, 2019). When discussing Property Reinsurance, the first noticeable factor is that, unlike Casualty and Specialty, Property Reinsurance achieved a negative Underwrit-

ing Result for 2019. This outcome can be attributed to a comparatively elevated amount of losses incurred in relation to the premiums earned in that particular year. Also, due to consecutive years of above-average loss activity and unfavourable development of certain losses from previous years, Lloyd's declared that the Reinsurance Property line would undergo increased scrutiny regarding the selection of risks.

When examining the cluster analysis for 2020, Specialty forms a distinct cluster, while Casualty and Property are grouped together. This year was the first financial year to fully experience and report the effects of the global Sars-Cov-2 pandemic on the business. All three lines saw a decrease in the Gross Written Premium. However, looking into the details, it can be seen that the Marine, Aviation and Transport Insurance line (reported under Specialty) experienced a rise in Gross Written Premium compared to the previous year. Furthermore, the Specialty claims mostly experienced a decrease in the Motor, Marine, Aviation and Transport lines due to decreased exposure to losses caused by for instance, grounded aircraft fleets or social distancing. In terms of the Casualty and Property cluster, as already mentioned, both business lines experienced an insignificant fall in prices. What is more, both of the analysed lines underwent a demanding year, characterized by significant challenges and losses resulting from various events. The first thing to mention is that the Casualty segment experienced unfavourable results in directors' and officers' liability, non-US financial institutions, and US business professional indemnity. Additionally, the Property line was affected by claims related to business interruption caused by the Covid-19 pandemic, along with natural weather catastrophes etc. These events, combined with the impact of Covid-19, also contributed to adverse performance in certain segments among the Casualty and Property lines. Also, both lines encountered significant changes related to expectations regarding Syndicates' risk appetite and market capacity.

Moving on to analysis of Reinsurance for 2020, the clusters visible in Figure 3 and Table 2 formed one grouping consisting of Specialty and Casualty, and a second comprising Property. The first observation is that all of the lines underwent an escalation of Gross Written Premium, which indicated positive performance in terms of income generation. In the case of

market capacity, Specialty Reinsurance experienced little to no change, while Casualty Reinsurance boosted its capacity after the previous year's slowdown. As can be found in the 2020 Lloyd's annual report 'Informal reports indicate that it is anticipated that substantial increases were achieved during the reinsurance renewal season at the end of the year.' (Lloyd's, 2020). If we focus on Underwriting Performance, the Specialty line achieved a positive value (£73m), while Casualty achieved a negative value (£288m). This performance was significantly greater than the previous year's result of -£94m. Meanwhile, the second cluster consisting of Reinsurance Property experienced the severe impact of Covid-19, including for instance losses due to BI (business interruption). In addition, 2020 was also a year when the frequency of natural disasters was high around the world, resulting in Lloyd's Reinsurers incurring significant losses. This contributed to the final results of Underwriting Profit for Reinsurance Property, which equalled a loss of £441m. Nevertheless, Lloyd's reported that despite the numerous losses due to natural catastrophes in the previous couple of years, there was still a surplus of capacity in the Reinsurance market.

Overall, despite the fact that the cluster analysis highlighted differently grouped lines in insurance and reinsurance, there seem to be no significant differences between the performance of the lines and the distances between the various data in 2020. The explanation for this could be the global pandemic and the general slowdown in the worldwide economy due to the spread of Covid-19.

Turning attention to the year 2021, as Figure 3. shows, in insurance the clusters were divided into Specialty on its own, and Casualty and Property together. What is more, for both insurance and reinsurance lines, the clusters were formed according to the same division. The underwriting performance of Specialty was a positive result at £472m, however, the result was worse than in 2020. Despite slight easing in lockdown measures, the Marine, Aviation and Transport lines still experienced reductions in exposure to risks. In addition, in an attempt to address the issues within the business line, since 2020 most of the business was subject to minimum and deposit premiums as a part of remediation efforts. For the Casualty-Property lines cluster, most notable was the continued impact of the

Covid-19 pandemic, which caused a slowdown in almost all Casualty policies. For the first time in the years analysed, the Casualty Gross Written Premium (£ 10,360m) surpassed the Property result (£9,587m), as in previous years Property had had a higher value. Also, both of the lines reported a positive but rather significant growth in prices. On the other hand, the impact of Covid-19 continued to affect underwriters' risk appetite, and efforts were made to try and mitigate the risks, and/or optimize new underwriting strategies. This was to some extent due to the high losses caused by natural disasters. On the other hand, Lloyd's reported losses for the Casualty line in the contingency sector of their business as a result of the Covid-19 pandemic. The market capacity for Casualty remained more or less unchanged.

The Reinsurance cluster, as mentioned before, was grouped in the same way: Specialty forming one cluster, and Casualty and Property another. All Reinsurance lines achieved an improvement in Gross Written Premium as compared to the previous year. Also, for the first time in the analysed period, all three Reinsurance lines reported a positive Underwriting Result. Specialty, comprising the Marine, Aviation and Transport lines together with Energy reported an increase in pricing in 2021. This suggests a favourable market trajectory for these industries during the pandemic. Also, in certain lines a rise in interest and capability within Lloyd's was observed, indicating an increase in the willingness and ability to take on risks. On the other hand, the second cluster comprising Casualty and Property Reinsurance suffered similar losses caused by natural disasters, for instance hurricanes and storms. What is more, in 2021, the Casualty treaty market continued the trends seen in the previous year, as policy coverage became more restrictive and prices increased for troubled and high-risk accounts across various lines of business. The casualty reinsurance and property reinsurance segments both acknowledged the availability and reduction of capacity in the reinsurance market. Although casualty reinsurance witnessed a new capacity entering the market, it was anticipated that capital availability would remain limited for riskier or more vulnerable accounts (customers/policies that might have a higher level of associated risk). Also, property reinsurance noted that among the surrounding years there was more insurance capacity

than needed, however, in the mentioned year a significant decrease was observed, especially for the capacity for lower-level and aggregate coverage.

Moreover, it is worth noting that as early as 2021, Lloyd's referred in its Annual Report to the thorough monitoring of the development of the conflict between Ukraine and Russia, and the likelihood of an invasion of Russian troops onto Ukrainian lands. Lloyd's Chairman, Bruce Carnegie-Brown noted that the corporation was working on a plan to support governments and regulators, in order to make sure that Lloyd's of London will interpret and implement correctly the sanctions requirements that have been imposed, along with further legal changes that have been introduced due to the conflict.

In 2022, as the global economy started to recover from the influence of the global pandemic, the beginning of the year saw the start of the conflict in Ukraine at the end of February. The first effects on the insurance industry began to be visible almost immediately. The cluster analysis grouped the division of business lines in the same way as in 2021. For insurance, the first cluster comprised Specialty, while the second included Casualty and Property. Starting with Specialty, after noting a fall in the previous year in Gross Written Premium, in 2021 the Specialty line achieved a higher result than ever before during the analysed period. However, in case of Underwriting Result, the achievement was lower than in 2021, but still positive at £376m. In other words, in three sectors (Marine, Aviation and Transport, as well as Life and Energy) Specialty experienced a positive price improvement. It is important to highlight that in the context of the geopolitical conflict, notable rises were observed in Aviation war and specific Marine war breach claims. Additionally, Marine liability experienced substantial price escalations and more stringent policy provisions (wordings). In the Energy sector, pricing was influenced by higher retail costs, while energy security also slightly increased due to the greater risk exposure caused by war. What is more, all lines under Specialty were also influenced by the natural catastrophes. Analysis of the second cluster, comprising Casualty and Property, showed that both lines achieved a higher Gross Written Premium than in recent years. The same applies to Underwriting Result. The conflict in Ukraine turned out to be significant for these types of insurance, especially for

Casualty and political violence and terrorism policies, which became more popular on the market. The same applied to Property. In addition, the losses connected with Covid-19 continued.

Moving on to the Reinsurance sector, as mentioned earlier, for 2022 the formation of the clusters was the same as in 2021: the first cluster comprised Reinsurance Specialty, while the second included Reinsurance Casualty and Property. Reinsurance Specialty experienced a slight increase in Gross Written Premium, however, analysis of the Underwriting Result shows that it was much worse than in 2021 (£336m), but still positive (£67m). It may therefore be concluded that underwriting performance worsened. The challenges caused by the Russian invasion of Ukraine influenced all business lines, as described in the previous subsections. In terms of Casualty and Property, both lines achieved a slight improvement in Gross Written Premium in 2022. The same was true for Underwriting Result, but in this case the annual improvement was much more visible. This may suggest that both lines succeeded in attracting increased business and generating higher premium revenues. Further, both lines witnessed stricter policy coverage, particularly for high-risk accounts across various business sectors. The conflict in Ukraine influenced the Property line in a similar way as in the Insurance sector. In addition, natural catastrophes also generated major losses in Property Reinsurance.

4. Conclusions and Implications

The contribution of this paper starts by noting the changes in the activities of insurance business lines due to crises related to the Covid-19 pandemic and the conflict in Ukraine in comparison to the period before these crises. The main contribution of this paper is therefore to capture preliminary classifications and insights for further more advanced research, resulting in more effective insurance activities.

This article examines the performance of the insurance and reinsurance businesses run by Lloyd's of London, one of the leaders in the global insurance market. The study employed cluster analysis with the use of Ward's method. The results highlighted various groupings into clusters of individual business lines at 3 stages of the 4 years analysed:

before the Covid-19 pandemic, during the pandemic and during the recovery from the pandemic, which coincided with the beginning of the conflict in Ukraine.

The preliminary conclusions drawn from the research are as follows:

1. The Reinsurance Specialty line of business seemed to be the least affected (compared to the other lines of business) by the crises that occurred on the international market during the analysed period. This can be seen from the annual performance and its differences over 4 years. In other words, the Gross Written Premium levels for Specialty developed year on year at a sustainable pace, and there was little to no influence of either Covid-19 pandemic or Ukrainian-Russian conflict. On the other hand, in the face of the conflict in Ukraine, the aforementioned line recorded increases in prices, with particular emphasis on Marine, followed by Aviation and Energy. However, it is worth noting that the values of the gross premiums obtained in insurance are slightly higher than in reinsurance. This rule applies to all lines of business.

2. Meanwhile, the biggest losses recorded in the Underwriting Result for insurance and reinsurance during the study period belonged to Property in 2020. Interestingly, this is not related to the fall GWP. This may mean that the losses incurred as a result of the start of the global Covid-19 pandemic turned out to be a threat to the whole insurance and reinsurance industry. At the stage of recovery from the period of losses caused by the pandemic, the Underwriting Result for Property (both in insurance and reinsurance) recorded a positive result.

3. Another conclusion derived not only from the above analysis, but also from in-depth analysis of Lloyd's of London's Annual Reports, its official website, its official brochures and materials, is that Marine (being part of the Marine, Aviation and Transport line reported under the Specialty business line) has over the years, beginning with the first historically confirmed mention of Lloyd's of London, was a somewhat prestigious line for the business. To this day, the line remains a source of pride for Lloyd's of London.

4. As for the cluster analysis, its division into particular groups over the years is not insignificant. It

can be observed in both insurance and reinsurance that despite the recorded losses in the Underwriting Result for Cluster 2, which surpass the losses in Cluster 1, it still performs better than Cluster 1.

Also, another visible feature is the repeated presence of the Specialty business line in Cluster 1. For example, in insurance Specialty appears as a separate cluster in 3 out of the 4 years: in 2020, 2021 and 2022. In reinsurance it appears in 2 out of the 4 years: in 2021 and 2022. What is more, in reinsurance, Specialty is present in Cluster 1 in each of the analysed years. It is worth pointing out that cluster formation in insurance and reinsurance in the years 2021 and 2022 is exactly the same. This may mean that the response of the market to the ongoing crises somehow prepared it for the new challenges that violated economic stability, and may have influenced the performance of the market during events that occurred while it was recovering from losses connected with Covid-19.

With regard to the research questions posed at the beginning of the study, the following main conclusions can be drawn:

RQ1. Is it possible to specify clusters of specific business lines (Property, Casualty, Marine, Aviation, Transport, Energy and Life) that have different levels of main indicators describing their activity (Table 1), and if so, how many clusters may be specified (separately for insurance and reinsurance)?

The composition of the clusters according to the reported business lines differ distinctly for the years 2019 and 2020. In the case of 2021, they differ only partially. Accordingly, in order to continue the study, a division into three business lines was adopted: Property, Casualty and Specialty. This breakdown was applied for both insurance and reinsurance.

RQ2. Are the clusters resulting from the cluster analysis different or similar in specified subperiods of 2019-2022? (the pre-Covid-19 period, the Covid-19 period and the Covid-19 recovery period – which occurred at the same time as the deepening of the conflict in Ukraine).

As regards the crises discussed in the study, their impact on cluster formation is not insignificant. The rationale behind the division of clusters presented in Table 3 can be broken down into 3 time

periods: the pre-Covid-19 period, the Covid-19 period and the Covid-19 recovery period (which occurred at the same time of the worsening conflict in Ukraine). Looking at the period of recovery from the negative impact of the Covid-19 pandemic on all business lines, which occurred during the increased tensions between Russia and Ukraine that flared up at the beginning of 2022, it can be seen that these crises significantly affected the performance of individual lines of business (to a greater or lesser extent).

RQ3. Are the clusters resulting from the cluster analysis different or similar for insurance and reinsurance?

The research shows that there is a lack of uniformity in the division into clusters over the analysed years. As presented in Table 3, the division into clusters for insurance and reinsurance is also not uniform. The exceptions are the years 2021 and 2022, in which the clusters are formed identically for insurance and reinsurance. The breakdown is as follows: Cluster 1: Specialty, Cluster 2: Casualty and Property. In addition, as shown by the analysis above, despite experiencing higher losses in UR than Cluster 1, Cluster 2 still demonstrates superior performance in comparison to Cluster 1.

However, it must be emphasized that the study adopted an approach that focused mainly on conducting the research based on data available in annual reports issued by Lloyd's of London. It is also worth mentioning that this data is not always uniformly reported from year to year. This creates certain limitations that may affect the depth of the research. Considering the above, there is a need to conduct further research in the area. This may also lead to further conclusions that express the need for possible changes in the style of reporting for the insurance industry. Possible changes may relate to the need for more open-access data. One example of future research avenues may be the analysis of individual business lines broken down by region of the world (Lloyd's last reported a breakdown by region in 2020).

In summary, there is a need for further exploration of the topic area in order to ensure the best possible future sustainable development of the insurance industry, and to better prepare it for any

inconveniences or crises that may affect it in the future. Lloyd's of London is an excellent example of the development of the insurance market which could be used as a source of material for future research.

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