TOPICAL REVIEW

Continuity of Essential Services as an Emerging Challenge for Societal Resilience

MICHAŁ WIŚNIEWSKI[1], **KRZYSZTOF SZWARC**[2], **AND WITOLD SKOMRA**[1]
[1]Faculty of Management, Warsaw University of Technology, 00-661 Warsaw, Poland
[2]Faculty of Security, Logistics and Management, Military University of Technology, 00-908 Warsaw, Poland

Corresponding author: Michał Wiśniewski (michal.wisniewski@pw.edu.pl)

ABSTRACT Critical infrastructure (CI) business continuity is fundamental in today's turbulent times. The new trend is the reference to essential services (ES). This paper aims to identify lead topics in the ES area and analyze actions to provide ES business continuity. The goal will be achieved by (1) identifying leading research topics using Latent Dirichlet Allocation, (2) conducting a systematic literature review using VOSviewer, (3) mapping the results obtained, and identifying possibilities for further research. Web of Science, Scopus, and specific keywords were used to select peer-reviewed papers discussing the ES issue. The results showed that, despite the importance of the ES issue, there are few publications related to the business continuity of ES. The work focuses on the relevance of ES to individual entities such as companies, cities, municipalities, and countries. There are also isolated works on ES security, but mainly in cybersecurity. The added value of the article is that it organizes the knowledge related to leading topics in the ES area from a Business, Management, and Accounting perspective and indicates the research areas that require further scrutiny. It is the first comprehensive literature review focusing specifically on ES.

INDEX TERMS Business continuity, critical infrastructure, critical services, essential services, key services, literature review.

I. INTRODUCTION

Systems critical to the functioning of economies and societies are called critical infrastructure. In legal circulation, the term first appeared in the US in 1998. The US Patriot Act (replaced in 2015 by the Freedom Act) defined CI as systems and physical or virtual resources so essential to the United States that the failure or destruction of those systems and resources would have a debilitating effect on security, the safety of the national economy, national health care, or any combination of these matters. In the European Union, the concept of CI came much later but also emerged. According to Article 2 of the Council Directive on the Identification and Designation of European Critical Infrastructure (abbreviated as ECI), critical infrastructure means a component, system, or part of infrastructure located within the territory of the Member States that is essential for the maintenance of essential societal functions, health, safety, security, material or social well-being of the population, and the disruption or destruction of which would

The associate editor coordinating the review of this manuscript and approving it for publication was Lorenzo Ciani.

have a significant impact on a Member State as a result of the loss of these functions. Notably, the designation of a facility as critical under the directive was to be determined by the following criteria [1]:
- cross-cutting (casualties, economic impacts, and social impacts assessed by the degree of loss of public confidence, physical suffering, and disruption of daily life, including loss of essential services);
- sectoral (relating to the characteristics of individual sectors).

As part of implementing this directive, the concept of critical infrastructure has also appeared in the Polish legal order. According to the Act on Crisis Management whenever the term critical infrastructure should be understood as systems and their functionally related objects, including buildings, equipment, installations, and services that are key to the security of the state and its citizens and that serve to ensure the efficient functioning of public administration bodies, as well as institutions and entrepreneurs [2].

A common approach to the emergence of CI is to focus on objects, for example, installations, equipment, and other

facilities. At the same time, however, studies have suggested that recognizing a facility as a CI defined in this way needs to be revised, as it needs to indicate what the critical infrastructure is intended to serve. An alternative solution has been proposed, for example, in the "Six ways to die" methodology [3], where three types of needs that should be protected (individual, group, and national) are identified, along with groups of tasks incumbent on the state of each kind of need. For example, at the individual level, the state should protect residents from the six threats: hunger, lack of water, illness, injury, excessive heat, and excessive cold. Each of the tasks was assigned the services necessary for their proper implementation. In this approach, the goal of protective measures was to ensure the continuity of services, while the typing and protection of CI is only a means of achieving the goal, not an end.

The incompleteness of the approach based on typing and protection of CI facilities has been repeatedly demonstrated when analyzing events causing emergencies. The most spectacular was the aftermath of the attack on the World Trade Center on 11/9/2001. The worldwide recession [4] and the collapse of several airline and travel companies [5] were in no way related to the sectoral characteristics that guided the typing of CI facilities. For example, Hurricane Sandy in 2012 was detected eight days before it hit the coast of North America [6]. Its route was known, and, considering the wind speed, it was considered a medium-category hurricane. The place where the hurricane hit the US coast was the heavily urbanized northeastern part of the United States. In addition to the expected destruction in the form of damaged power lines or devastated buildings, the disruption of fuel supplies led to a domino effect and the disruption of a whole series of supply chains related to the operation of critical infrastructure. Ultimately, the seemingly harmless hurricane was the fourth costliest hurricane in US history. Existing typing and protecting CI methods proved inadequate to the risks involved [7]. At the same time, using a risk analysis that considers the interconnectedness of the objects considered CI, the actual level of impact could have been predicted in advance [8].

A series of similar events became the reason for the search for new solutions in the field of CI protection. The need to extend special protection to entire supply chains became one of the topics discussed at the World Economic Forum in 2012 [9]. The need for a different approach to protecting the population from the effects of, among other things, unavailability of services was also highlighted in a 2015 OECD report [10].

As a result of the search for a new approach to the protection of infrastructure essential to the functioning of modern society, the US CISA (Cybersecurity and Infrastructure Security Agency) developed the National Critical Functions Set and a new CI typing scheme [11]. It is based on the critical functions of the state, which the services and operators of these services maintain. The infrastructure is the final step in determining what should be specifically protected.

In the European Union, the approach assuming the importance of maintaining the continuity of services appeared with the Directive of the European Parliament and of the Council of July 6, 2016, concerning measures for an ordinary high level of security of network and information systems across the Union, known as the NIS Directive for short [12]. According to the Directive, the subject of protection against threats from cyberspace is essential services, while the operators of these services are the implementers of the requirements. The issue of the infrastructure necessary to maintain the services should have been mentioned by the directive. As a result, two approaches are operating simultaneously within the European Union. The object-based approach results from the ECI Directive, and the service-based approach results from the NIS.

To unify the two approaches, the European Commission is working on a new directive called Critical Entities Resilience (CER) [13], which will replace the ECI Directive with a new NIS Directive2, which will replace the NIS Directive. Both directives are complementary. According to the CER directives, member countries first select essential services and assess the risk of their disruption. Essentially, essential service operators are typed, and the infrastructure is identified to maintain the service. At the same time, all operators covered by CER requirements must implement cyber-security at the level required by NIS2, and digital service operators selected under NIS2 will be required to implement other forms of security required by CER, in addition to providing cyber-security. As a result of the implementation of the directive CER, the service approach will become the primary approach, whether it is digital services or the provision of physical goods.

The importance of essential services to the modern global economy and the planned legislative changes in the EU raising the requirements for essential service operators in the area of security prompt the research questions:

- Q1 – What issues regarding essential services are raised in the scientific discussion?
- Q2 – Are there any works indicating framework guidelines for the issue of business continuity management of essential services? What research directions do they point to?
- Q3 – Which works are leading for essential services business continuity management?
- Q4 – In what form is the essential service business continuity management implemented?
- Q5 – Are there methods for identifying the extent of a crisis based on the disruption of an essential service?

This paper will perform a literature-based analysis to find a relationship between essential services and business continuity. In particular, a research challenge on the continuity of essential services is seen for industrial applications. This relation which is still quite fuzzy lies in a comprehensive qualitative assessment based on a literature review. To address this concern, this scientific paper focuses on systematic literature network analysis to find the link between essential services

and business continuity. Besides the extensive research on the continuity of essential services, a systematic literature review aims to investigate the bidirectional relationship of business continuity with essential services. Therefore, this paper can motivate understanding of the scale of interest and implications while, on the other hand, systematizing the existing knowledge about separate concepts (essential services and business continuity) and extending this knowledge about research towards the integration of the mentioned concepts, making a valuable theoretical contribution to the body of scientific literature in this research field. The consequence of the studies is to develop directions for further research. It would allow scholars and other interested parties to conduct more complex research on developing quantitative assessment methods that maintain the business continuity of essential services [14].

The advantage of the authors' paper over another scientific article lies in a comprehensive systematic literature review on the relationship between essential services and business continuity:

- rationalizing and systemizing the state-of-the-art knowledge on the considered topics using the dynamic, systematic literature network analysis;
- presenting the literature analysis in terms of its three dimensions: (1) systematic review, (2) type and application of reviewed study, and (3) bibliographic networks of literature review;
- attempting to deliver answers addressing research questions in the current published studies on these topics;
- contributing to the existing research literature focused on combining the concepts.

The paper is structured as follows. Section II presents the research methodology and the bibliometric software used. The results of the systematic literature network analysis are described in Section III. Section IV discusses results from the systematic literature network analysis-based reference framework illustrating the discovered essential services and business continuity relations. Directions for future research are also described in Section IV, while Section V outlines the conclusions.

II. MATERIALS AND METHODS
A. SELECTION OF METHODS AND TOOLS
The dynamic development of scientific research in many fields, combined with its increasing interdisciplinarity, has contributed to scientific knowledge. However, it has also made it difficult for researchers to keep themselves up to date with the current state of research. Limited cognitive resources prevent a complete literature review. The selection of publications based on search engines using specific ranking algorithms runs the risk of omitting interesting papers with low citations but with high potential impact. As a result, it becomes increasingly more work to obtain a reasonably comprehensive picture of research in a given field and identify an exciting gap in knowledge.
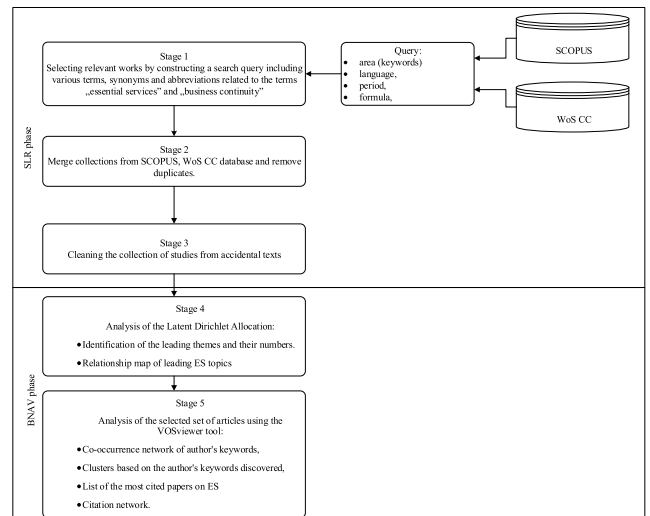

FIGURE 1. Research methodology based on SLNA.

Data mining and machine learning methods can be employed in such situations, especially in natural language processing and analysis, knowledge extraction, and document classification. Clustering and visualization techniques using tools such as VOSviewer [15], [16], topic modeling analysis methods [17], or trend detection [18] are prevalent among researchers. These methods' maturity and continuous improvement encourage researchers to develop methodologies for employing the same in literature review processes as additional tools.

We employed a systematic literature review method, deepened by network analysis, using the VOSviewer tool. This was followed by Latent Dirichlet Allocation (LDA) to identify leading research topics conducted in the ES area.

The literature search was conducted in two scientific databases: Web of Science Core Collection (WoSCC) and Scopus. The databases were chosen because they are the most commonly used for literature searches [19] and are leading databases with significant scientific impact scores. Due to their restrictive indexing procedures, the documents returned from queries processed in the databases are good quality [20]. The databases are also considered the two most important multidisciplinary bibliometric databases [21] used for field delineation [22].

B. SYSTEMATIC LITERATURE REVIEW ANALYSIS
Systematic Literature Network Analysis (SLNA) [23] is the methodology chosen for the selection and analysis of papers (Fig. 1).

The SLNA methodology consists of two main steps. A systematic literature review (SLR) is the first step. It allows us to determine the scope of research and generate studies for use as input in the next step (namely, bibliographic network analysis and visualization). The SLR approach [24] identifies and selects the most relevant papers for further secondary data analyses. SLR differs from other literature

review methods due to its principles of transparency, inclusivity, and explanatory and heuristic nature, allowing for a more objective overview of search results and eliminating any bias and errors. This step determines the selection criteria for language, period, formula, and area (keywords) papers. The second step is bibliographic network analysis and visualization (BNAV). This allows us to determine the development of major existing topics and emerging research trends using network analyses, e.g., citation network analysis (CNA) and co-occurrence of keywords.

An SLNA was chosen as it entails strict procedures in searching for and selecting papers to be reviewed. Therefore, it effectively synthesizes what the studies shows in a particular question and can provide evidence of the effect that can inform policy and practice [25].

Exploring the existing literature on ES was based on identifying available studies, which in turn was facilitated by a specific set of keywords. The selection of relevant papers for bibliometric research focused on constructing a search query covering wanted terms.

The selection of keywords relevant to ES was based on analyzing the most cited papers in the SCOPUS database [26]. This action was intended to reduce the number of papers that will accidentally contain terms that are similar in meaning.

Abbreviations were omitted to include only papers where the complete term appears in the abstract or title. In this case, adding abbreviations would only artificially inflate the number of results by including texts where those abbreviations are used in other meanings. Based on the above keyword considerations, the query was formulated for the search within titles, keywords, and abstracts, with a time restriction and restriction to texts in Business, Management, and Accounting. Papers published in 2016 or later were sought. This limitation stems from the introduction of the term "essential service" to public discussion for the first time by Directive (EU) 2016/1148 of the European Parliament and the Council on July 6, 2016, concerning measures for an ordinary high level of security of network and information systems across the Union. The query was entered into the Scopus (Equation 1) and WoSCC databases on June 10, 2022. The dataset obtained from the WoSCC database was fully contained in the dataset obtained from Scopus. Hence only the results from the Scopus query are presented hereinbelow.

Equation 1

TITLE-ABS-KEY("essential service″ OR "key service″ OR "critical service″) AND (LIMIT − TO (PUBYEAR, 2022) OR LIMIT − TO (PUBYEAR, 2021) OR LIMIT − TO (PUBYEAR, 2020) OR LIMIT − TO (PUBYEAR, 2019) OR LIMIT − TO (PUBYEAR, 2018) OR LIMIT − TO (PUBYEAR, 2017) OR LIMIT − TO (PUBYEAR, 2016)) AND (LIMIT − TO (SUBJAREA, "BUSI″)) AND (LIMIT − TO (LANGUAGE, "English″)) (1)

This step is significant because the results may change if another query is used. This choice was made in line with the paper's aim, i.e., presenting the landscape of scientific literature about the issues raised in connection with the ES. The selected set of keywords allowed the analysis of specific topics and their trends using the adopted methodology.

Only studies in English (including papers in press) with available abstracts and references were considered for further analysis (inclusion criteria). There were no other exclusion criteria. Altogether, 277 papers from Scopus were considered in further analyses.

The results of the analysis were obtained by implementing three measures:
- review of topics and abstracts,
- searching for leading topics using the LDA method
- searching for links between papers using the VOSviewer tools

Once the collection of works had been established based on keywords, the entire collection was reviewed. The review consisted of reading the topic and abstract of the study. A review of topics and abstracts was done to discard papers unrelated to the topic under consideration. This action completed the first stage of the SLNA method. In the second stage (BNAV), LDA and VOSviewer tools were used to visualize the results.

The next part of the study aimed to identify and analyze the essential topics in ES areas using the Latent Dirichlet Allocation (LDA) method. This provided the basis for generating a visualization of a relatively comprehensive representation of the current research related to the discussed subject matter. The input for the LDA analysis was a clean dataset containing Abstracts from the Scopus database. LDA was used to analyze all the identified papers discussing applications of essential services and business continuity extracted from Scopus after rejecting off-topic works. The analysis of the abstracts gives a broader picture of the factual content pored over in the paper than keyword analysis. Content analysis of abstracts using the LDA method makes it possible to identify the topics raised in the scientific discussion without classifying them using keywords.

Latent Dirichlet Allocation is one of the most popular topic modeling methods used in scientific research to identify key research topics or trends in fields such as medical sciences, software engineering, political sciences, geography, or enterprise architecture [27], [28]. First introduced by Blei, Ng, and Jordan [29], it is a generative probabilistic model of a corpus. It represents topics by word probabilities, and the words with the highest probabilities in each topic serve as an idea of the topic characteristics. To make the interpretation easier, Chuan, Manning, and Heer introduced Termite: a method for visualizing and interpreting topics [30], which later inspired Sievert and Shirley to create LDAvis: one of the most popular methods used for LDA results interpretation [31].

The input for the LDA analysis was a clean dataset containing Authors, Titles, and Abstracts from the Scopus database. In our analysis, we used an open-source PyCaret library [32]

which utilizes a reliable LDA algorithm implementation supported by the LDAvis visualization technique. In the first step, we initiated the model with the most popular irrelevant words (e.g., use, paper, research, start, etc.) as the so-called stopwords. The results obtained were then analyzed to identify other irrelevant words. This activity was performed several times. Finally, the following words were eliminated:

'use', 'paper', 'research', 'start', 'study', 'management', 'base', 'base', 'result', 'provide', 'area', 'call', 'analysis', 'also', 'process', 'present', 'show', 'need', 'include', 'support', 'new', 'may', 'author', 'high', 'examine', 'effect', 'important', 'first', 'find', 'impact', 'finding', 'value', 'performance', 'type', 'increase', 'well', 'approach', 'case', 'purpose', 'issue', 'make', 'consider', 'aim', 'implication', 'understand', 'offer', 'propose', 'focus', 'improve', 'many', 'different', 'context', 'affect', 'market', 'relate', 'however', 'enable', 'capacity', 'key', 'society', 'work', 'number', 'access', 'discuss', 'suggest', 'agency', 'function', 'help', 'age', 'emerald_publishing_limite', 'large', 'especially', 'lead', 'article', 'non', 'order', 'give', 'provision', 'address', 'role', 'potential', 'outcome', 'individual', 'various', 'take', 'goal', 'emerge', 'experience', 'organization', 'form', 'great', 'level', 'factor', 'condition', 'explore', 'contribute', 'benefit', 'environment', 'opportunity', 'insight', 'rate', 'conduct', 'serve', 'often', 'highlight', 'main', 'manager', 'create', 'could', 'interview', 'significant', 'current', 'rights_reserve'

We computed a coherence value for each iteration to identify the optimal number of topics. The highest coherence score (0.3549) was obtained for twenty-four topics. The coherence score for the first iteration was 0.3193 for twenty-nine topics. Eight iterations were performed. The best results were obtained in the fifth iteration. Subsequent iterations yielded increasingly poor results, so the results from the fifth iteration were selected for further analysis, determining the division of the set of texts into twenty-four leading topics.

Next, we analyzed the co-occurrence network for authors' keywords and the citation network analysis using the VOSviewer approach and tool. Co-occurrence analysis aims to analyze information characteristics. It applies to words, authors, classifications, and other records in books, journals, proceedings, and other literature [33]. There are three basic types of co-occurrence analyses [34]:

- co-occurrence (co-operation analysis),
- author-keywords co-occurrence (coupling analysis),
- keywords co-occurrence (co-word analysis).

In the paper, it was decided that the keywords co-occurrence and co-occurrence analysis would be used. This analysis allowed us to obtain the most important results from the point of view of the article's purpose. It concerns the analysis of keywords indicated by authors in their studies and keywords indexed by bibliometric databases. This quantitative analysis method allows one to discover the structure of the research area within the considered set of papers and its potential importance for the discipline. Due to the increasingly accurate bibliographic indexing, co-word

analysis is widely used to analyze keywords in books and journals. Keywords co-occurrence analysis allows one to obtain information on the number of times given keywords appeared simultaneously in a published article [35]. The co-occurrence of the keywords creates a map in which the nodes' size corresponds to the keyword's frequency, while the lines show the relationships between respective keywords [36]. A citation network is a network where the nodes are papers, and the links mean that there are citations between them. Hence, we can observe the flow of knowledge and trace the citation connections between papers. This, in turn, makes it possible to isolate clusters (smaller networks), which include papers with at least a single connection with another paper within the cluster. Among other reasons, this is done to facilitate a more accessible definition of the thematic scope of the cluster.

III. RESULTS
A. STAGE 1 – SELECTING RELEVANT WORKS BY CONSTRUCTING A SEARCH QUERY

The research was conducted in June 2022. Data from the databases were downloaded on June 10, 2022. In the first phase of the research, we searched the SCOPUS and WoSCC databases to identify papers referring to the term ES. For this purpose, queries were developed, searching for the term "essential service," "key service," or "critical service" in titles, keywords, abstracts, articles, book chapters, and conference proceedings. The results of this activity are illustrated in Table 1.

Using the inclusion criteria for the work affiliation to the Business, Management, and Accounting area published after 2016, 277 papers were found in the SCOPUS database and 31 papers in the WoSCC database. The small number of papers related to ES classified as Business, Management, and Accounting caused the authors to check the search result after excluding the criterion related to discipline affiliation. This resulted in 2943 papers collected in the SCOPUS database and 710 papers in the WoSCC database (Table 1).

As part of the preliminary research, a search of papers was also performed to identify the collection related to both business continuity and essential services or key services or critical services. For this purpose, a query (2) was developed and implemented in the SCOPUS database.

Equation 2

TITLE-ABS-KEY("essential service″ or "key service″ or "critical service″ AND "business continuity″) AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT − TO (PUBYEAR, 2020) OR LIMIT − TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016)) AND (LIMIT-TO (SUBJAREA, "BUSI″)) AND (LIMIT-TO (LANGUAGE, "English″))   (2)

TABLE 1. The incidence of essential service or key service or critical service topics in scientific databases as of June 10, 2022.

| QUERY	SCOPUS	WOS CC
"essential service" with a limit to Business, Management, and Accounting	Numbers: 277 Query: TITLE-ABS-KEY ("essential service" OR "key service" OR "critical service") AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016)) AND (LIMIT-TO (SUBJAREA, "BUSI")) AND (LIMIT-TO (LANGUAGE, "English"))	Numbers: 31 Query: ((TS=("essential service")) OR TS=("key service")) OR TS=("critical service")
"essential service" is not limited to Business, Management, and Accounting	Numbers: 2943 Query: TITLE-ABS-KEY ("essential service" OR "key service" OR "critical service") AND (LIMIT-TO (PUBYEAR, 2022) OR LIMIT-TO (PUBYEAR, 2021) OR LIMIT-TO (PUBYEAR, 2020) OR LIMIT-TO (PUBYEAR, 2019) OR LIMIT-TO (PUBYEAR, 2018) OR LIMIT-TO (PUBYEAR, 2017) OR LIMIT-TO (PUBYEAR, 2016)) AND (LIMIT-TO (LANGUAGE, "English"))	Numbers: 710 Query: ((TS=("essential service")) OR TS=("key service")) OR TS=("critical service")
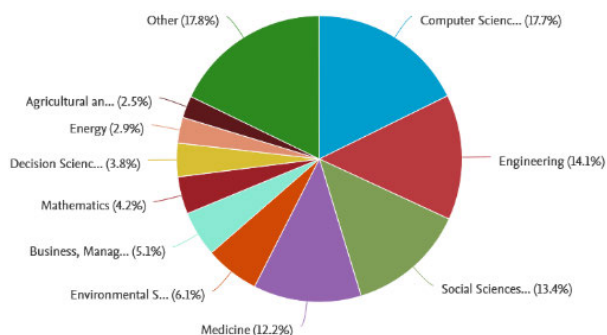
FIGURE 2. The number of papers related to ES by scientific discipline.

Query 2 returned a set of 4 papers containing the term "essential service," "key service," or "critical service," and "business continuity" together in the title, keywords, or abstract. Query 2 was performed again, excluding the restriction to papers in the Business, Management, and Accounting s. This resulted in a set of 18 papers. Due to the small size of the set of papers, the authors decided to analyze the set of papers obtained by performing query 1.

B. STAGE 2 –MERGE COLLECTIONS FROM SCOPUS, WoS CC DATABASE

Merging both data sets showed that all works indexed in WoSCC are found in the SCOPUS database. Therefore, only the set from the SCOPUS database was considered for further analysis. Table 2 shows the number distribution of papers containing the searched keywords. Fig. 2 indicates the number of papers related to ES by scientific discipline. The merging of the two datasets was done using MS Excel software. The search results were copied into a single file. Then, the duplicate records were identified using the remove duplicates function. Records were compared by the values of the "Title" and "DOI No." fields.

The allocation of interest in ES among scientists from different disciplines indicates a spread of interest in the topic. It is not possible to indicate a leading discipline. Although the papers assigned to the Computer Science discipline constitute 17.7% and the Engineering discipline 14.1%, the number of disciplines visible in Fig. 2 and the percentage of papers given to another category (17.8%) indicate significant segmentation.

C. STAGE 3 – CLEANING THE COLLECTION OF STUDIES FROM ACCIDENTAL TEXTS

The further analysis consisted of reading the titles and abstracts to eliminate papers that were not thematically related to the established understanding of the term ES. As a result of this activity, 3 papers were eliminated from the set of papers that were assigned to the area of Business, Management, and Accounting, and 153 papers were eliminated from the set of papers without the limitation of affiliation to the extent of Business, Management, and Accounting.

D. STAGE 4 – ANALYSIS OF THE LATENT DIRICHLET ALLOCATION

We used the LDAvis method to identify and analyze the leading topics in the ES area [31]. As a result, 24 emerging leading topics addressed in the literature in the ES area were obtained. The topics were identified through content analysis of the abstracts of the analyzed papers. Content analysis of abstracts is better than keyword analysis identifying the content addressed in the paper [28].

Table 3 presents the results of the LDA analysis showing the essential terms, the most frequent strings of two words, the number of papers in the topic, and the topic group. The most important terms and the most frequent strings of two words were both created by the LDA algorithm based on words in abstracts of analysis papers. The most important terms mean the terms considered by the LDA algorithm to be the most

TABLE 2. Distribution of the number of papers containing the searched keywords.

	ESSENTIAL SERVICE	KEY SERVICE	CRITICAL SERVICE	TOTAL
Papers on Business, Management, and Accounting	125	76	76	277
Papers with no breakdown by discipline	1544	489	926	2943
A common part of papers without a breakdown by discipline for the keywords "essential service" and "key service."		4		
A common part of papers without a breakdown by discipline for the keywords "essential service" *and* "critical service."		10		
A common part of papers without a breakdown by discipline for the keywords "key service" *and* "critical service."		2		

important for the topic under consideration (characterized by the highest number of links with other terms in the topic). The most frequent strings of two words are the terms that statistically occur most frequently in the topic under consideration. The topic group represents the author's attempt to give a title for the analyzed topic.

In the next step, a relationship map of the observed topics was made using the Xmind tool (Fig. 3). From the map of the occurring topics, we can see the interest of ES researchers in the subject context. There are works on enterprises, cities, municipalities, and states. Works on cities represent a particular range of topics in this group. In this context, the relevance of ES is considered from the perspective of smart cities, traffic management and optimization, municipal services, fire services, and municipal buildings.

Other papers address the impact of the COVID-19 pandemic on ES, especially in the context of drug production and business implications. There are also papers on sustainability and corporate social responsibility, the issue of government funding of ES is addressed, and the aspect of ES for the agricultural sector. Researchers focus on proving the relevance of ES and the need for a management paradigm shift in this area.

The LDAvis method was also applied to the set of papers without limitation to the area of Business, Management, and Accounting. By increasing the size of the set of analyzed papers, the authors hoped to limit the number of topics to the expected standard values (between 3-7 topics). LDA analysis, in this case, indicated 15 leading topics. Although this number has been reduced, it exceeds twice the expected result. Table 4 presents the results of this analysis showing the essential terms, the most frequent strings of two words, the number of texts in the topic, and the topic group (proposed by the authors).

In the next step, a relationship map of the observed topics was made (Fig. 4). From the map of occurring topics, a slightly different distribution of topics covered emerges. The dominant area is issues related to the challenges of the COVID-19 pandemic, where there are three sub-topics health care and law (671 papers), risk mitigation (80 papers), and health care (92 papers). Health care as ES is also present in other thematic areas: as a separate issue (879 papers), in the context of ES for cities (204 papers), or as CI (314 papers).

Other contexts for ES in the set of papers not limited to the Business, Management, and Accounting disciplines are the topics of ICT, public administration, smart cities, and CI.

E. STAGE 5 – ANALYSIS OF THE SELECTED SET OF ARTICLES USING THE VOS VIEWER TOOL

The following research stage was to perform bibliometric analyses using the VOSviewer tool. The number of keywords was adopted according to the proposals tested in available studies [37], [38]. Using VOSviewer, a network consisting of nodes grouped into clusters was obtained. A different color highlights each cluster. The frequency of keywords was used as weights, with no division between keywords identified by the authors and keywords indexed by the SCOPUS database. A node's size and distinctness correspond to its occurrence frequency in the analyzed set. In turn, the proximity of individual elements indicates more frequent co-occurrence in specific sets compared to more distant parts.

The analyzed papers limited to Business, Management, and Accounting contained 1717 keywords. The minimum number of keywords was 4. This means only those keywords in a minimum of four papers were selected for further analysis. If a higher value, the number of keywords, had been chosen, the number of identified clusters would have decreased. This could have led to excluding an important issue that has not yet been sufficiently researched, described, or highlighted in the papers. On the other hand, setting a value lower than three would return too many words as keywords, leading to a loss of interpretability of the linkage map.

Thirty-five keywords met the minimum number of occurrences condition. The VOSviever program grouped them into 7 clusters (Fig. 5). The clusters and the keywords assigned to them are illustrated in Table 5.

Analysis of the ratio of all keywords showed a small number of links, which is not an expected result. Typically, link maps contain more keywords grouped into clusters and a much more extensive network of connections.

Analyzing the relationship map, it is difficult to identify the leading cluster. According to the logic of the VOSviewer tool, it should be the cluster located in the center of the relationship map. In our research, this place is occupied by cluster 1 (Sustainable development of essential services) and cluster 3 (Transformative service research). The two clusters are thematically linked by two pairs of terms ''barriers'' - ''transformative service research'' and ''network security'' - ''machine learning.'' This means that the central focus of the discussion is on research into the barriers to ES transformation by the principles of sustainable development with a particular emphasis on network security and the

TABLE 3. Leading topics for ES in the Business, Management, and Accounting area.

TOPIC	MOST IMPORTANT TERMS	MOST FREQUENT STRINGS OF TWO WORDS	NUMBER OF PAPERS	TOPIC GROUP
Topic 1	service, program, essential, technology, network, community, system, government, urban	supply network, essential service, smart city, cross-boundary, big datum, boundary information, information exchange, service delivery, single drone, smart service, co-occur, engage citizen, privacy security, distributional equity, become smart, minority group, flourishing life	9	Essential services for smart cities
Topic 2	service, essential, sustainability, tourism, development, business, water, economic	donate time, civic participation, community member	5	Essential services and sustainable development
Topic 3	service, essential, covid, customer, pandemic, tourist, policy, lockdown, government, mobility	service logic, service principle, municipality interaction, municipality place, essential service, proposition municipality, place good, good life	11	Municipal essential services and pandemic challenges using COVID-19 as an example
Topic 4	service, government, local, essential, resource, model, stets, budget, soft, distribution	essential service, front line, public transport, moral economy, resource distribution, economy framework, blend learning, urban public, morality managerial, time distribution, teaching-learning, service time, disaster region, socio-economic, phase service	12	Essential services for the state
Topic 5	service, city, water, essential, system, server, provider, economic, customer	a health system, local government, policy city, elected official, complexity theory, essential service, policy maker, employee elect, ethic policy	8	Essential services for cities
Topic 6	service, customer, public, repair, server, storage, security, essential, cloud, technology	essential service, ICT innovation, voluntary service, stationary probability, living standard, parking configuration, queueing system, server prone, develop the country	24	Essential services in the sense of ICT
Topic 7	social, community, health, discourse, corporate, responsibility, online, service, discursive, essential	Single occurrences of keywords	5	Essential Services and Corporate Social Responsibility (Sustainability)
Topic 8	essential, service, platform, death, lockdown, framework, international, model, regulate, covid	the pharmaceutical company, culinary festival, local small, water supply, drug manufacturing, community expectation, essential service, small culinary, reflexive isomorphism	9	Essential services and pandemic with the example of COVID-19 (drug manufacturing)
Topic 9	service, distribution, framework, essential, line, model, front, moral, governance, affordability	essential service, local authority, equity index, service worker, receive less, share state, state funding	10	Essential services and government funding
Topic 10	network, service, smart, disruption, supply, information, security, big data, essential	essential service, local government, budget distribution, historical datum, behavior preference, state debt, local public, government unit, public budget, return investment, service population, end user	10	Government essential services and information security
Topic 11	service, technology, system, parking, country, essential, breakdown	loan applicant, loan repayment, ease secure, secure loan, employment earning, program participant, essential service, employment program, government sponsor, sponsor employment, ease microfinance_loa, extend the loan, participant receive, basic service, country ease essential service, water system, special district, service quality, human resource, water service, resource development, private provider,	14	Essential services and banking system (loans)

TABLE 3. *(Continued.)* Leading topics for ES in the Business, Management, and Accounting area.

Topic 12	customer, service, system, cost, firm, failure, expect, resource	strategic human, drink water, service delivery, passenger loyalty, enterprise drive, public sector, loyalty passenger, quality image, service provider, essential phase, ordinary customer, system city, analyze influence, broadband infrastructure, airport service, image perceive	11	Essential services and self-service technologies (SST)
Topic 13	service, strategy, risk, identify, business, mitigation, pandemic, contingency, coronavirus	essential service, service co_creation, covid pandemic, service delivery, customer relationship, municipal infrastructure, pandemic tourism, service capability, service co, spread virus, customer satisfaction, customer participation, customer capability, covid outbreak, covid policy, tourist site, aggregate mobility, cause poor, capability firm	17	Essential services in pandemic conditions using COVID-19 as an example (implications for business)
Topic 14	volunteer, community, water, service, utility	real-time, road safety, traffic load, traffic inflow, smart navigation, essential service, socio-economic, optimized smart, navigation vehicle, load balance, inflow prediction, safety intersection, optimal traffic, vehicular traffic, time optimization	6	Essential services for cities (traffic optimization)
Topic 15	the company, pharmaceutical, service, festival, community, drug	essential service, water utility, inclusive growth, informal labor, island sustainability, tourism island, identification system, transaction service, dependent resource, survival strategy, informal business, security effectiveness, transaction efficiency, conceptual framework, utility operation, water destination, big business, identification revolution, assessment indicator, strength aspiration	19	Essential services for cities (municipal services)
Topic 16	service, fire, fighter, probability, customer, motivation, essential	essential service, cloud storage, service server, temperature strain, optional service, expect wait, multi optional, negative customer, delay repair, repair man, server busy, cultural influence, optional service, wait time, ajp technology, analyze security, water corporation, security threat	9	Essential services for cities (fire department ICT)
Topic 17	traffic, time, smart, real, international, road, challenge, protection, vehicle, navigation, service, urban	essential service, service mode, digital platform, accounting model, service interaction, covid death, traditional infrastructure, quantity quality, quality information, promotion prevention, platform mediate, mediate interaction, customer brand, lockdown essential, conceptual framework,	5	Essential services for smart cities (traffic management)
Topic 18	resilience, system, politic, complexity, surge, government, framework, essential	water consumption, agricultural water, wue would, oilseed rape, essential service	7	Essential services for agriculture
Topic 19	water, consumption, crop, decrease, wue, service, corn, agricultural, irrigation, yield, essential, service	essential service, technology program, program scope, nursing staff, regional mobile, public service, knowledge system, service quality, social economic, road network, service provider, financial inclusion, program competency, care service, training program, federal technology, educational sector	11	Essential services for agriculture (ICT)

TABLE 3. *(Continued.)* Leading topics for ES in the Business, Management, and Accounting area.

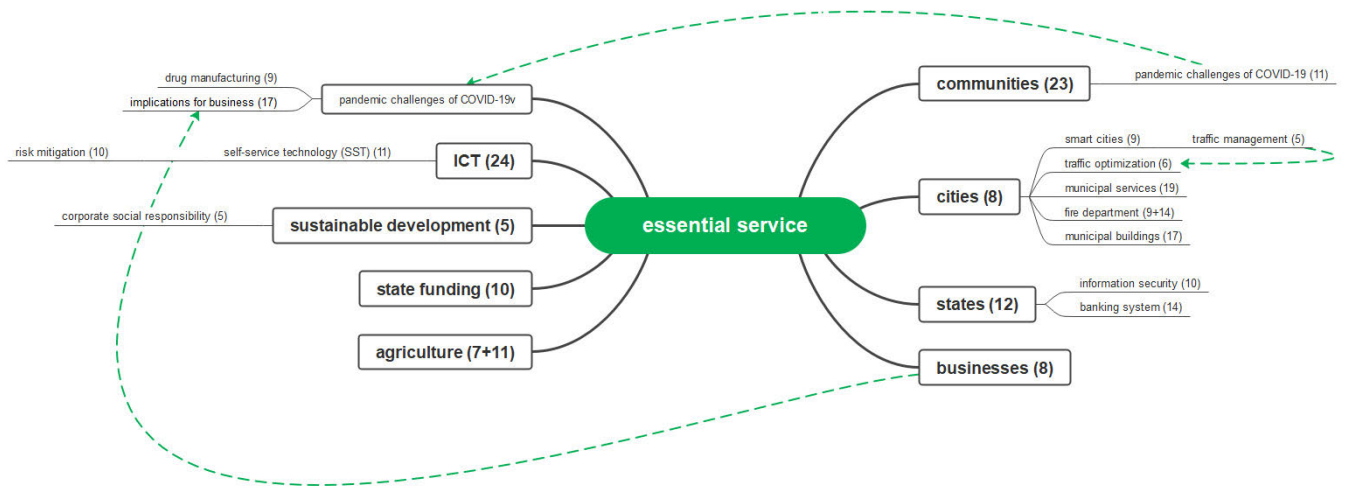|				
Topic 20	municipality, service, place, resident, live, good, logic, essential, delivery	community building, output model, essential service	23	Essential services for communities
Topic 21	marketing, volunteer, organization, segmentation, participation	firefighter, essential service, motivation fire, fire service, leave the system, system probability, specific situation, optional service, social responsibility, corporate social	14	Essential services for cities (fire department)
Topic 22	building, Australian, community, government, model, service, component	essential service, responsibility discourse, online community, alternative discourse, physical behavior, health development, discursive closure, responsibility communication, discursive strategy, discursive field, garment industry, covid crisis, health disparity, entry school, industry corporate, intervention optimizes, adaptive competency, supply chain, managerial corporate, child health, life course, behavioral health	17	Essential services for meats (municipal buildings)
Topic 23	technology, consumer, right, protection, electricity, adoption, essential, service	local government, essential service, organizational identification, public utility, outdoor water, government service, evolution organizational, rice project, utility regulation, protect consumer	8	Essential services for businesses
Topic 24	cost, firm, service, customer, resource, chatbot	mitigation strategy, risk mitigation, analyze risk, identify strategy, coronavirus business, supply chain, post coronavirus, competitive entry, food supply, clear idea, essential service, identify analyze	10	Essential services versus self-service technology (SST) (risk mitigation)

FIGURE 3. Relationship map of leading ES topics in the Business, Management, and Accounting area.

application of machine learning methods to enhance this security. An analysis of the links to the other clusters confirms this conclusion. Cluster 1 links to Cluster 2 (Decision-making and risk management in the context of the COVID-19 pandemic) through the terms "sustainability," "decision-making," "risk management," and "covid-19." This indicates the impact of the COVID-19 pandemic on the

sustainability of essential services, highlighting the role of risk management in the decision-making process. It aims to increase ES resilience. The tool that responds to the increase in the complexity of decision-making is numerical models hence the combination of cluster 2 with cluster 4 (Health care as an essential service) and another cluster 7 (Queue theory as a method of decision support) through the terms "numerical

TABLE 4. List of ES lead topics without a breakdown by discipline.

TOPIC	MOST IMPORTANT TERMS	MOST FREQUENT STRINGS OF TWO WORDS	NUMBER OF PAPERS	TOPIC GROUP
Topic 1	service, law, health, coverage, government, pandemic, model, disease, right, group, public, essential, care, covid	the informal settlement, achieve population, see luxury, outpatient care, palliative care, philanthropy see, population health, proximal city, redistribution country, retaining wall, see critical, service combine, nuclear drill, settlement far, shaft retain, smart city, state weak, summary ambulatory, traditional ambulatory, walkability drive, weak welfare, wealth redistribution, organize facilitating, monitoring service, ambulatory care, critical instrument, ambulatory outpatient, architect dietary, care to achieve, care to see, carry informal, city organizing, city walkability, country state, describe experimentation, intake monitoring, dietary intake, drill shaft, drive informal, experimentation carry, facilitating secure, far outskirt, health traditional, instrument wealth, welfare institution	671	Essential services and the pandemic using the example of COVID-19 (health care and law aspect)
Topic 2	the system, service, security, change, essential, care, public, risk, cost, health, design, reduce, resilience,	covid pandemic, weather event, essential service, resilience, law policy, critical infrastructure	80	Essential services and pandemic with the example of COVID-19 (risk mitigation)
Topic 3	essential, service pandemic, covid, health, global, state, worker, political citizen, source, pay requirement	congenital council, covid pediatric, information website, perception taxation, predict taxis, progress information, prosocial perception, taxation predict, website fast	15	Essential services and the pandemic using COVID-19 as an example (health services)
Topic 4	service, essential, customer, recovery, company, system, thus, appropriate, implement	covid pandemic, covid patient, care covid	77	Essential services and the pandemic using COVID-19 as an example (health services)
Topic 5	economic, far, social, country, inequality, energy, system, life, internet, look, range, available, stability, rapid, lockdown	essential service, essential inessential, plight elderly, repair facility, facility essential, insufficient social, reliability system, system repair, system design, inessential service, critical infrastructure	29	Essential services and critical infrastructure
Topic 6	hospital, power, infrastructure, city, technology, community, effective, world, sustainability, pandemic, covid, theme, modern, indigenous	mobile phone, cell phone	17	Essential services for cities (health care)
Topic 7	communication, quality, control, mental, covid, health, event, requirements, conclusion, strategy, improvement	essential service, mental health, health service, health system, public health, quality coverage, care provider, covid pandemic, service coverage, foreign bear, sustainable development, move forward, local public, electricity service, initial contact, relationship nature, immigrant refugee, parole officer, patient group, political change, health facility, group intervention, program combine, family engagement, semi-structured, institutional parole,	314	Essential services and critical infrastructure (health care)

TABLE 4. *(Continued.)* List of ES lead topics without a breakdown by discipline.

|				
Topic 8	program, service, education, reform, survey, refugee, additional, component, organize, facilitate	winter storm, early medical, service comprehensive, achieve quality, antenatal care, care service, central government, structural change, solid waste, service even, poverty reduction, cyber attack, correctional worker, critical infrastructure adaptive distributed, administration engine, marginalization perspective, network heterogeneous, parameter urban, perspective design, plant community, protocol design	14	Essential services (public administration)
Topic 9	disaster, basic, hospital, infrastructure, sector, structure, industry, covid, repair, action, worldwide, material	climate change, adoption empirically, influence tourism, empirically intervention, examination man, forestry evolution, guide monitor, indicator guide, limited internet, man wealth, monitor climate, partnership nationally, station country, storm climate, tourism resource, autonomous station, calm storm, change adaptation, change drive, climate target, compliance climate, country limited, disparate partnership, drive forestry, wealth disparate	498	Essential services (health care)
Topic 10	patient, covid, care, pandemic, report, activity, attack, little, day, assistance, people, human, standard, combine, newborn	emergency disaster, resilient hospital, essential service, disaster situation, hospital doctor, hospital emergency, disaster normal, social right, south African, hospital disaster, disaster supervisor, doctor emergency interdependent infrastructure, literature review	67	Essential services (health care)
Topic 11	network, development, government, delivery, aid, accessibility, transportation, wireless, primary, disadvantage, flood	essential service, clinical laboratory, laboratory service, heterogeneous service, wireless technology, water sanitation, water corporation	253	Essential services (examples)
Topic 12	cells, sustainable, mobile, phone, cellular, protocol, model, care, Australian, telephone, wireless	essential service, heart disease, disease adult, right self, security aid, childhood heart, zoonotic disease, digital technology, cybercrime law, health pandemic, health insurance, health coverage, social worker, patient childhood, penalty punishment, health service, criminal activity, freedom institution, concern acquire, universal health, institutional freedom, covid pandemic	314	Essential services (health care)
Topic 13	eid, adaptation, storm, climate, change, influence, geosphere, adoption, tourism	movement control, communication mission, control center, ground team, spacecraft control, meet communication, mental health, metropolitan regional, essential service, patient metropolitan, short communication, human flight, communication cardiac, care patient	21	Essential services (examples)
Topic 14	concept, crisis, covid, urban, respiratory, framework, depotentiation, double	essential service, internet of things, social economic, social distancing, monetary life	204	Essential services, and smart cities
Topic 15	congenital, pandemic, process, covid, council, prosocial, taxation, taxis, predict	essential service, service consist, server service, general service, covid pandemic, social isolation, information system, information security, front line, service compulsory, editorial contributor, service customer, single server, additional service, system attack, consist general, batch arrival, successful coop, steady state, science digital	216	Essential services (ICT)
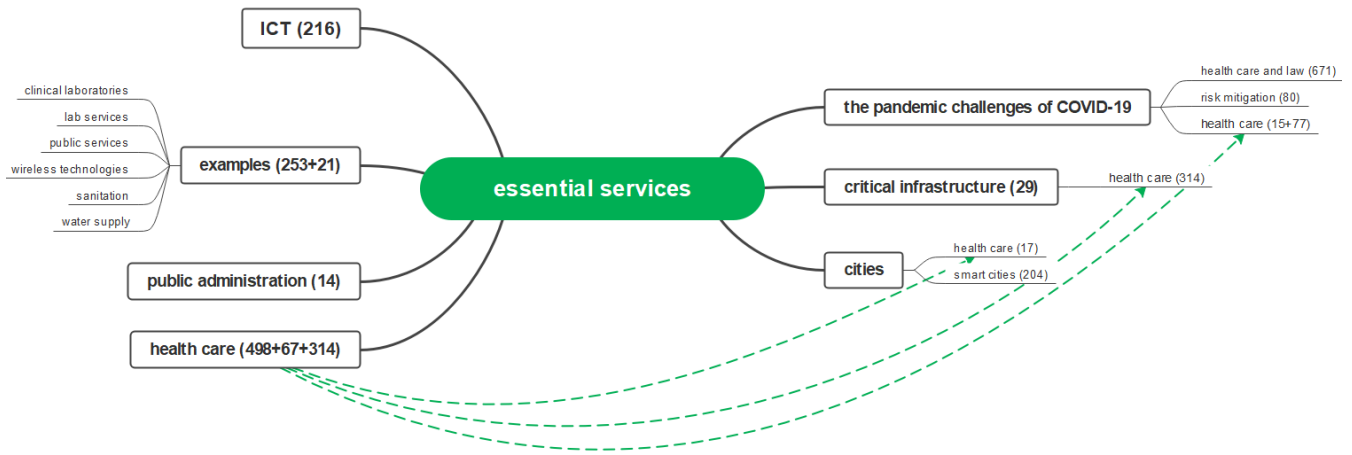
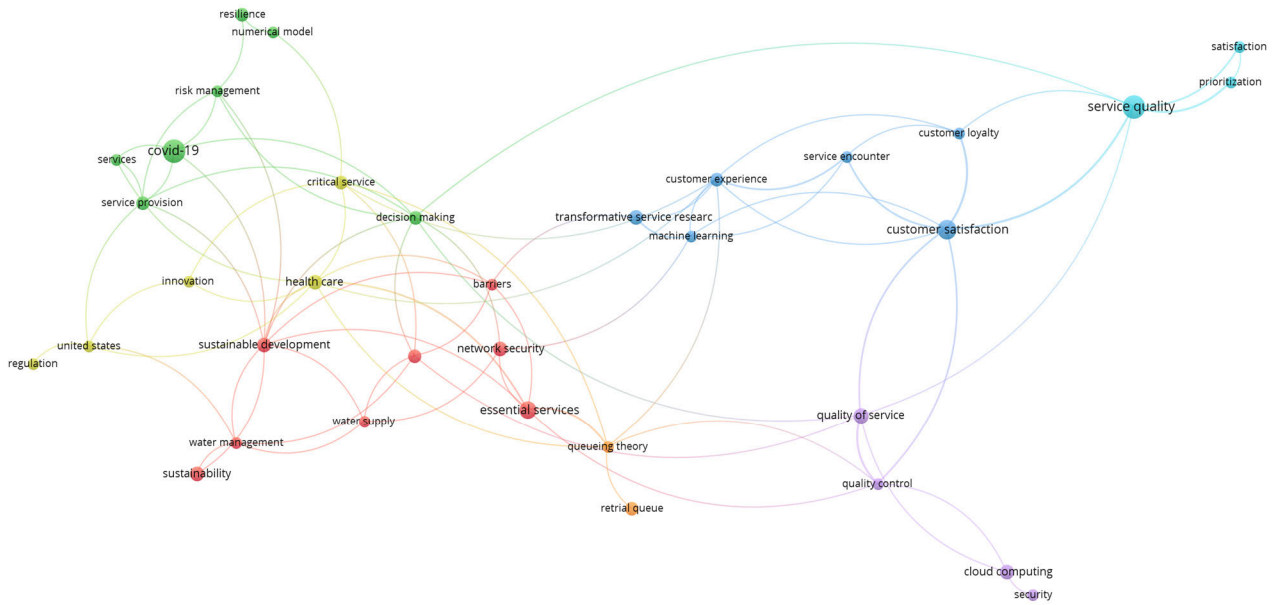**FIGURE 4.** Relationship map of leading ES topics without breakdown by discipline.

FIGURE 5. Co-occurrence map of ES keywords in the Business, Management, and Accounting area.

model'' - ''critical service'' - ''queueing theory.'' This combination indicates that currently, the leading theory supporting the increase in ES resilience is queue theory. It is used in areas such as healthcare (cluster 4), using cloud computing to improve service quality (cluster 5), and customer experience (cluster 3). Cluster 3 (Transformative service research) connects to cluster 6 (Service quality) through the concepts of ''customer loyalty,'' ''customer satisfaction,'' and ''service quality,'' which indicates ES transformation research considers service quality by maintaining customer loyalty and ensuring satisfaction with service delivery.

In addition, an analysis was performed showing when each keyword was popular (Fig. 6). The blue color indicates popularity in 2016, green in 2020, and yellow in 2022.

To explain the small number of links and the lack of a clear leading theme in the ES area, an additional analysis was performed by identifying the top study. This identification was carried out based on a citation network analysis. As a result, it became possible to identify the network of cross-citations in the entire collection of 274 papers. The cross-citation analysis showed that the papers are cited (Table 6). On the other hand, only in the case of 20 papers is cross-citation observed,
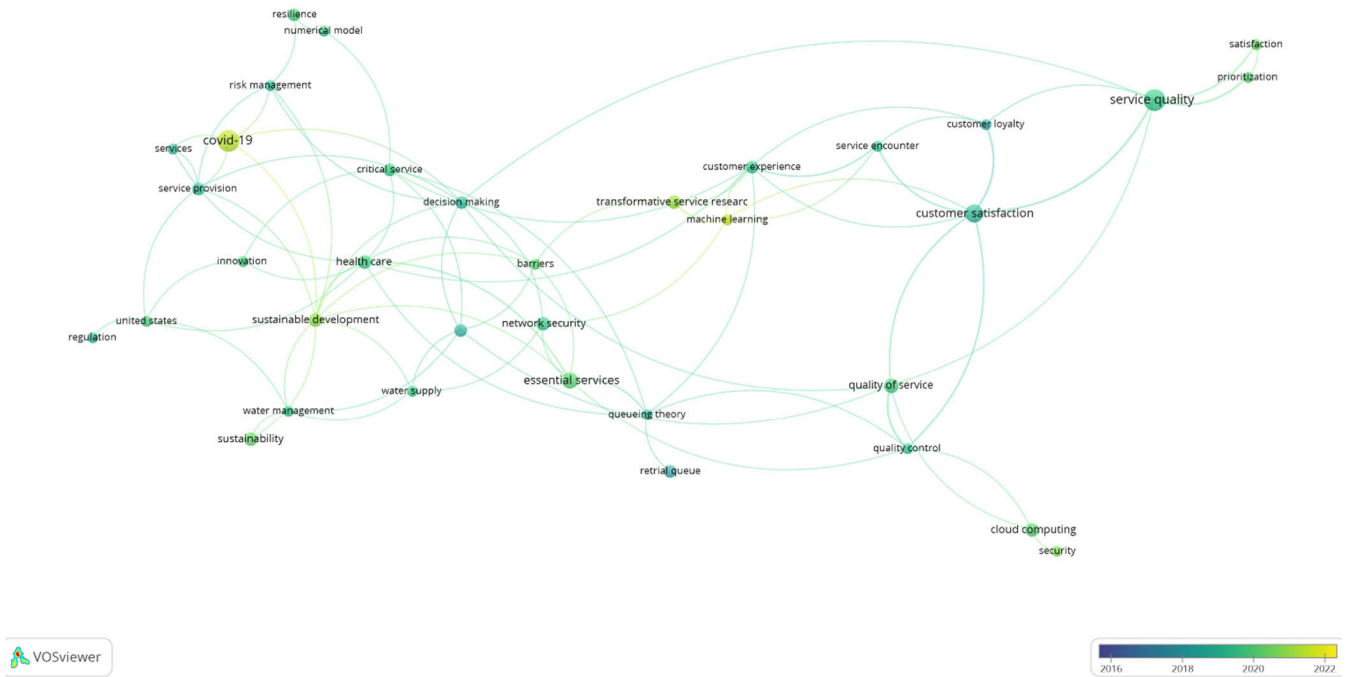
FIGURE 6. Map of keyword popularity distribution over time.

TABLE 5. Thematic clusters identified in the VOS viewer tool.

CLUSTER NAME	KEYWORDS	TOPIC GROUP (SPECIFIED BY THE AUTHORS)
Cluster 1	barriers, essential services, knowledge management, network security, sustainability, sustainable development, water management, water supply	Sustainable development of essential services
Cluster 2	covid-19, decision making, numerical model, resilience, risk management, service provision, services	Decision-making, and risk management in the context of the COVID-19 pandemic
Cluster 3	customer experience, customer loyalty, customer satisfaction, machine learning, service encounter, transformative service research	Transformative service research
Cluster 4	critical services, health care, innovation, regulation, united states,	Health care as an essential service
Cluster 5	cloud computing, quality control, quality of service, security	Using cloud computing to improve service quality
Cluster 6	prioritization, satisfaction, service quality	Service quality
Cluster 7	queueing theory, retail queue	Queue theory as a method of decision support

TABLE 6. List of the most cited papers on ES within the area of Business, Management, and Accounting.

DOCUMENT	CITATIONS	CROSS-CITED
[39]	360	2
[40]	235	1
[41]	94	0
[42]	86	1
[43]	80	0
[44]	57	1
[45]	48	0
[46]	48	1
[47]	42	1
[48]	37	0

Business, Management, and Accounting areas. The entire analyzed a set of papers (2790 papers) containing 10053 keywords. The minimum number of keywords in the set of selected papers was 4. In this case, 2004 keywords met the condition of the minimum number of occurrences (Fig. 7). The VOSviever program grouped them into 7 clusters.

In the authors' opinion, interpreting the relationship map shown in Fig. 7 is impossible. However, the cluster marked in red, in which essential services is the dominant keyword, stands apart from the others—indicating that it is a group of issues on the periphery of the mainstream.

An interesting result was obtained by analyzing the network of cross-citations for a set of papers without limita-

with an average number of cross-citations per work of 1.1 (Table 7).

To compare the results, analogous statistical studies were performed for a set of papers without limitation to the

TABLE 7. List of the most frequently cross-cited papers on ES within the area of Business, Management, and Accounting.

Document	Citations	Cross-cited
[49]	6	2
[39]	360	2
[50]	1	1
[22]	32	1
[51]	15	1
[52]	13	1
[30]	4	1
[53]	7	1
[54]	1	1
[55]	4	1
[56]	27	1
[57]	11	1
[58]	19	1
[46]	48	1
[42]	86	1
[59]	7	1
[47]	42	1
[60]	21	1
[44]	57	1
[40]	235	1
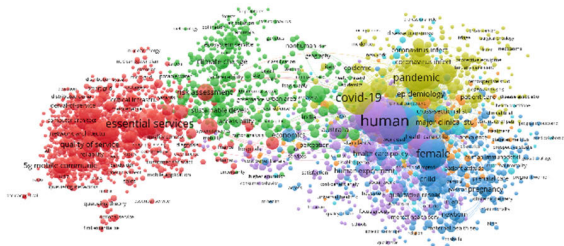
FIGURE 7. Co-occurrence map of ES keywords without a breakdown by discipline.

tion to the Business, Management, and Accounting areas. Of 2,790 papers relating to ES from different scientific disciplines, only 186 papers show cross-citation. With the average number of citations in this group is 1.28.

IV. DISCUSSION

Few works discuss ES, whether we consider a single area, e.g., Business, Management, and Accounting (277 studies) or all disciplines (2943 studies). The entire ES topic area is diverse and dispersed. This is evidenced by the diversity of results obtained through the LDAvis method and the VOSviewer tool. LDA analysis based on the content of

abstracts identified 24 leading topics (Table 3). The analysis by the VOSviewer tool, based on keywords assigned by authors and indexed by bibliometric databases, indicated 7 topic clusters (Table 8). Each leading topic can be posted from 2 to 4 thematic clusters. This shows that the content of the papers is not as homogeneous thematically as the authors decry using keywords. According to the study's authors, this indicates the early stage of research conducted in area ES.

The results of the LDA analysis and aggregation of the identified main topics indicate the presence of the ES topic in the scientific discussion. Business, Management, and Accounting researchers are interested in ES from a subjective perspective. There are works on enterprises, cities, municipalities, and entire countries. The works devoted to cities represent a particular thematic range in this group. In this context, the importance of ES in smart cities, traffic management and optimization, municipal services, fire service, and municipal buildings are considered. Scientists will focus on proving the importance of ES and the need to change the management paradigm in this area. This change concerns the need to submit availability before productivity. It means that the essential service has to be available to specific recipients despite the potential unprofitable of its provision.

Analyzing the relationships of keywords for the set of works limited to the area of Business, Management, and Accounting yielded non-standard results. First, the number of keywords that met the occurrence criterion in at least four developed ones was only 35 out of 1717. Secondly, the number of relationships between keywords is also minimal.

Currently, Covid-19 and machine learning are the most-discussed issues. Given the timing of the pandemic, the popularity of Covid-19 topics comes as no surprise—similarly, the popularity of issues related to machine learning. The indications regarding resilience and risk management are much more enjoyable. According to the data, these issues' peak popularity fell in 2018-2020 (Fig. 6). According to the authors, this suggests the start of research by researchers on the issue of ES resistance, which was then dominated by works devoted to the covid-19 pandemic. There is a visible connection between these issues through the relationship between works dealing with Covid-19 and risk management. Interestingly, however, the flood of papers related to covid-19 did not increase the number of works related to risk management and resilience. This may suggest that the authors who write about the Covid-19 issue refer to the existing solutions in the field of risk management and the lack of new solutions in this area generated due to the materialization of the pandemic.

The analysis of the ratio of the number of all keywords to the percentage of keywords that meet the criterion of inclusion in the analysis and the relationships between them in the analyzed group shows the need for leading topics and a large dispersion of the issues raised. On the other hand,

TABLE 8. Map of the affiliation of the leading topics obtained by the LDA vis method to the topic clusters generated by VOS viewer.

	CLUSTER 1	CLUSTER 2	CLUSTER 3	CLUSTER 4	CLUSTER 5	CLUSTER 6	CLUSTER 7
TOPIC 1			x			x	
TOPIC 2	x						
TOPIC 3			x			x	
TOPIC 4		x	x	x		x	
TOPIC 5			x			x	
TOPIC 6					x		x
TOPIC 7	x						
TOPIC 8		x			x		x
TOPIC 9			x				
TOPIC 10		x	x	x		x	
TOPIC 11		x	x	x		x	
TOPIC 12				x			x
TOPIC 13		x			x		x
TOPIC 14			x			x	
TOPIC 15			x	x		x	
TOPIC 16			x			x	
TOPIC 17			x			x	
TOPIC 18	x				x		
TOPIC 19	x				x		
TOPIC 20	x	x				x	
TOPIC 21			x			x	
TOPIC 22			x			x	
TOPIC 23	x						
TOPIC 24		x			x		x

the analysis of the content of the selected clusters indicates research topics related to:
- barriers to the implementation of sustainable development in the field of water management,
- managing the risk of providing services using numerical models in the context of covid-19,
- analysis of the services provided in the context of managing the realizations with clients,
- healthcare as a critical service,
- cloud computing and service security,
- prioritization and the quality of services,
- use queuing theory to conduct simulations to retain retail services.

The cross-citation analysis performed revealed a surprising fact. The works in the analyzed collection are cited, as shown in Table 6. However, these citations come from works that do not relate to ES issues. This may indicate that researchers treat the entire area associated with ES as complementary to other main research trends. The second observed fact concerns the low number of mutual citations within the analyzed set. The only cross-citations observed were in the works:
- [39], [22], [56],
- [55], [59], [49],
- [50], [51],
- [46], [58],
- [30], [47],
- [60], [57],
- [44], [54],
- [52], [40].

In the analyzed collection, only two works were cited more than once in other works under consideration. In both cases, the number cited was 2 (Table 7). Therefore, there are no significant studies in the analyzed group.

Analyzing the connection between keywords and cross-citations may indicate a significant dispersion of research and the disaggregation of the obtained results. Moreover, indicating any meaningful research direction was impossible, as the individual topics were quite distant. This may have been because all authors focused on narrow areas of ES.

In the collection of works, without being limited to the area of Business, Management, and Accounting, the dominant site is issues related to the challenges of the COVID-19 pandemic, where there are three sub-topics: healthcare and regulation, risk reduction, and healthcare. This phenomenon is unsurprising despite the significant domination of works devoted to health care and legal rules. In the era of a pandemic, the availability of health care and the necessary legal changes have become a prominent area focusing researchers' attention. This conclusion is confirmed by the analysis of the popularity of keywords over time (Fig. 5). The analysis of the collection of works on ES without being limited to the area of Business, Management, and Accounting again leads to the conclusion that there is a dominant trend in taking up topics aimed at discussing examples of ES for a given entity and proving their significance. The extension of the collection of analyzed works resulted in only an increase in the range of examples cited, which include examples of ES from the point of view of clinical laboratories, laboratory services, public services, wireless technologies, sanitary services, or water supply.

In the authors' opinion, interpreting the map of links of keywords for works isn't possible without being limited to Business, Management, and Accounting. However, the cluster marked in red (Fig. 7), in which essential services is the dominant keyword, deviates from the others. This observation

coincides with the conclusion that ES is not the mainstream of considerations among scientists and that it complements other thematic threads.

The result was obtained by analyzing the cross-citation network for a set of works without being limited to the area of Business, Management, and Accounting. The authors expected to get a relationship map similar to the map showing keyword relationships (Fig. 7). Meanwhile, a result was again obtained indicating a low number of cross-citations. Of 2790 works related to ES from various scientific disciplines, only 186 have cross-citations. The average number of people cited in this group is 1.28. This result confirms the conclusion that the research is highly dispersed and the results are disaggregated.

A specific area of interest for the authors is the continuity of operation of essential services. For this reason, ES's work on risk management and business continuity has been analyzed in more detail.

An interesting observation is the low percentage of work devoted to risk reduction issues in the set limited to the area of Business, Management, and Accounting (less than 3%). Despite the common determinant of risk management, these studies are dispersed thematically.

Ito and Aruga developed a framework to assess hospitals for disaster risk reduction, to continue providing primary health care services in times of crisis, and manage community resilience to disaster in standard times. This framework consists of (1) hospital business continuity plans within hospitals (providing essential services and receiving aid from non-disaster areas) and (2) hospital management to reduce the risk of a disaster outside the hospital (strengthening the healthcare coalition and promoting infrastructure and management). This framework shows how hospitals can proactively act as important institutions in disaster risk reduction activities [61].

Sneddon J. indicates how using standard risk management methods such as bow-tie analysis and an appropriate assurance and verification process (e.g., the line of defense model) can help better understand the risks associated with resuming or continuing operations in an environment. Pandemic and to ensure that the measures put in place to manage these risks are adequate and effective [62].

AbouZahr et al. showed significant variation between countries and grouped them according to the level of interference in the population registration system. Only a minority of 66 countries could maintain service continuity during the COVID-19 restrictions. In most of them, a combination of legal and operational problems has led to a decline in birth and death registrations. Only some countries have developed business continuity plans or strategies to deal with backlogs after lifting restrictions [63].

Kumar et al. defined risk mitigation strategies for perishable food supply chains during the COVID-19 pandemic. Among the risk mitigation strategies, "collaborative management," "proactive business continuity planning," and "financial stability" are the most important risk mitigation

strategies. This research is a novel attempt to identify and analyze risk mitigation strategies to improve socio-economic and ecological outcomes in achieving the sustainable development goal of healthy and safe food for all [45].

Gomes et al. studied the effectiveness of rapid response measures to mitigate the effects of COVID-19 in an essential service organization that continued to operate despite the pandemic. Their study expands the literature on business continuity planning. It emphasizes that the evaporating cloud (a tool of the Theory of Constraints) is a mechanism that broadens the possibilities of analyzing conflicts. For practitioners, this research provides a valuable resource for dealing with trade-offs at the enterprise level [64].

Outlander et al. researched the role of the risk manager in the organization. As a result of the research, five topics and one model were selected: 1) Crisis management is not the first response; 2) Unrealistic expectations of the role of "by the side of the desk."; 3) Bridging the gap between academia and practice with a "general social" approach; 4) Personal readiness is usually poor; 5) Behind-the-scenes roles can have an impact on mental health. Based on the above topics, a model identifies the occupational risks that risk managers may encounter when performing skills, tasks, and roles related to their work [65].

Tracey et al. look for organizational-level resources that support resilience and contribute to the empirical database on business continuity planning. Inductive analysis was used to identify eight emerging topics highlighting the importance of resources at the organizational level and their contribution to adaptability. The dominant topics were leadership and culture in adopting and promoting preparedness strategies and the importance of communication and linkages at the micro, meso, and macro levels. Twenty-five resources were identified and grouped into seven categories: (a) awareness, (b) human resources, (c) information and communication, (d) leadership and culture, (e) operational infrastructure, (f) physical resources, and (g) social capital. The study results can be used as a template to guide resource mapping activities and support organizations involved in business continuity planning [66].

Ali et al. discussed the different business continuity approaches implemented in IoT services. According to the authors, assessing the vulnerability and threats of IoT services is necessary to limit damage and ensure service continuity in times of crisis. There needs to be more frameworks and guidelines for the continuity of IoT services. Therefore, in the article, they reviewed and analyzed various types of IoT architectures and the risks associated with them. As a result, the analysis results are used to propose a business continuity framework for IoT. Their solution explains the different types of IoT architectures and business continuity measurements for IoT services [67].

An analysis of the results of the topics leading to the collection of works without being limited to the area of Business, Management, and Accounting again showed a low percentage

of work devoted to risk reduction issues (just over 2%). These studies appear in the context of the challenges related to the COVID-19 pandemic, cybersecurity, and smart city.

Van den Ade et al. demonstrated the importance of targeting the cross-border exchange of information on the inter-organizational network responsible for CI and increasing the intensity of such activities when disruptions in CI coincide and are unprecedented. The study contributes to the understanding of how network-level processes (i.e., cross-border information exchange) can be managed to ensure the resilience of inter-organizational (supply) networks to daily CI-related disruptions [68].

Jacobson et al. conducted a qualitative study using community resilience to natural disasters and the theory of institutional work to analyze the response of Canadian food retailers to the COVID-19 pandemic. Research results illustrate how food retailers emerged as an essential service and extended their reach beyond the boundaries of basic institutional logic to include the public good [69].

Nazemi and Dehghanian developed a framework for modeling and characterizing seismic hazards, assessing electrical systems' vulnerability to earthquakes, and implementing corrective actions and mitigation strategies to ensure operational resilience using Monte Carlo Simulation. They proposed a new seismic risk metric that considers the likelihood and susceptibility of a threat and the financial implications of disruptions to the power plant following an earthquake. In addition, they developed a new earthquake mitigation strategy based on corrective control of the grid topology to maximize power recovery after disturbance [70].

Labaka et al. developed a maturity model to help cities assess and improve their resilience to threats. The model co-creation process was carried out using various methodologies with an interdisciplinary group of international experts who contributed their knowledge and experience to the model development process [58].

Therrien et al., exploring the health system resilience, developed a model of the four ''S'' resilience (personnel, things, structures, and systems) and proposed a complexity-based framework to understand better and evaluate the resilience factors that enable resilience development in complex health systems. The framework proposes a balanced and innovative process to integrate resilience factors in a pragmatic approach built around the four ''S'' rapid response capabilities to increase the health system's resilience. The resilience factors have been classified according to these types of complexity and their time dimensions: proactive factors, which increase the willingness to face both ordinary and exceptional requirements, and passive factors, which enable responding to unexpected needs during a crisis. The framework is complemented by further categorizing immune factors according to their stabilizing or destabilizing effects based on the feedback processes described in complexity theory [71].

On the one hand, the focus on cybersecurity is not surprising, as ESs have been brought into scientific discussion in this context. The presence of works devoted to intelligent city security is also unsurprising because their operation is based on digital technologies. What is surprising, however, is the absence of other security areas related to the provision of ES, i.e., physical security, personnel security, technical security, legal security, or business continuity (only four works associated with this issue in the area of Business, Management, and Accounting and 18 works without division into disciplines).

The business continuity problem of ES is discussed in only four studies within the area of Business, Management, and Accounting and 18 works without division into scientific disciplines. Moreover, the current literature covers only selected elements of ES and often focuses on the importance of ES for specific entities or the impact of specific events on ES. Studies have yet to be observed on the overall view of ES security, considering physical security, technical security, legal security, personnel security, cybersecurity, and business continuity. The small number of works on ES business continuity and the authors' focus on many specific issues indicate the need for further holistic research.

Work in CI security management can be an inspiration and a starting point for developing a framework for business continuity management of critical services.

Argyroudis et al. discuss the resilience assessment framework for critical infrastructure in a multi-hazard environment. The paper proposes a novel framework for the quantitative resilience assessment of critical infrastructure subjected to multiple hazards, considering the assets' vulnerability to hazard actions and the rapidity of the damage recovery, including the temporal variability of the threats. The study puts forward a well-informed asset resilience index, which accounts for the full, partial, or no restoration of asset damage between the subsequent hazard occurrences. The paper concludes with a demonstration of the importance of the framework and how this can be utilized to estimate the resilience of networks to provide a quantification of the resilience at a regional and country scale [72].

Yu et al. explore a deep-learning-based proactive APT detection scheme in IIoT. In this scheme, considering the characteristics of long attack sequences and long-term continuous APT attacks, our solution adopts a well-known deep learning model, bidirectional encoder representations from transformers (BERT), to detect APT attack sequences. The APT attack sequence is also optimized to the ineffectiveness of the model's long-term sequence judgment. The experimental results show that the proposed deep learning method is feasible and effective for APT detection but also certify that the BERT model has better accuracy and a lower false alarm rate when detecting APT attack sequences than other time series models [73].

Skraparlis et al. develop a scheme to perform a threat assessment of neighboring critical infrastructures, aiming at preventing explosions of truck-bombs. To do so, each

crucial point of critical infrastructure is initially associated with a level of importance. Next, three scenarios are analyzed: (a) single-attack single-infrastructure, (b) multiple-attack single-infrastructure, and (c) multiple-attack multiple-infrastructure. In this way, an area of threat assessment is estimated for each critical infrastructure. Then, the threat level is assessed in real time by an innovative algorithm, which: (a) estimates the impact of multiple consecutive explosions, (b) uses five adapted threat levels, and (c) introduces multiple criteria and minimum classification conditions based on the number of crucial points and their levels of importance [74].

Wiśniewski discusses the issues of critical infrastructure security management from the perspective of entities responsible for its security and the development of an integral model of critical infrastructure security and shows the methodology of situational management of critical infrastructure safety. Proposed solutions are used for CI mapping, enabling the generation of adverse event scenarios, estimation of the risks dependent on the considered CI, and determination of decision problem, indicating a set of protection activities to eliminate or reduce the risk in the security threshold [14].

The results of the systematic literature review on ES indicate that this is a topic in the scientific discussion, but it is not treated as a mainstream issue. The subject of ES is complementary to other research issues. Moreover, it is a very scattered area with no dominant issue and no breakthrough work determining the main directions of research and scientific discussions. According to the authors, the subject of ES is in the development stage. Considering the planned legislative changes at the EU level, the interest of researchers in this subject will increase significantly. Especially in the field of Business, Management, and Accounting s.

Research shows that ES is strongly associated with the human factor (Fig. 7). This is particularly interesting because, in the context of CI interpretation, this relationship is marginalized, which was raised as a kind of objection to the methods of determining CI objects [75].

According to the authors, the critical research area already slightly signaled in the available literature is the safety of ES. Security is a sum of the components: physical security, technical security, legal security, personnel security, cybersecurity, and business continuity. At the same time, the leading area in security will be the continuity of ES.

V. CONCLUSION

There are few papers discussing ES. This is regardless if we consider a single area, e.g., Business, Management, and Accounting (277 papers), or all disciplines together (2943 papers). The ratio of papers categorized as Business, Management, and Accounting discussing the issue of essential services is 5.1% (Fig. 2) concerning all identified papers on this issue collected in SCOPUS databases. The number of leading topics in the number of papers indicates a wide dispersion of researchers' attention. An analysis of the

number of keyword occurrences and their links, and a map of cross-citation of papers leads to a similar conclusion.

Answer to Q1 – What issues regarding essential services are raised in the scientific discussion?

An analysis of the leading topics of works limited to the area of Business, Management, and Accounting (Fig. 3) shows that the interest of researchers in ES topics is focused on their relevance to entities. There are works on companies, cities, municipalities, and entire countries. Works on cities represent a particular range of topics in this group. In this context, the importance of ES is considered from the perspective of smart cities, traffic management and optimization, municipal services, fire services, and municipal buildings. Other papers deal with the impact of the COVID-19 pandemic on ES, especially in the context of drug production and business implications. There are also papers on sustainability and corporate social responsibility. The issue of government funding of ES is addressed, as well as the aspect of ES for the agricultural sector.

In contrast, a slightly different picture emerges from an analysis of the map of the leading topics of the work without limitation to the Business, Management, and Accounting area (Fig. 4). The dominant site is issues related to the challenges of the COVID-19 pandemic where there are three sub-topics health care and regulation, risk mitigation, and health service. Health service as ES also appears in other thematic areas: as a stand-alone issue, in the context of urban critical services, or as infrastructure. Different contexts for ES in the body of work not restricted to the area of Business, Management, and Accounting are the topics of ICT, public administration, smart cities, and CI.

Answer to Q3 – Which works are leading for essential services business continuity management?

Analysis of the leading topics, keyword correlations, and cross-citation of papers in the analyzed groups indicates a lack of leading works and a high degree of isolation of ongoing research. There has to be a reference to existing research works in this area (Table 7).

Answer to Q2 – Are there any works indicating framework guidelines for the issue of business continuity?

A total lack of holistic works on ES is observed. On the other hand, the problem of ES business continuity is addressed in only 18 studies, including four from Business, Management, and Accounting. Moreover, the available literature covers only selected elements of ES and often focuses on the importance of ES for specific entities or the impact of specific events on ES. Work has yet to be observed on a holistic approach to ES security that takes into account: physical security, technical security, legal security, personnel security, cyber security, and business continuity.

Answer to Q4 – In what form is the essential service business continuity management implemented?

Papers on ES and business continuity have yet to identify a framework that defines the principles of security management understood as maintaining service continuity. However,

works in this area provide research results on several partial forms of ES business continuity management:

- application of standard risk management methods,
- risk mitigation strategies: collaborative management, proactive planning,
- effectiveness of rapid response measures,
- a set of resources at the organizational level that supports resilience and contributes to the empirical database on business continuity planning: (a) awareness, (b) human resources, (c) information and communication, (d) leadership and culture, (e) operational infrastructure, (f) physical resources, and (g) social capital,
- the importance of standardizing procedures and resources,
- a business continuity framework for IoT that considers different types of IoT architectures and different business continuity measurements for IoT services.

Answer to Q5 – Are there methods for identifying the extent of a crisis based on the disruption of an essential service?

The collection of texts under review does not provide information on solutions to determine the extent of an emergency based on ES disruptions.

The conclusion, in the area of ES business continuity management, is observed:

- lack of holistic tools to manage ES business continuity,
- lack of tools to identify threats to ES business continuity (including domino effects),
- lack of methods to identify the extent of an emergency based on the disruption of an essential service,
- lack of a maturity model indicating a set of ES business continuity management forms adequate for the level of sophistication of the entity under consideration.

It leads to the conclusion that a comprehensive study of ES business continuity management is needed, taking into account: physical security, technical security, legal security, personnel security, cyber security, and business continuity. This research should include the possibility of simulating the spread of adverse events of the so-called "domino effect" using simulation tools. Such activities will allow verification of the safeguards used and highlight the gaps that need to be eliminated. In the analyzed literature, single works relating to this topic were observed.

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