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Review

Bibliometric Analysis on the Application of Fuzzy Logic into Marketing Strategy

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Abstract: Fuzzy marketing considers the degree to which a customer belongs to specific segments and subsequently allows them to be targeted with messages that engage them emotionally. To better understand the application and importance of fuzzy logic in marketing strategy, we developed a systematic literature review with bibliometric analysis to examine a sample of 96 studies from the SCOPUS database to identify research activity on this topic until December 2022. It was possible to create a connection between these concepts, marketing and fuzzy logic, to increase the efforts of marketing professionals. For instance, the results show that adopting approaches such as fuzzy marketing or the fuzzy marketing mix model enhances the company's capability to build stronger customer relationships, enhance profitability, and improve marketing performance.

Keywords: fuzzy logic; fuzzy marketing; marketing strategy; consumer behavior

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1. Introduction

Today's business environment is highly competitive due to increasing diversification and globalization. As a result, companies have recognized the importance of developing and implementing customer-centric marketing strategies to increase customer retention and maximize profits. Consequently, fuzzy logic was integrated into marketing models to create solutions tailored to each customer. Hernández and Hidalgo [1] explain that fuzzy logic is based on observing human behavior. For example, fuzzy logic mimics how people analyze problems and make decisions using ambiguous or imprecise values rather than relying on absolute facts or falsehoods. Scott [2] describes fuzzy logic as a computing approach that stems from the mathematical study of multivalued logic that processes possible truth values through the same variable. Unlike classical logic, which requires statements to be absolutely true or false [3], fuzzy logic involves using true values ranging from 0 to 1, indicating that the algorithm can provide solutions based on data ranges rather than in a discrete data point [4]. In this case, fuzzy logic can be used to interpret data for information with relative or subjective definitions. In real-life situations, falsehood or absolute truth statements are rare since people perceive and interpret information differently [5]. For example, customers may interpret marketing information differently, leading to different decisions and intentions. Thus, employing fuzzy logic in marketing allows marketers to make decisions based on various data ranges from different customers and partners.

Applying fuzzy logic principles to marketing decisions led to the establishment of the "fuzzy marketing" concept. It reflects how people think and behave, estimating the results of their previous knowledge and experience [6]. In this case, fuzzy logic in marketing finds that the truth coefficients are somewhere on the scale of 0–1. This suggests that consumer

behaviors and marketing content consumption cannot simply be black and white (i.e., true/false binary absolutes) but rather 'shades of grey' perspectives [4]. Customers are not predictable or predefined; they are confusing by definition. For example, even if a customer purchased a specific product this week, he might still need to repurchase the same product next week [7]. Therefore, instead of treating them collectively within a given segment through signal data, fuzzy logic encourages treating customers as individuals and real people [2]. Consequently, this approach allows for creating promotional messages that engage them emotionally and increase potential positive behaviors and outcomes [8]. Despite the clear contributions of applying fuzzy logic to marketing strategy, scarce research analyzes the integration between these two concepts. Therefore, a systematic literature review with bibliometric analysis of 96 sources was performed to illustrate further the connection between fuzzy logic and marketing to enhance marketing professionals' efforts to achieve competitiveness in the unpredictable business environment.

2. Materials and Methods

A systematic literature review with bibliometric analysis (SLRBA) was performed to analyze and synthesize data on fuzzy logic and marketing strategies. The main objective of this research was to illustrate how the integration of fuzzy logic increases the effectiveness of a marketing strategy and its associated results. Consequently, the SLRBA approach was considered desirable because it helps researchers in the interrelationships and impacts of published research in the field of interest [9]. It involves analyzing large amounts of scholarly literature to provide diverse perspectives and findings that can be integrated to improve practice and inform policymaking and decision-making. According to Donthu et al. [10], a bibliometric analysis should be used when the scope of the review and the dataset are huge, "for example, to reveal research trends over time, to show shifts in the boundaries of scientific fields, and identify most productive scientists, institutions and countries" [11] (p. 2). Thus, bibliometric analysis is an appropriate method to present the state of the academic structure and the emerging trends of fuzzy logic because it is a broad concept used in several fields.

The SLRBA involves screening and selecting information sources to ensure the validity and accuracy of data presented in a process consisting of three phases and six steps [12–15] (Table 1).

Table 1. Process of systematic LRSB.

Stage	Step	Description
Exploration	Step 1	formulating the research problem
	Step 2	searching for appropriate literature
	Step 3	critical appraisal of the selected studies
	Step 4	data synthesis from individual sources
Interpretation	Step 5	reporting findings and recommendations
Communication	Step 6	Presentation of the LRSB report

Source: own elaboration.

The methodological approach began with bibliographical research in the SCOPUS online indexing database of scientific articles, the most critical peer-reviewed in the academic world. The use of Scopus alone is because it is the primary source of articles for scholarly journals/journals, covering approximately 19,500 titles from more than 5000 international publishers, including coverage of 16,500 peer-reviewed journals in scientific, technical, and scientific sciences. Thus, providing a clear view of the topics researched with scientific and/or academic relevance. Moreover, we understand that this comprehensive database ensures relevant and reliable research with enriched data associated with the academic literature. However, we assume the study is limited to considering only the SCOPUS database, excluding other academic databases.

The procedure started with using the keyword "fuzzy" in the Scopus directory to identify appropriate sources. The screening was limited to titles, abstracts, and keywords, and 370,090 references were generated. However, other search boundaries were implemented based on Linnenluecke et al. [16], who argue that only articles in journals judged as "high quality" should be synthesized in a literature review, recommending that researchers adopt appropriate inclusion and exclusion criteria. Xiao and Watson [17] further explain that literary analysis improves readers' understanding of the breadth and depth of the existing literature. Therefore, to restrict the search to the most relevant literature, the keyword "marketing" was added, reducing the numbers to 1973 documents. A more exact keyword, "marketing strategy", was added, reducing the document results to 96 scientific and/or scholarly papers: 47 conference papers, 46 articles, 2 reviews, and 1 book chapter (Table 2). The scientific documents were published until December 2022.

Table 2. Screening Methodology.

Database Scopus	Screening	Publications
Meta-search	keyword: fuzzy	370,090
Inclusion Criteria	keyword: fuzzy, marketing	1973
	keyword: fuzzy, marketing, marketing strategy	
Screening	Published December 2022	96

Source: own elaboration.

3. Literature Analysis: Themes and Trends

Peer-reviewed documents were analyzed until December 2022 (Figure 1). Additionally, 2009 and 2012 were the years with the most peer-reviewed Fuzzy and Marketing Strategy documents, with 12 publications each. The publications were classified as follows: Expert Systems with Applications (5); Advances in Intelligent Systems and Computing (4); IEEE International Conference On Fuzzy Systems (4); Communications in Computer and Information Science (3); Journal Of Intelligent And Fuzzy Systems (3); Advanced Materials Research (2); Huazhong Ligong Journal Daxue Xuebao Huazhong Central China University of Science and Technology (2); Marketing Intelligence Planning (2); World Scientific Proc Series On Computer Engineering and Information Science 7 Uncertainty Modeling in Knowledge Engineering and Decision Making Processes of the 10th Flins International Conference (2) and with one remaining publication.

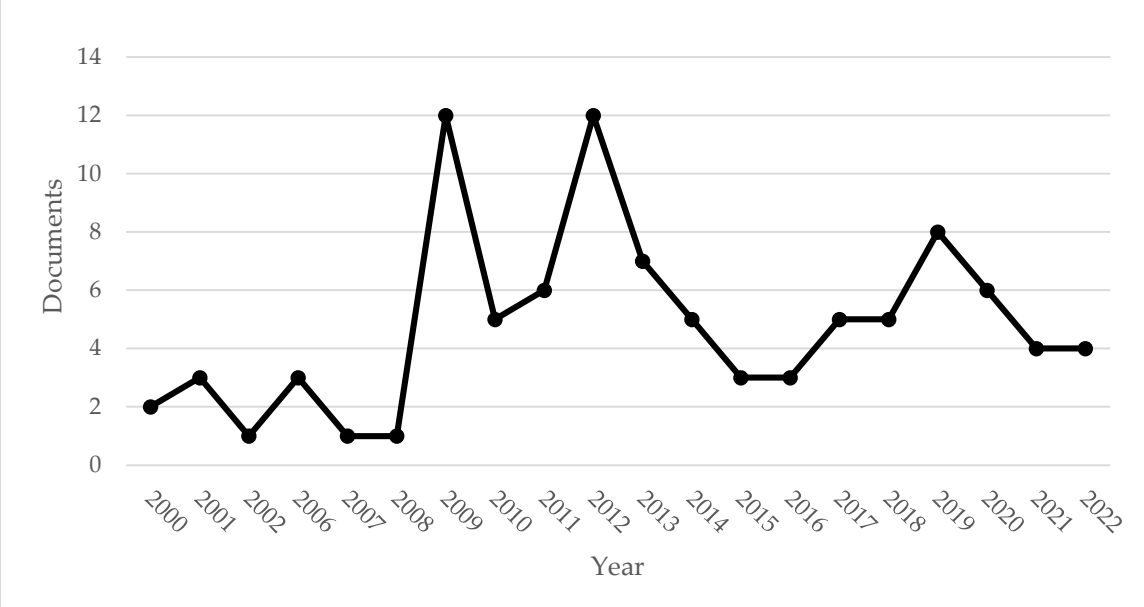

Figure 1. Documents by year. Source: own elaboration.

In Table 3, we analyze the Scimago Journal & Country Rank (SJR), the best quartile, and the H index by publication. The Administrative Sciences with 15,100 (SJR), Q1, and H index 181 is the best-positioned journal.

Table 3. Scimago journal & country rank impact factor.

Title	SJR	Best Quartile	H Index
European Journal Of Operational Research	2.350	Q1	274
Future Generation Computer Systems	2.230	Q1	134
Computers In Human Behavior	2.170	Q1	206
Expert Systems With Applications	2.070	Q1	225
Energy	2.040	Q1	212
Applied Soft Computing Journal	1.960	Q1	156
Computers And Industrial Engineering	1.780	Q1	136
Engineering Applications Of Artificial Intelligence	1.730	Q1	114
Applied Intelligence	1.210	Q2	72
Journal Of Organizational And End User Computing	1.210	Q1	36
Management Decision	1.160	Q1	106
Applied Mathematical Modelling	1.110	Q1	122
International Journal Of Computer Integrated Manufacturing	1.100	Q1	59
Neural Computing And Applications	1.070	Q1	94
Applied Mathematics And Computation	1.040	Q1	154
Industrial Management And Data Systems	1.010	Q1	109
Computational Intelligence And Neuroscience	0.860	Q1	61
Sustainability Switzerland	0.660	Q1	109
Asia Pacific Education Review	0.610	Q2	32
Assembly Automation	0.610	Q2	44
International Journal Of Information Technology And Decision Making	0.550	Q2	46
Computational And Mathematical Organization Theory	0.540	Q2	28
International Journal Of Computational Intelligence Systems	0.490	Q2	45
International Journal Of Innovative Computing Information And Control	0.480	Q2	52
Journal Of Discrete Mathematical Sciences And Cryptography	0.450	Q3	18
International Journal Of System Assurance Engineering And Management	0.430	Q2	28
Lecture Notes In Computer Science Including Subseries Lecture Notes In Artificial Intelligence And Lecture Notes In Bioinformatics	0.410	Q2	415
Journal Of Intelligent And Fuzzy Systems	0.390	Q2	64
Uncertain Supply Chain Management	0.360	Q2	19
IEEE International Conference On Fuzzy Systems	0.350	- *	61
International Journal Of Electronic Commerce Studies	0.290	Q3	12
Frontiers In Artificial Intelligence And Applications	0.260	Q4	54
IFIP Advances In Information And Communication Technology	0.250	Q3	56
International Journal Of Technology Intelligence And Planning	0.250	Q3	17
ACM International Conference Proceeding Series	0.230	- *	128
Journal Of Multiple-Valued Logic And Soft Computing	0.230	Q4	25
Advances In Intelligent Systems And Computing	0.220	Q4	48
Nanjing Li Gong Daxue Xuebao Journal Of Nanjing University Of Science And Technology	0.220	Q3	14
Communications In Computer And Information Science	0.210	Q4	55
International Journal Of Electronic Customer Relationship Management	0.210	Q3	14
Lecture Notes In Electrical Engineering	0.150	Q4	36
International Journal Of Services Technology And Management	0.120	Q4	24
Advanced Materials Research	0	- *	43
Huazhong Ligong Daxue Xuebao Journal Huazhong Central China University Of Science And Technology	0	- *	0

Table 3. *Cont.*

Title	SJR	Best Quartile	H Index
2011 International Conference On E Business And E Government Icee2011 Proceedings	0	- *	8
2012 International Conference On Fuzzy Theory And Its Applications Ifuzzy 2012	0	- *	8
2015 12th International Conference On Fuzzy Systems And Knowledge Discovery Fskd 2015	0	- *	12
2019 IEEE Symposium Series On Computational Intelligence Ssci 2019	0	- *	19
2nd International Conference On Information Science And Engineering Icise2010 Proceedings	0	- *	10
6th International Conference On Soft Computing And Intelligent Systems And 13th International Symposium On Advanced Intelligence Systems Scis Isis 2012	0	- *	11
Annual International Conference Of The American Society For Engineering Management 2012 Asem 2012 Agile Management	0	- *	4
Embracing Change And Uncertainty In Engineering Management Conference Proceedings IEEE International Conference On Systems Man And Cybernetics	0	- *	62
Data 2019 Proceedings Of The 8th International Conference On Data Science Technology And Applications	0	- *	4
Icnc Fskd 2017 13th International Conference On Natural Computation Fuzzy Systems And Knowledge Discovery	0	- *	8
Ie And EM 2009 Proceedings 2009 IEEE 16th International Conference On Industrial Engineering And Engineering Management	0	- *	9
International Review On Computers And Software	0	- *	16
Metallurgical And Mining Industry	0	- *	23
Picmet 2016 Portland International Conference On Management Of Engineering And Technology Technology Management For Social Innovation Proceedings	0	- *	9
Proceedings 2009 Asia Pacific Conference On Information Processing Apcip 2009	0	- *	13
Proceedings 2013 4th International Conference On Digital Manufacturing And Automation Icdma 2013	0	- *	43
Proceedings 2017 2nd International Conferences On Information Technology Information Systems And Electrical Engineering Icitisee 2017	0	- *	8
Proceedings International Conference On Management And Service Science Mass 2009	0	- *	11
Proceedings Of The Universities Power Engineering Conference	0	- *	32
Research Journal Of Applied Sciences Engineering And Technology	0	- *	30
Wmsci 2006 The 10th World Multi-Conference On Systemics Cybernetics And Informatics Jointly With The 12th International Conference On Information Systems Analysis And Synthesis Isas 2006 Proc	0	- *	4
World Academy Of Science Engineering And Technology	0	- *	31
Marketing Intelligence Planning	- *	- *	- *
World Scientific Proc Series On Computer Engineering And Information Science 7 Uncertainty Modeling In Knowledge Engineering And Decision-Making Proceedings Of The 10th International Flins Conf	- *	- *	- *
2009 International Conference On Management Science And Engineering 16th Annual Conference Proceedings Icmse 2009	- *	- *	- *
Dianwang Jishu Power System Technology	- *	- *	- *
Intelligent Systems Concepts Methodologies Tools And Applications	- *	- *	- *
Lecture Notes In Business Information Processing	-*	-*	49

Table 3. *Cont.*

Title	SJR	Best Quartile	H Index
PCI 2009 13th Panhellenic Conference On Informatics	- *	- *	- *
Proceedings Academia Industry Working Conference On Research Challenges 2000 Next Generation Enterprises Virtual Organizations And Mobile Pervasive Technologies Aiworc 2000	- *	- *	- *
Proceedings Of 2020 IEEE International Conference On Information Technology Big Data And Artificial Intelligence Iciba 2020	- *	- *	- *
Proceedings Of SPIE The International Society For Optical Engineering	- *	- *	- *
Proceedings Of The 2016 2nd International Conference On Contemporary Computing And Informatics Ic3i 2016	- *	- *	- *
Proceedings Of The 3rd International Conference On Intelligent Sustainable Systems Iciss 2020	- *	- *	- *

Note: * data not available. Source: own elaboration.

There is a total of 53 publications in Q1, 16 in Q2, 10 in Q3, and 6 in Q4. Publications from the best quartile Q1 represent 30% of the 53 publications titles; best quartile Q2 represents 19%; best quartile Q3 represents 11%; best quartile Q4 represents 2%, and data from 20 publications are unavailable. As evident from Table 3, most articles on Fuzzy Logic and Marketing Strategy rank on the Q1 best quartile index.

The thematic areas covered by the 96 scientific and/or academic documents were: Accounting (17); Decision Sciences (14); Energy (5); Environmental Science (2); Materials Science (2); Medicine (2); Social Sciences (2); and Arts and Humanities, Earth and Planetary Sciences, Neuroscience, Physics and Astronomy, and Psychology (1).

The most cited article was "DEMATEL revised: resolving DEMATEL infeasibility" by Hsuan-Shih et al., with 123 citations published in Applied Mathematical Modeling and Environment with 1.110 (SJR), the best quartile (Q1) and an H index (122). The article shows that raising the initial relation matrix to the power of infinity may not converge to zero, and therefore, the total influence may not converge.

In Figure 2, we can analyze the evolution of document citations until December 2022. The number of citations shows a positive net growth with R2 of 54% for the year 2021 with 156 citations, with a total of 905 citations (Appendix A).

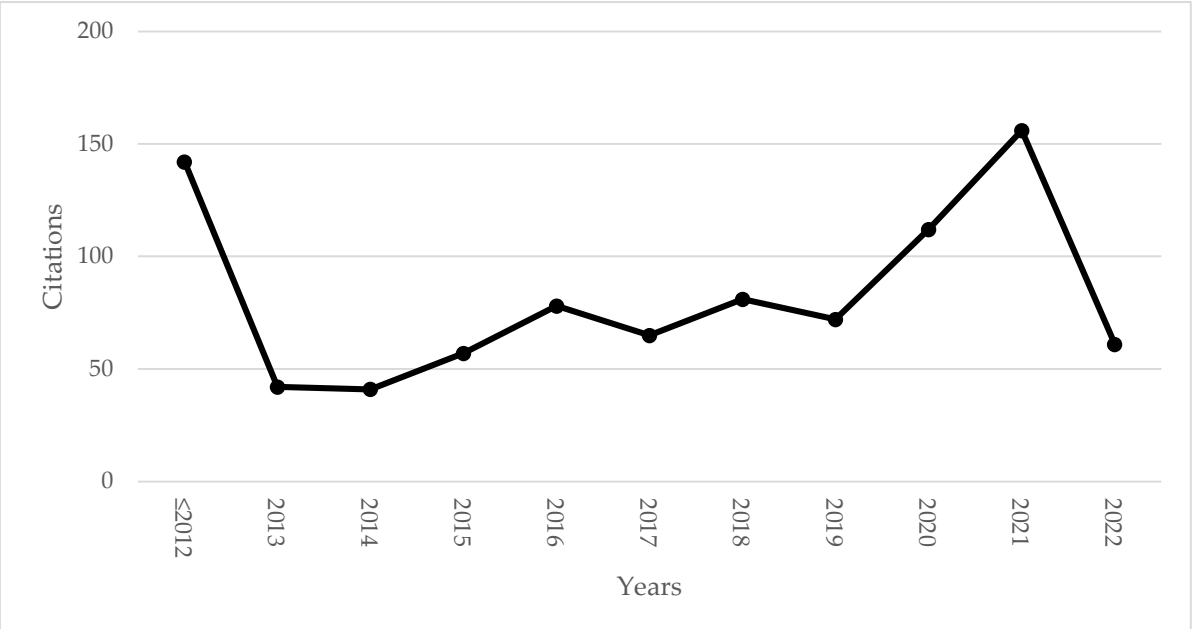

Figure 2. Evolution of citations between ≤2012 and May 2022. Source: own elaboration.

The h-index was used to ascertain the productivity and impact of the published work based on the most significant number of articles with at least the same number of citations. Of the documents considered for the h-index, 17 have been cited at least 17 times.

Figure 3 presents the bibliometric study to investigate and identify indicators of the dynamics and evolution of scientific information. Using scientific software, VOSviewer 1.6.19 is intended to identify the main search keywords in studies that integrate topics of fuzzy logic and marketing strategy.

Figure 3. Network of all keywords.

The associated keywords are shown in Figure 4, making clear the network of keywords that appear together/linked in each scientific article, thus allowing us to know the themes studied by the researchers and identify future research trends. Figure 5 presents a profusion of bibliographic couplings with a cited reference analysis unit.

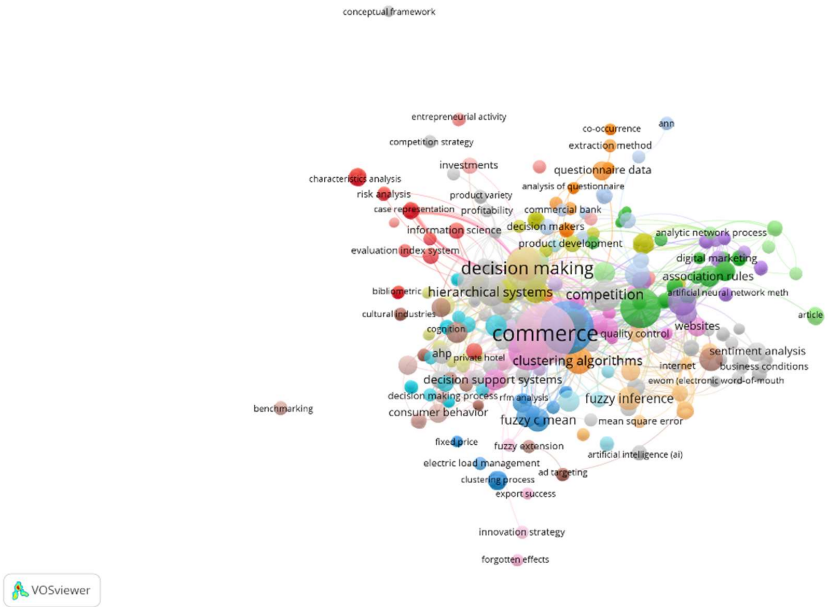

Figure 4. Network of Linked Keywords.

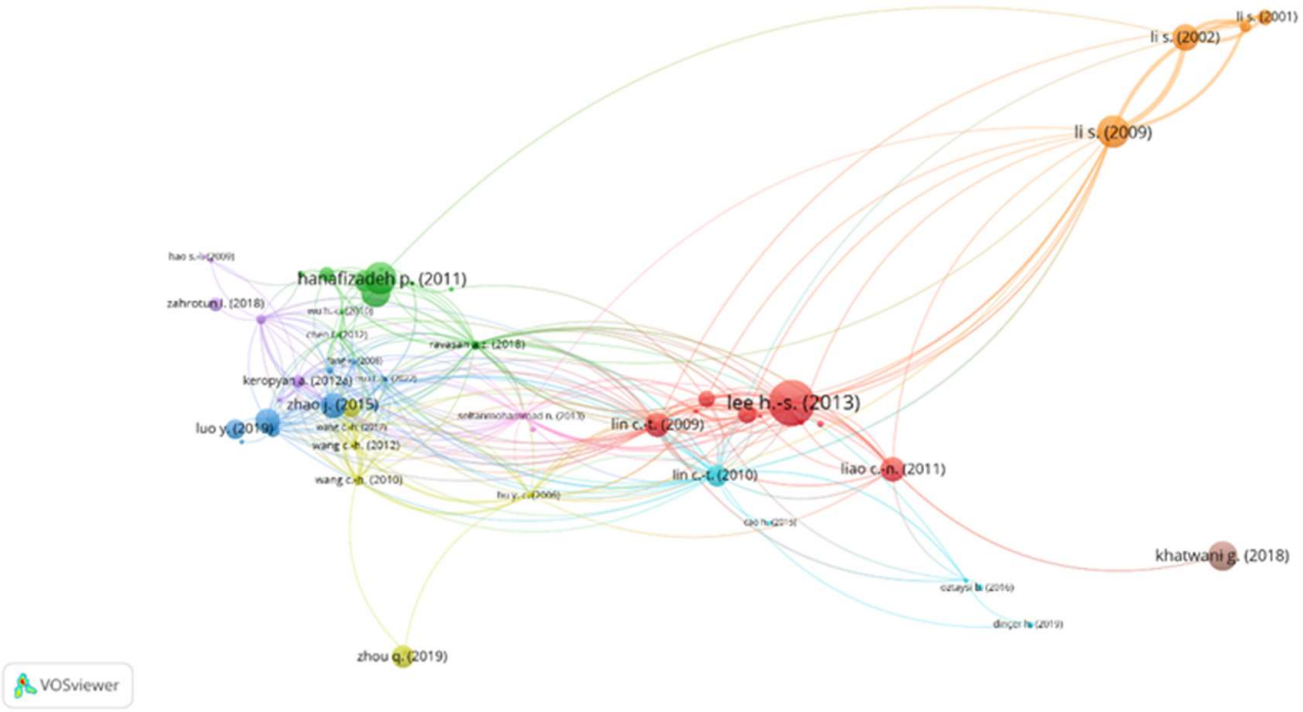

Figure 5. Networks bibliographic coupling.

4. Theoretical Perspectives

4.1. The Fuzzy Logic and Its Origins

Fuzzy logic is a procedure that allows the processing of multiple truth variables using the same variable. In this case, the researcher uses an open and imprecise spectrum of data and statistical approaches to draw accurate conclusions [18]. He encourages the generalization of standard logic by illustrating that a concept has a certain degree of truth that can vary between 0.0 and 1.0. In formal logic, ideas are often believed to be totally true (truth value 1.0) or completely false (truth value 0.0) [19]. However, fuzzy logic suggests that some concepts humans use to define problems or analyze situations may be vague and characterized by subjective or relative definitions. Therefore, they cannot be classified as absolute truth or absolute false [20]. For example, describing someone as "beautiful" is subjective and cannot be classified as an indisputable fact. Fuzzy logic provides a flexible reasoning engine that can deal with partial truths or determine conclusions for real-life situations that are difficult to decide whether true or false [21]. Therefore, fuzzy logic is a problem-solving technique used to evaluate all available information and thus make the best decisions.

Although Lotfi Zadeh introduced the concept of fuzzy logic in 1995, its history and development are rooted in earlier theories of logic that examined the structure and principles of correct reasoning. For example, Aristotle and his predecessors developed ideas in logic and mathematics, including the Law of Excluded Middle, which implies that every proposition can be true or false [22]. However, the Greek philosopher Plato disagreed with this notion, arguing that there is a third realm beyond true and false where concepts 'fell' [23]. These different perspectives influenced the mathematical study of logic and later led to the development of fuzzy logic [24]. For example, in the 19th century, George Boole used the Aristotelian perspective to develop an algebra. He set a theory that mathematically dealt with Aristotelian two-valued logic by mapping true and false to 1 and 0, respectively. Jan Lukasiewicz developed a three-valued logic (true, possible, faulty) in the early 20th century. However, he did not win the approval of other mathematicians and philosophers.

Other philosophers studied the principles of uncertainty and imprecision before the fuzzy set theory was adopted in mainstream research and practice. For example, Bertrand Russell proposed the paradox of "all sets that do not contain themselves" [25] (p. 72).

Likewise, Max Black, a German philosopher and scientist, introduced the theory of "vague sets", which analyzed the problem of imprecision. Max Black argued that Russell's theory confused vagueness with generality, thus suggesting that vagueness should be represented with appropriate details, such as terms and symbols that describe borderline cases [26]. The German philosopher proposed that a consistency curve or profile should be used to analyze the ambiguity of a symbol or word. These curves resemble the fuzzy set membership functions (type 1) in Lofti Zadeh's fuzzy set theory [27]. Therefore, the concepts and ideologies of fuzzy logic developed over time from various thinkers in different fields who recognized the shortcomings of the traditional two-valued truth logic.

The concept was officially recognized in 1965 when Professor Lotfi A. Zadeh of the University of California at Berkeley published "Fuzzy Sets". The professor based the notion of a fuzzy set on the concept of partially or gradually belonging to a set [28]. Zadeh explained that most objects do not have precise criteria for association in the real physical world, although they play a critical role in human thinking. For example, these imprecise categories influence various aspects of pattern recognition [29] as well as the communication and abstraction of information [30]. An example of a real-life situation is assuming that someone is considered tall if they are 180 cm or more and short if they are 140 cm or less. How would we classify someone who is 178 cm? Under the two-value logic, the degree of belonging to the high group is zero, even if such a person is closer to the high requirements than the low ones. Such representation may be inaccurate, as some consider 178 cm tall rather than short. Thus, an intermediate degree of truth is needed to provide appropriate conclusions, accommodating the imprecision of human reasoning [31]. In this case, the concept of nebulosity understands that a proposition can be partially true or false simultaneously and is based on human thought and communication processes.

4.2. Fuzzy Expert Systems (FES)

An expert system is a computer program that uses knowledge and inference steps to deal with complex problems and provide decision-making capabilities comparable to humans [32]. The first expert system was developed in 1970 as part of artificial intelligence (AI) to solve complex questions like an expert [33]. It uses heuristics and facts stored in the knowledge base to facilitate decision-making and improve performance [34]. It has three main components, user interface, inference engine, and knowledge base [35]. The expert system uses the user interface to interact with the user, taking the user's query as input and displaying the query results as output. Thus, it helps the user to communicate with the expert system to find a solution [36]. The inference engine is the brain of the expert system that takes the query and processes it by applying the inference rules or engine rules to the knowledge base to deduce new information or derive a conclusion [37]. An inference engine based on facts and rules is called a deterministic inference engine and provides conclusions that are assumed to be true. On the contrary, a probabilistic inference engine is based on probability and contains uncertainties in the solutions [38]. The third component of the expert system, the knowledge base, is used to store knowledge from various experts in a given field and solve problems [39]. Knowledge can be factual, that is, based on facts, or heuristic, that is, based on practice, evaluations, and experiences [40]. The expert system increases efficiency and expertise in a specific domain, allowing automated access to vast knowledge from various experts and rapid processing to acquire desired, high-quality solutions.

A fuzzy expert system (FES) is used to interpret vague or incomplete information to overcome data challenges using fuzzy sets and logic. This system solves decision-making problems without an exact algorithm, using human approximate reasoning mechanisms expressed in fuzzy if–then rules [41]. Integrating fuzzy set theory into FES increases its ability to linguistically describe a given process or phenomenon and represent them with few flexible rules [42]. A primary advantage of FES is that using specified steps, mathematical formulas, and interconnected subsystems makes it possible to explain how the results are obtained [43]. The FES subsystems or components comprise fuzzification,

inference rules, knowledge database, and defuzzification [44]. Therefore, FES is well suited to solving challenges resulting from imprecision, inaccuracy, and subjectivity.

The Rulebase contains all the rules and if–then conditions experts provide to regulate decision-making [45]. However, recent updates in fuzzy theory require a significant decrease in rules and conditions, providing various methods for designing and tuning fuzzy controllers. Fuzzification converts inputs by transforming crisp numbers into fuzzy sets [41]. Under this subsystem, the sensors measure the sharp numbers before passing them to the control system for further processing [46]. The inference engine is the subsystem used to determine the degree of correspondence between rules and fuzzy input [47]. After deciding the % match, the inference engine identifies the specific rules to develop the control actions [48]. The final component of the fuzzy expert system is the defuzzification that performs the crisp yield operations that involve converting the fuzzy sets into crisp values that indicate the degree of truth.

FES can be designed for implementation in various fields, including marketing, medicine, and automotive [49]. Although the factors and variables tested are different depending on the area, the successful design of a good FES follows the following steps [50]:

(i) Identify the problem and select the appropriate type of fuzzy system: it is recommended to adopt a modular system, as it can be configured in several ways to serve several purposes and satisfy multiple needs [51]. Furthermore, system modules can be improved over time to accommodate changes and new challenges, thus improving performance;
(ii) Definition of input and output variables: it is essential to identify the input parameters and classify the crisp values based on ambiguity indices in different fuzzy sets [52];
(iii) Defining the fuzzy heuristic rules: the if–then rules provide a convenient way of expressing knowledge, providing interpretations that can process information in a specific way at the inference level [53]. For example, some rules express certainty or obligation, while others describe possibility or feasibility [54];
(iv) Selection of fuzzy inference method: Fuzzy inference refers to the process of formulating the mapping of a specific input to output using fuzzy logic [55]. Thus, it involves the determination of aggregation operators for preconditions and conclusions [56]. This procedure creates the basis from which decisions are made and standards identified;
(v) Defuzzification methods: this step involves converting the fuzzy output into a crisp value. Examples of shapes that can be used for this procedure include the center of maximum (CoM), the center of the area (CoA), less than maximum (SoM), weighted average (WA), and greater than maximum (LoM);
(vi) Test the prototype of the fuzzy system to ensure that it works properly and make the appropriate adjustments in the membership functions, fuzzy rules, and objective function between input and output fuzzy variables.

4.3. Marketing Strategy

For any successful company seeking long-term participation in a market, it is essential to have a clear marketing strategy that organizes marketing activities and resources to enhance an organization's ability to gain competitive advantage [57]. Morgan and others [58] (2019) define a marketing strategy as an integrated pattern of decisions of a company that specifically identifies the products and services it offers, target markets, marketing activities, and resources. Keropyan and Gil-Lafuente [56] (2012) also indicate that it involves exchange, communication, and relationships to achieve specific goals. The marketing literature widely suggests that a firm's economic performance in a given market is determined by its marketing strategy, which guides critical marketing activities such as resource deployment [59]. Furthermore, the marketing strategy identifies specific objectives that help streamline organizational business processes, marketing efforts, customer needs, and other stakeholder expectations to improve performance in the competitive business environment.

The formulation–implementation dichotomy of marketing strategy encourages the establishment of long-term decision-making structures that look to the company's future. In this perspective, the formulation of marketing strategy requires that managers and their teams make precise decisions about "what" about the objectives they intend to achieve. Similarly, Khatwani and Srivastava [60] (2016) state that it also identifies the techniques they intend to apply to achieve them, including target market selection, scheduling, positioning, and determination of value offerings [61]. Therefore, this marketing strategy involves executing detailed marketing techniques and accompanying them with resources and actions necessary to implement the marketing decisions made earlier. The success of the marketing strategy formulation and implementation processes is determined by properly using the strategy content and the strategic process [62]. The content of the marketing strategy should specifically identify several aspects, including specifying target segments, the company's value proposition, selecting marketing media, and planning sales force incentives [63]. In this case, the marketing strategy content addresses the specific strategic decisions and identifies the appropriate tactical marketing program decisions to ensure the success of the marketing efforts. Instead, the marketing strategy process identifies the organizational mechanisms that lead to these decisions [64]. These processes include situation assessment, marketing mix planning, performance measurement and monitoring, top-down versus bottom-up strategic planning process, budgeting, and goal setting [65]. Therefore, a competitive marketing strategy encompasses the decisions, activities, and procedures necessary to achieve a company's desired objectives over time, including the means to develop, deliver, and communicate its offerings to target markets.

Organizations adopt different marketing strategies depending on multiple factors, including objectives, marketing relationships, products or services offered, target markets, and resources. Igor Ansoff, in 1957, identified four broad categories of marketing strategies: marketing penetration strategy, market development strategy, product development strategy, and market diversification strategy [66]. These ratings are based on the nature of the company's products and existing and new customers.

4.3.1. Market Penetration Strategy

The market penetration strategy begins with assessing the size of the market and the percentage of consumers who buy the company's products and services. From this aspect, marketing creates and implements a strategy to overcome competitors to acquire a larger market share [67]. Therefore, market penetration strategy refers to a company's initiatives to make its existing products and services in an already booming market to increase sales and organizational performance [68]. According to Hussain et al. [66], the market penetration strategy improves business performance by increasing sales among existing customers or looking for new customers for existing products or services. Various tactics can be adopted to achieve these goals, including lowering prices to compete with alternative products, acquiring competitors, and revamping the digital marketing roadmap to increase brand awareness among target markets [68]. Therefore, the main objective of this marketing approach is to generate more revenue by promoting or repositioning existing products to new or existing customers that fit the target market.

4.3.2. Market Development Strategy

A market development strategy is an approach that companies use to introduce existing products or services to new markets. Once a company reaches maturity in its current market, exploring new markets for an ongoing product is essential to increase sales and ensure organizational performance and stability [69]. The product remains the same but is promoted to new target customers to facilitate corporate growth [70,71]. A market development strategy is an essential marketing tool as it helps companies reach a wider audience of potential customers, especially in the modern-day globalized business environment [72]. In addition to acquiring new customers, it can improve the quality of products or services, reduce the cost of production per unit, increase brand awareness, build

organizational resilience, generate more leads and sales, and bolster long-term corporate growth and financial performance [73]. However, companies must conduct market research to identify development opportunities, develop a marketing plan and allocate adequate resources to ensure the success of the market development strategy.

4.3.3. Product Development Strategy

Product development strategy refers to an organization's tactics of launching new products into a market or modifying existing ones to meet customer demands and expectations. Hussain et al. [66] explain that this strategy involves the development of organized methods to guide all processes related to introducing a new item in the target market. The product development strategy can be applied in multiple situations [74]. For example, companies can develop new products when they see a decline in demand for an existing product in current market segments to secure growth and improve financial performance [75]. In addition, companies can develop new products that offer solutions to specific customer problems, basing all their production processes and activities on a comprehensive analysis of their needs, wants, and demands [76]. Demand for items or services creates business opportunities that can be exploited to achieve greater organizational performance. A great strength of product development strategy is that it uses market research to create a plan for successfully launching products or services in specific markets. In this case, planning can help companies overcome multiple challenges, adopting appropriate methods and techniques throughout product development [77]. Various tactics can be used under this marketing strategy to remain competitive, including changing product ideas, modifying existing ones and creating new products, specialization, customization, discovering new markets, and increasing product value [72]. A solid and clear product development strategy can help an organization turn an idea into a profitable product and enable modifications to remain competitive in the marketplace.

4.3.4. Market Diversification Strategy

Companies use market diversification to expand their market share or increase their market presence by acquiring or launching new products or entering new markets. Some techniques used in this strategy include licensing, acquisitions, and mergers [73]. This strategy's main objective is to increase an organization's profitability, expanding into markets and sectors that have not yet been explored [78]. In addition to greater profitability, companies can diversify to reduce the risks of an industry downturn, improve brand recognition and image, and defend against increased competition in local markets [73]. Various forms of diversification strategies are adopted based on the company's business objectives and offerings. These include horizontal, concentric, conglomerate, and vertical diversification.

Horizontal diversification is when companies expand their market presence by introducing products and services unrelated to their original offerings [79]. Vertical diversification is a strategy used when a company assumes some or all the functions associated with the production and distribution of its main products [78,80]. Concentric diversification is a strategy used to enter a new market with a new product technologically similar to the company's current one. This approach allows the company to obtain multiple advantages, leveraging its industry experience, already implemented manufacturing processes, and technical know-how [66]. A cluster diversification strategy occurs when a company diversifies into entirely new markets, offering new products unrelated to its current sales to reach new consumer bases [81]. Regardless of a company's choice of diversification strategy, these approaches, if employed correctly, can help organizations offer a broader range of products and services, build a stronger brand image, and increase company profitability.

4.4. Application of Fuzzy Logic and Fuzzy Methods in Marketing Strategies

In this age of data-driven marketing, most companies are missing out on human marketing opportunities by losing sight of the distinctive human context of marketing.

In this context, promotional messages based on signaling data are often misleading and inappropriate due to the often generalized information about market segments [82,83]. The integration of fuzzy logic and methods solves this problem, allowing marketers to assess the extent to which an individual customer fits into a market segment [84]. Modern customers want to be treated like real people rather than being fully identified with a specific market segment [85]. Rather than using yes/no binary analysis of customers' past behaviors to determine their lifestyle and consumption decisions, fuzzy marketing allows consideration of multiple perspectives and variables that allow marketers to create marketing messages that emotionally engage customers and make them feel understood and valued [86]. Fuzzy marketing demonstrates that customers are not mere sets of data and should not just be targeted; instead, they must be recognized and treated as subtle, unpredictable, and imprecise human beings.

4.4.1. Fuzzy Marketing Model

The fuzzy marketing model helps refine marketing campaigns, allowing for the exact classification of objects and optimal allocation of resources. In traditional marketing management, companies have adopted strategies such as the RFM model (Recency, Frequency, Monetary value), ABC, and portfolio analysis to analyze, evaluate, and segment customers based on their value to the company [87]. These methods have enabled marketers to improve marketing performance, increase organizational profitability, and build customer relationships [88,89]. However, reports and decisions based on these methods are often misleading due to classification errors resulting from assigning values to predefined classes [90]. The fuzzy marketing model eliminates these problems, allowing marketers to classify objects and allocate resources accordingly [91] accurately. Rather than categorizing variables in binary terms {0 or 1, yes/no}, fuzzy methods allow marketers to assess varying degrees of contexts ranging from 0 to 1 [92]. This means that variables can be accurately ranked based on how they influence marketing performance.

A significant advantage of fuzzy classifications is that an element can be assigned multiple classes, expanding analysis degrees and accurate representation. For example, customers under fuzzy ABC analysis can be partially classified into three classes, four classes under fuzzy portfolio analysis, and several classes at once under fuzzy scoring methods. Statistical analyzes allow traders to calculate the degree of adherence to each type and measure [93]. Fuzzy methods can analyze, categorize, evaluate, and manage various marketing indicators [94]. Additionally, it can be used to analyze multiple measures, including customer lifetime value (CLV) and customer equity, which are used to improve organizational marketing initiatives.

A fuzzy marketing model uses fuzzy sets to define customer segments with overlapping characteristics. Rather than strictly assigning customers to a segment, fuzzy sets allow for degrees of association, reflecting the imprecision in classifying individuals. Fuzzy logic can also be applied in market forecasting, where traditional rules and models may not adequately capture the complexity of market dynamics. Fuzzy forecasting techniques can deal with vague and imprecise data, allowing marketers to make predictions based on incomplete or uncertain information. Furthermore, fuzzy logic can be used in product positioning and brand management. Fuzzy sets can represent the degrees to which a product has certain attributes or meets specific customer needs. This allows marketers to identify the ideal positioning of a product in a market that is not easily categorized into distinct segments.

Generally, a fuzzy marketing model would incorporate fuzzy logic or fuzzy sets into marketing analysis, segmentation, forecasting, decision-making, or any other relevant marketing activity. It provides a means of dealing with the inherent ambiguity and imprecision in marketing data and customer behavior, leading to more nuanced and flexible marketing strategies.

4.4.2. Fuzzy Marketing-Mix Model

Most companies struggle with the marketing mix problem due to uncertain, vague elements and dynamic and nonlinear relationships. These issues undermine the ability of companies to make appropriate decisions that lead to positive and measurable marketing outcomes [95]. For example, input variables such as sales forecasts are uncertain as it is challenging to know what will happen to specific product markets in the future [96]. Furthermore, estimating competitors' sales, distribution, and advertising expenditures to determine the level of competition can be difficult and lead to inaccurate assumptions [97]. In this case, most of the data used in developing and deploying the classic marketing mix model are based on estimates and pure reliance on expert judgment, which can be vague and unreliable [98,99]. Other issues that make up the marketing mix problem are changes in market environmental conditions, availability of financial resources, market performance, uncertainties with the organization's competitive strength, and estimation of market response and economic variations [100]. However, the fuzzy marketing mix model solves these problems by allowing marketers to apply expert if–then decision rules.

Fuzzy logic suites enable marketers and marketing researchers to analyze and draw accurate conclusions from vague, uncertain, and subjective inputs, facilitating improved decision-making. Furthermore, fuzzy methods can explore nonlinear relationships between inputs and outputs of problems, allowing marketers to understand how a change in one variable affects the rest of the aspects of marketing [101]. Aly and Vrana [7] (2005) created a fuzzy marketing mix model based on the Fuzzy Decision Making System (FDMS) that can be used to illustrate the integration of fuzzy logic and fuzzy methods in marketing. Thus, using fuzzy logic and strategies, which leverage marketing experts' knowledge, intuition, and experience in the form of if–then rules, provides a more convenient analysis technique.

The input variables considered are those aspects that frequently affect marketing decision-making processes in most organizations, as identified through expert views and knowledge of their market environment. These factors affect the fixed production variables that make up the marketing mix configurations: price (P), fuzzy logic can be applied to pricing decisions by considering multiple pricing levels and their corresponding degrees of desirability for different customer segments; can model customers' perceptions of value and willingness to pay, allowing for flexible pricing strategies; advertising (A), fuzzy logic model the effectiveness and impact of promotional activities by considering factors like message clarity, emotional appeal, and audience segmentation; distribution (D), fuzzy logic can help determine the optimal distribution channels and locations by considering factors such as proximity to customers, accessibility, and competitive positioning; and product quality (R), fuzzy logic allows for a more nuanced representation of customer preferences and perceptions, enabling marketers to analyze the fuzzy relationship between product attributes and customer satisfaction [102]. The fuzzification interface transforms input data from experts and analysts into fuzzy variables. The rule base comprises the experts' decision rules to guide the transformation of the input variables in the marketing mix configurations [103]. The inference engine combines the consequents of the inference rules with the knowledge base to deduce new information that is deffuzified to obtain the crisp values of the outputs [104]. This process allows the company to determine marketing initiatives that accurately and approximately indicate all requirements associated with factors that affect performance within a specific market environment (Wu et al., 2010) [105]. Classifying elements into various classes over the analysis period allows marketers to avoid strategic failures and economic losses as they can access more accurate and representative data [106]. Leveraging these reports improves marketing decision-making, planning, resource allocation, and implementation of marketing initiatives and campaigns [107]. Therefore, integrating fuzzy logic and fuzzy methods into marketing strategies can help improve a company's competitiveness and lead to higher performance and productivity in today's ever-changing business environment.

5. Conclusions

Globalization and diversification have increased competition in local and international markets, leading companies to adopt consumer-centric marketing approaches through data analytics. However, data overload and reducing customers to mere data sets have hampered these companies' human marketing optimization. For example, in a marketing strategy, customers within a given market segment are collectively targeted, regardless of their differences. This approach causes companies to miss opportunities to emotionally engage their customers in long-term, mutually beneficial relationships that increase their competitive advantage. Integrating fuzzy logic and methods into marketing strategies solves this problem by encouraging marketers to understand their customers as unpredictable and imprecise individuals. Unlike classical logic, which clarifies contents as true or false, fuzzy logic recognizes that most information used in real life is subjective or relative. It has no clear definition or truth value. Thus, truth values can be anything between 0 and 1 under fuzzy logic. In this case, fuzzy reasoning recognizes that yes/no responses do not necessarily reflect on the client's behaviors or intentions, encouraging consideration of the 'maybe' and 'if's' that occur when clients don't have absolute answers. Fuzzy marketing involves analyzing how a customer fits into a specific market segment. In this case, companies prioritize personalized marketing actions that make the customer feel understood and valued instead of sending mass customized promotional messages.

Adopting approaches such as fuzzy marketing or the fuzzy marketing mix model increases a company's ability to build stronger customer relationships, increase profitability, and improve marketing performance. For example, with a fuzzy marketing model, marketers and researchers can accurately classify objects and allocate resources using fuzzy methods that indicate the degree to which a given factor or indicator contributes to the marketing effort. Management using fuzzy logic will allocate adequate resources to increase the company's competitive strength since they provide a more explicit representation of reality, allowing companies to make informed and accurate decisions.

One of the main limitations of this study is the inclusion only of the SCOPUS database, excluding other academic databases, for the development of the systematic literature review. Future studies may combine several databases to better generalize the results. Second, the review focused on publications in English, not including relevant publications in other languages. As for the keywords used in the research, we consider there will be the possibility of using other keywords that allow us to broaden the search. Future research is expected to use other databases such as EBSCO and ISI Web of Science to be able to see a map of the development of search trends and to use other keywords related to the term fuzzy logic and marketing strategy.

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Appendix A

Table A1. Overview of document citations period 2012 to 2022.

Documents		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Research and implementation of the customer-oriented modem ...	2021										1	1	2
Fine-Grained Context-aware Ad Targeting on Social Media Plat ...	2020										1		1
Modified dynamic fuzzy c-means clustering algorithm -Applic ...	2020									1	6	6	13
Evaluation of entrepreneurial support projects by using IFS ...	2020										1		1
[Bidding Strategy of Comprehensive Energy Based Power Sellin ...	2019									5	1	1	7
User sentiment analysis based on social network information ...	2019							2	3	10	10	5	30
Predicting the helpfulness of online restaurant reviews usin ...	2019								1	4	12	5	22
Exploring eWOM in online customer reviews: Sentiment analysi ...	2019								4	11	18	2	35
lnnovative capacity-based approach to blue ocean strategies ...	2019										2		2
Comparative analysis of store clustering techniques in the r ...	2019									1			1
A fuzzy DEMATEL method for analyzing key factors of the prod ...	2018									3	1		4
lmpact of information technology on information search chann ...	2018								2	9	28	10	49
Optimal marketing strategy for electricity retailer consider ...	2018								2				2
A Fuzzy ANP-based weighted RFM model for customer segmentati ...	2018							1		4	1		6
lmplementation of data mining technique for customer relatio ...	2018							1	2	4	4		11
A fuzzy optimization method for product variety selection un ...	2017								1	2	1		4
An intelligent cloud-based customer relationship management ...	2017							1			2		3
Application of artificial neural network method to analyze u ...	2017								1				1
Predicting the influence of group buying on the restaurant's ...	2016								1				1
Target marketing strategy determination for shopping malls u ...	2016							2				1	3
Using fuzzy logic approach in estimating individual guest lo ...	2015							1			1		2
Pricing and retail service decisions in fuzzy uncertainty en ...	2015				1	7	9	5	6	2	7	2	39

Table A1. *Cont.*

Documents		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
A study on extraction of minority groups in questionnaire da . . .	2014								1	1			2
Study of collective user behavior in Twitter: A fuzzy appro . . .	2014					4	2	1	2	3			12
A group decision support system for selecting a SocialCRM	2014						1						1
Analysis of user behaviors by mining large network data sets	2014			1	2	4	7	6	2	2	4		28
Criteria Weighting and 4P's Planning in Marketing Using a Fu . . .	2014			2	4	2		2		2	2	2	16
Revised DEMATEL: Resolving the infeasibility of DEMATEL	2013		1	4	8	9	15	16	15	14	30	11	123
Ranking important factors influencing organizational strateg . . .	2013					1	1			1			3
Formulating an optimal strategic marketing model by integral . . .	2013				1	1	1						3
The risk assessment of marketing management system on the ba . . .	2013			2							1		3
Mining association rules uses fuzzy weighted FP-growth	2012			1	1		1			2			5
Derivations of factors influencing the word-of-mouth marketi . . .	2012	1					1					1	3
A fuzzy decision support method for customer preferences ana . . .	2012		1	1		1	2				2		7
Fuzzy evaluating management performance and marketing strate . . .	2012			1		1	1						3
Customer loyalty programs to sustain consumer fidelity in mo . . .	2012				2	2	2		2	1	1		10
Applying cluster-based fuzzy association rules mining framew . . .	2012			3	1	4		4	1	1	4		18
Evaluation of children's after-school programs in Taiwan: FA . . .	2012					1			1				2
Future-oriented positioning analysis with Bayesian networks	2012									1			1
The RFM-FCM approach for customer clustering	2012				1								1
A neuro-lFS intelligent system for marketing strategy select . . .	2011					1	1						2
Applying Fuzzy Data Mining to Telecom Churn Management	2011					1		2	1	1		1	6
"Made-in" Nigeria or "owned-by" lreland?: Country-of-origin . . .	2011			1	1		1	3		1			7
Fuzzy analytical hierarchy process and multi-segment geai pr . . .	2011	4	4	4	3	6	6	1	3	3	1	1	36
Visualizing market segmentation using self-organizing maps a . . .	2011	8	7	5	5	5	4	7	9	4	2	4	60
Power customer credit rating based on FCM and the differenti . . .	2010	1											1
Applications and extensions of quality function deployment	2010	2	3		5	4		6					20
Analyzing customer sales data with a fuzzy set approach	2010	1				1							2
Applying fuzzy FP-growth to mine fuzzy association rules	2010	1	1		1	1				1			5
Fuzzy group decision-making in pursuit of a competitive mark . . .	2010	14	1	3	1	5	1		1	1			27

Table A1. *Cont.*

Documents		2012	2013	2014	2015	2016	2017	2018	2019	2020	2021	2022	Total
Study on analysis of questionnaire data based on interactive . . .	2009								1				1
Extraction ofimportant keywords in free text of questionnai . . .	2009	2	1						1				4
Two-stage fuzzy clustering approach for load profiling	2009	4	3	2	1	3		4					17
The customer marketing strategy of commercial banks based on . . .	2009		1										1
Personal credit scoring model based on integration of rough . . .	2009			1									1
Hybridising human judgment, AHP, simulation and a fuzzy expe . . .	2009	19	5	6	7	5	3	3	4	3	4	1	60
Optimizing a marketing expert decision process for the priva . . .	2009	8	2	2		3	1	2	2	8	3	5	36
A case study of applying data mining techniques in an outfit . . .	2009	12	8	5	3	8	2	3	2	4	2	2	51
Fuzzy logic: a realistic toei for management of customer rei . . .	2008	1					2						3
Effective marketing of a closed-loop supply chain network: A . . .	2006	1		1									2
A knowledge acquisition method for determining utilities of . . .	2006	2						1					3
lntegrating group Delphi, fuzzy logic, and expert systems for . . .	2002	24	3		4	2	2	4	1	1			41
GloStra-A hybrid system for developing global strategy and . . .	2001	13					1						14
Developing marketing strategy with MarStra: the support syst . . .	2000	8									1		9
Neural networks and customer grouping in e-commerce: . . .	2000	12			1					1	2		16
	Total	138	41	45	53	82	67	78	72	112	156	61	905

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