

Exploring Fuzzy Theory's Adoption in Digital Marketing: Systematic Literature Review

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Abstract: *This review explores the integration of fuzzy theory into digital marketing by analyzing 88 peer-reviewed studies through a systematic literature review and bibliometric analysis. It examines the evolution of fuzzy applications across domains such as decision-making, personalization, sentiment modeling, and platform evaluation. The study highlights how fuzzy models address ambiguity and partial truths, making them especially relevant in complex marketing environments. Key findings reveal growing academic interest post-2011, methodological fragmentation, and limited real-time adoption in live systems. The paper identifies research gaps and proposes a future agenda focused on practical deployment, hybrid AI-fuzzy integration, and cross-cultural modeling. This work serves as a comprehensive resource for academics and practitioners aiming to leverage fuzzy approaches in modern marketing strategies.*

Keywords: Fuzzy logic, Digital marketing, E-commerce, MCDM, Consumer behavior

1. Introduction

In the realm of digital marketing, where uncertainty and complexity often reign, the integration of fuzzy theory emerges as a beacon of innovation. Traditional marketing, rooted in deterministic models, often struggles to grapple with the inherent vagueness and imprecision characteristic of real-world marketing scenarios. Fuzzy theory, in stark contrast, offers a paradigm shift by acknowledging and embracing this inherent fuzziness, providing a robust framework for decision-making in ambiguous environments. Fuzzy theory has introduced a new approach to decision-making in uncertain environments. At its core, fuzzy theory goes beyond the binary nature of traditional logic by acknowledging and embracing the inherent fuzziness of human reasoning and perception. Developed by Lotfi Zadeh in the 1960s, fuzzy theory introduces the notion of partial truth, recognizing that many concepts and phenomena exist along a spectrum rather than in absolute terms.

Marketing entails the strategic processes employed by companies to promote their products or services, with a continual emphasis on acquiring new customers while retaining existing ones. In the contemporary landscape, digital marketing has emerged as a pivotal component, involving the utilization of digital platforms for promotional endeavours. Given the need for businesses to adopt technological advancements, digital marketing has become increasingly essential in reaching target audiences effectively. Leveraging digital technologies, particularly through internet-based platforms, has become instrumental in achieving marketing objectives in today's globalized and intensely competitive market environment [1]. The proliferation of digital technologies has spurred companies to adapt their marketing strategies to capitalize on the opportunities presented by online channels. A concerted focus on technological innovation and creative approaches has become central to enhancing competitive positioning and fostering growth. Consequently, there has been a notable

uptick in the adoption of advanced digital applications that furnish real-time, updated information to support various facets of organizational operations. Rakic and Rakic (2015) define digital marketing as the process of building relationships with digital consumers through value-driven technologies. This entails the creation, delivery, and presentation of digital values and experiences facilitated through a spectrum of digital technologies.

Traditional marketing strategies have become obsolete in today's highly competitive business landscape, where sustainable growth and maintaining a competitive edge are paramount [2]. To thrive in this dynamic environment, firms must focus on delivering value to customers and adapting their business models to embrace digital marketing strategies. Effective marketing communication not only fosters long-term relationships between customers and marketers but also enhances interaction among all stakeholders. The transition to digital marketing offers numerous advantages and has positively impacted businesses. Digital marketing encompasses a diverse array of platforms and techniques, including search engine marketing, digital advertising, online partnerships, public relations, email marketing, and social media engagement [3]. This shift has led to increased consumer engagement and improved customer experiences. With the widespread adoption of digital marketing, consumers now could compare products and prices across different companies conveniently. Digital channels improve pricing transparency, helping consumers understand costs more easily, thereby influencing their purchasing decisions. Furthermore, digital marketing has enabled firms to optimize their marketing costs by expanding the reach of their campaigns and facilitating inventory management[4].

In the realm of digital marketing, internet marketing plays a crucial role in providing timely information and valuable insights to businesses. Online reviews, feedback, and customer satisfaction metrics have become vital considerations for businesses, driving the emergence of new

marketing methodologies such as influencer marketing. As businesses navigate the complexities of digital marketing, there is a growing need for sophisticated analytics to assess website data, rank products, and evaluate marketing strategies. The integration of fuzzy theory in digital marketing analytics offers a novel approach to decision-making processes [5]. Unlike classical set theory, fuzzy theory acknowledges and accommodates the inherent uncertainties and ambiguities prevalent in real-world scenarios. This framework allows for partial truths, allowing for degrees of truthfulness that range from complete falsity to absolute accuracy. Moreover, with the rise in digital marketing technologies and its evaluation is multi-criteria decision making (MCDM)[6] in which fuzzy logics play important role. By embracing fuzzy logic, marketers can navigate the complexities of multi-criteria decision-making processes, evaluate technologies, rank e-commerce platforms, assess product performance, and analyze consumer behaviour. The utilization of fuzzy theory in digital marketing underscores its versatility and effectiveness in addressing the intricacies of modern marketing challenges. This approach not only enhances decision-making processes but also enables the development of innovative marketing strategies and models.

Our goal was to systematically review the relevant literature on this domain's study. In the realm of digital marketing, there exists a significant gap in understanding the adoption of fuzzy theory. While some studies have delved into specific applications of fuzzy logic within digital marketing contexts, a comprehensive examination of its overall usage and implications is lacking. This research seeks to address this gap by conducting a systematic literature review and bibliometric analysis. By synthesizing existing knowledge, identifying research trends, and highlighting areas for future investigation, this study aims to contribute valuable insights for both academics and practitioners in leveraging fuzzy theory effectively within digital marketing strategies. To that end, the following research questions (RQs) were formulated:

RQ1. What are the prevailing trends and developments in the research literature?

This research question aims to discern current trends in scholarly publications, including publication rates, the emergence of new research clusters, and shifts in the focus of research over time. By analyzing trends in digital marketing and the utilization of fuzzy theory, this study seeks to provide insights into the evolving landscape of academic inquiry.

RQ2. What are the primary subjects and issues central to digital marketing and fuzzy theory?

This inquiry seeks to identify the core topics and key concerns that have attracted researchers in the field of marketing, particularly in relation to the adoption of fuzzy theory. By examining the rationale behind the use of fuzzy approaches in digital marketing, this question aims to elucidate recurring themes, fundamental concepts, and emerging subfields within the academic discourse

RQ3. What are the various fuzzy methodologies employed in digital marketing practices?

This research question aims to conduct a comprehensive analysis of fuzzy methodologies utilized in digital marketing.

By examining the characteristics, adoption patterns, and potential implications of different fuzzy methods within the digital marketing domain, this study seeks to uncover the diverse applications and effectiveness of fuzzy logic in addressing various challenges and opportunities encountered in digital marketing strategies.

The goal is to thoroughly examine the theoretical frameworks, models, research methodologies and analytical tools used to analyze fuzzy adoption in the context of digital marketing. This study will benefit researchers and practitioners in identifying and developing new methodology in the field. This study aimed to contribute to the academic literature by way of identifying various digital marketing and allied fields in which fuzzy theory and methods are used. By systematically investigating these questions, we hope to give insights that can widen the perspective and support in decision-making as well as in new research. In order to do this, a thorough systematic literature review (SLR) of the literature on the adoption of fuzzy theory in digital marketing.

The study's following portions are laid out as follows. The research methodologies in Sections 2 and 3 examine the research literature production dynamics and provide a descriptive analysis. The most important takeaways from the extant literature are presented in Section 4. Analysis of scholarly literature is covered in Section 5. In what follows, we point out the gaps in the research and consider some possible next steps in Section 6. Section 7 is where the study ends.

2. Methodology

Our research endeavors to undertake an extensive examination through a bibliographic and systematic literature review (SLR), delving into the diverse applications of fuzzy methodologies and themes within the realm of digital marketing. As articulated by [7], the core mission of an SLR is to meticulously collect and assess all relevant research materials, fostering the generation of impartial findings that can withstand scrutiny in subsequent investigations[8]. Beyond the mere classification of previously published studies, the SLR process aims to furnish invaluable insights for practitioners by establishing evidence-based guidelines tailored to the specific domain under scrutiny[9]. Furthermore, the synthesis of findings from an SLR should offer a comprehensive overview of the current landscape, shedding light on the cutting-edge developments and gaps within the research domain, thereby underlining the study's contribution to the scholarly discourse.

2.1 Search methodology

Considering the study's scope, employing a keyword search emerges as the optimal approach to address its inquiries. Keywords were discerned based on contemporary trends and themes in the realm of digital marketing. The identified keywords include:

('Digital Marketing' OR 'Mobile Marketing' OR 'Internet Marketing' OR 'E commerce' OR 'Web marketing' OR 'Influencer marketing') AND ('Fuzzy')

Searches included just English-language journal articles, review papers and conference papers since the database's

establishment. No time limitations were imposed to ensure a longitudinal perspective on the evolution of the field. Only peer-reviewed journal articles published in English were considered. Grey literature, editorials, and these were excluded.

2.2 Selection criteria

The Preferred Reporting Items for Systematic Reviews and Meta-Analyses (PRISMA) framework was employed to guide the selection of studies used in this review. PRISMA is a well-established methodology that offers a systematic framework to guarantee transparency and rigor in the identification, screening, and inclusion of pertinent research [10]. PRISMA emphasizes four key stages: identification, screening, eligibility, and inclusion. In the identification phase, all potential studies are gathered through systematic searches of databases, ensuring that a wide range of research is considered. Next, the screening phase filters out irrelevant

or duplicate studies based on predefined criteria. In the eligibility phase, the full text of the remaining articles is reviewed to determine whether they meet the specific inclusion criteria for the study. Finally, in the inclusion phase, the studies that pass the previous steps are incorporated into the final analysis. The use of the PRISMA methodology ensures that the review process is comprehensive, objective, and thorough. It allows for the systematic appraisal of a large body of literature, which is essential in capturing the full scope of research on a particular topic, thereby providing a robust foundation for drawing valid conclusions and supporting evidence-based decision-making.

The search was then restricted to the subject fields of 'Business, management, and accounting', 'Economics, econometrics, and finance', 'Social science', 'Decision sciences' and 'Mathematics'. The search was limited to items published after 1990. Only peer-reviewed, open-access articles with full-text availability were included.

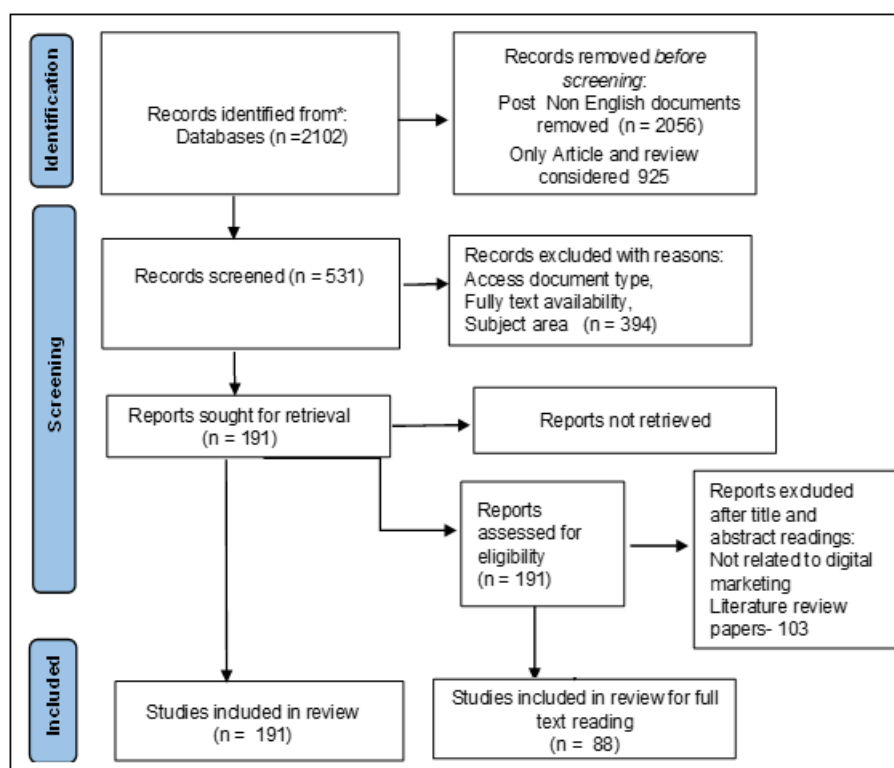


Figure 1: PRISMA

Source: Author's own work

Note: 88 studies met all inclusion criteria and were included in the qualitative synthesis

In November 2023, a search was done for a scholarly study and 2,102 documents were found in Scopus out this 925 based on article, and review papers were selected. Only English documents were selected for further screening. To ensure methodological rigor and relevance, a structured selection process was applied based on the PRISMA framework. After initial identification and removal of duplicates, the remaining studies were screened in two stages: first by reviewing titles and abstracts for thematic alignment, and then through full-text reading. The inclusion criteria were defined as follows: studies had to explicitly apply fuzzy theory (e.g., fuzzy logic, fuzzy AHP, fuzzy clustering, fuzzy inference systems) within digital marketing, e-commerce, or consumer behavior contexts. Articles were required to present a clear

methodological application of fuzzy models to marketing-related problems such as strategic decision-making, personalization, customer sentiment, or platform evaluation. Only peer-reviewed journal articles in English were considered. Studies were excluded if they focused solely on engineering or industrial applications without a marketing context, lacked full-text availability, were written in languages other than English, or fell outside the business and decision science domains. Of the 2,102 records identified in Scopus, 925 article/review records were retained after filtering by document type and language. Following title/abstract screening, 191 records were sought for retrieval; 88 met criteria for full-text assessment (see PRISMA in Figure 1).

3. Descriptive Analysis

3.1 Main information about data collected

Descriptive analysis of 191 articles was conducted using Biblioshiny software to identify publication trends of usage of fuzzy in digital marketing (Figure 2). Biblioshiny and VOSviewer were used for bibliometric analysis of 191 articles. Biblioshiny, a graphical interface for the R-based Bibliometrix package, was selected due to its robust capabilities for processing bibliographic metadata, generating descriptive analytics, and supporting PRISMA-compliant workflows. VOSviewer was chosen for its advanced network visualization features, particularly in mapping keyword co-occurrence, citation networks, and clustering of research themes. Together, these tools enabled both a quantitative overview of the intellectual structure of the field and the identification of core thematic domains that guided the subsequent qualitative synthesis. After going through the abstract and title readings of 191 articles and removing unrelated papers based on content, and separating the literature review papers and considering full-text availability, 88 articles have been extracted, which undergo full-text review to find out themes in usage of fuzzy in digital marketing, theories and models used. Table 1 provides detailed analysis of data.

Table 1: Information about Data

Particulars	Result
Timespan	1997–2024
Sources (Journals, Books, etc)	91
Documents	191
Annual Growth Rate %	0
Document Average Age	3.93
Average Citations per Doc	30.39
References	10,407
DOCUMENT CONTENTS	
Keywords Plus (ID)	1,056
Author's Keywords (DE)	736
AUTHORS	
Authors	536
Authors of Single-authored Docs	17
AUTHORS COLLABORATION	
Single-authored Docs	17
Co-authors per Doc	3.17

International Co-authorships %	25.13
DOCUMENT TYPES	
Article	188
Review	3

Source: Biblioshiny

The document pool, with an average age of 3.93 years, boasts an impressive average citation rate of 30.39 per document, underscoring the significance and impact of the research within the academic community. Spanning various document types, primarily articles with 188 contributions and 3 reviews, this corpus reflects the multifaceted exploration of fuzzy theory's application in digital marketing. Notably, collaboration among authors is prevalent, with an average of 3.17 co-authors per document, fostering an environment of interdisciplinary exchange and knowledge sharing. International co-authorships account for a substantial 25.13%, highlighting the global nature of research in this field. Moreover, keywords such as Keywords Plus (ID) and Author's Keywords (DE) enrich the document contents, further elucidating the diverse facets of inquiry undertaken by 536 authors. The volume and breadth of research represented in this dataset signify a rich tapestry of scholarly engagement with fuzzy theory's implications in the digital marketing sphere.

3.2 Publication trends in fuzzy and digital marketing

Across 91 peer reviewed publications, 546 authors wrote 191 articles, and covered topics under 'business management and accounting', 'mathematics', 'Economics, econometrics and finance', 'social sciences'. Publications are seeing increasing trend specially from year 2011 onwards. 1997 to 2009 have only 14 articles published which increased to 40 in a year by 2023. Figure 2 provide publication trend for fuzzy in digital marketing.

We found that research towards fuzzy approach in digital marketing saw renewed interest from 2014 onwards and number of publications increased reaching to 41 open access articles in 2023. Our analysis shows that China, India and United Kingdom are top three counties in terms of scientific production of papers on fuzzy approach in digital marketing. Figure 3 presents the article publication for top 10 countries.

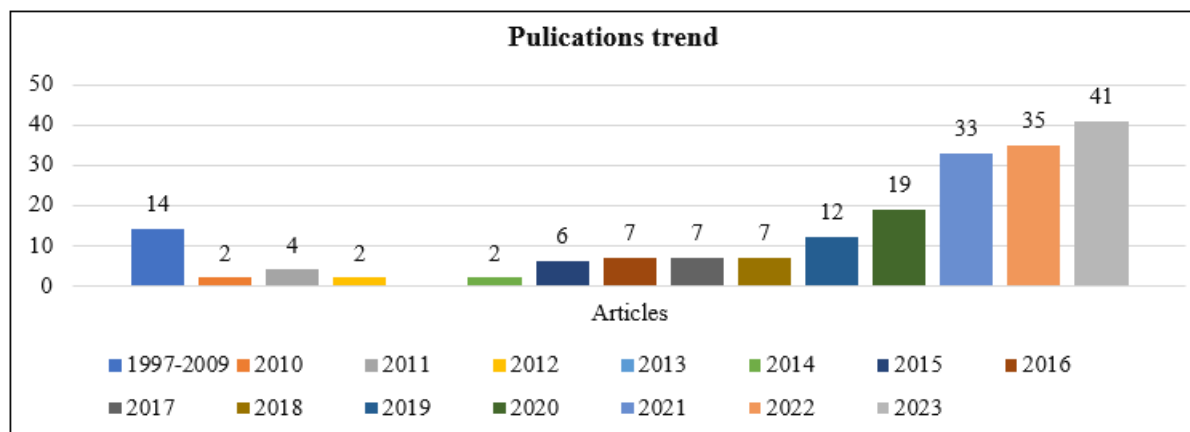


Figure 2: Publications trend for fuzzy approaches in digital marketing (1990–2024)

Data source: Scopus; document types: article + review; language: English; subject areas: Business, Management & Accounting; Economics; Social Sciences; Decision Sciences; Mathematics.
Tool: Bibliometrix (Biblioshiny)

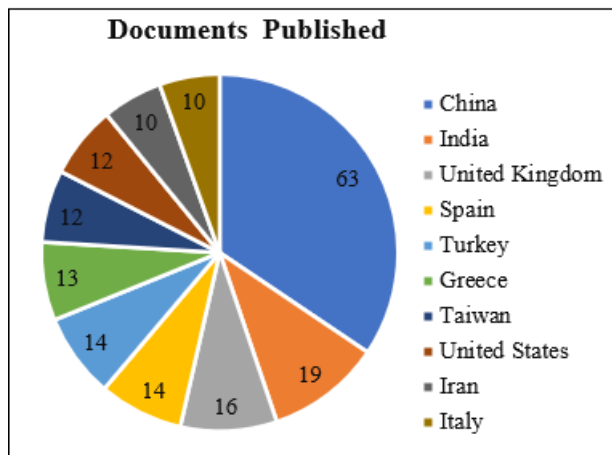


Figure 3: Top 10 countries by publications (1990–2024).

Data source: Scopus (same query as Figure 2); metric: publication counts.

Tool: Bibliometrix (Biblioshiny) export

4. Literature Review

4.1 Digital Marketing

Digital marketing has evolved rapidly since the 1990s, transforming how organizations reach and engage with consumers. The early emergence of clickable banners, search engines, and platforms like Yahoo and Google marked the start of a new era in advertising and brand interaction[11]. The subsequent rise of social media platforms—especially Facebook, Twitter, and Instagram, combined with tools like cookies, enabled marketers to track user behavior and deliver personalized campaigns.

Unlike traditional marketing, digital channels facilitate real-time, two-way interactions across B2B, B2C, and C2C domains[12]. Advances in mobile connectivity have further democratized access, allowing even small and medium enterprises (SMEs) to compete globally by leveraging targeted content, mobile commerce, and data-driven engagement strategies[13], [14], [15]. Mobile shopper marketing and integrated communication strategies now form a central part of digital campaigns, addressing evolving customer expectations[16], [17].

This digital transformation has also brought with it complex challenges: information overload, dynamic consumer behavior, and decision-making under uncertainty. To address these, researchers are increasingly turning to fuzzy logic—an approach capable of handling imprecision and ambiguity inherent in digital data environments.

4.2 Fuzzy Theory

Fuzzy set theory, introduced by Lotfi Zadeh in 1965, offers a mathematical framework to model uncertainty and linguistic ambiguity[18]. Unlike binary systems, fuzzy logic allows for degrees of truth, making it well-suited for scenarios where inputs are vague or qualitative—common in marketing and human behavior analysis.

Initially applied in engineering systems such as HVAC controls and industrial automation[19], fuzzy theory has since

expanded into diverse fields including decision sciences, life sciences, and increasingly, marketing[20]. In digital marketing specifically, researchers leverage fuzzy sets and fuzzy MCDM methods (e.g., AHP, TOPSIS, DEMATEL) to evaluate strategic alternatives, model consumer sentiment, and personalize customer experiences[6], [21].

The rise of big data and the increasing complexity of digital ecosystems have heightened the relevance of fuzzy theory. From customer segmentation to content targeting, fuzzy models are now being used to extract actionable insights from vague or overlapping data patterns. Techniques like fuzzy clustering and fuzzy rule-based engines allow for more human-like reasoning in decision-making, while hybrid models incorporating fuzzy logic enhance the robustness of marketing analytics[22], [23].

This growing adoption highlights fuzzy theory's evolving role as both a computational tool and a strategic enabler in digital marketing. Fuzzy logic models are capable of processing ambiguity and subjectivity in data by applying linguistic variables and human-like reasoning. These characteristics have made them increasingly popular in various digital marketing contexts such as recommendation systems, sentiment analysis, personalization engines, consumer segmentation, and digital platform evaluation[10], [24]. Given the range and scope of fuzzy applications, the following review is divided thematically across key fuzzy implementation areas relevant to the current digital marketing landscape.

4.3 Decision-Making and Strategic Evaluation Using Fuzzy MCDM

In digital marketing, decision-making often involves evaluating alternatives across multiple qualitative and quantitative criteria, many of which are inherently vague such as brand credibility, user trust, or perceived responsiveness. Fuzzy Multi-Criteria Decision-Making (MCDM) methods have therefore become vital tools for marketing strategists and researchers. These methods help convert subjective expert judgments into structured decision models capable of handling uncertainty and partial truths.

Among the most widely used fuzzy MCDM approaches are fuzzy AHP, fuzzy TOPSIS, and fuzzy DEMATEL. Fuzzy AHP is frequently employed for ranking digital marketing success factors, such as evaluating the relative importance of SEO components, mobile app features, or customer service variables [25]. For instance, studies have used fuzzy AHP to prioritize elements that enhance platform engagement, including website credibility, visual appeal, and ease of navigation [26].

Fuzzy TOPSIS, on the other hand, is particularly common in studies that compare digital marketing channels or service providers. Researchers have used it to rank logistics services [27], assess mobile app performance [28], and evaluate platform-based user experiences under fuzzy criteria such as satisfaction, trust, and service responsiveness [29].

Fuzzy DEMATEL has been used when modelling interdependencies among factors—for example, identifying

the causal influence of content relevance, page load time, and customer support on user retention [30]. Some studies further integrate fuzzy MCDM methods with other decision frameworks such as CRITIC, grey systems, or SWARA, improving model robustness and reducing subjectivity [31], [32].

Despite this variety, few studies critically compare the performance of different fuzzy models or offer methodological guidelines for tool selection. Most applications are highly context-specific, with limited replication across domains or validation using real-time data. As such, while fuzzy MCDM tools are methodologically sound and conceptually useful, their strategic application in digital marketing remains fragmented.

4.4 Personalization and Consumer Behavior Modeling Using Fuzzy Techniques

Personalization is a core component of digital marketing strategies, driven by the need to tailor content, recommendations, and engagement approaches to individual consumer profiles. However, consumer behavior data is often imprecise, incomplete, or linguistically expressed. Fuzzy logic provides a powerful means to address this challenge, enabling more human-like interpretation of behavioral signals.

A common approach in the literature is the use of fuzzy clustering techniques, particularly Fuzzy C-Means (FCM), to segment customers based on their preferences, purchase history, browsing patterns, and interaction levels. These methods allow users to belong to multiple clusters with varying degrees of membership, better reflecting real consumer overlap and behavioral ambiguity [33].

In addition, fuzzy rule-based systems and expert systems have been developed to model loyalty levels, engagement likelihood, or churn risk using linguistic inputs such as “frequent visitor,” “low spender,” or “moderate satisfaction” [34]. For example, some models assign consumers to loyalty tiers based on fuzzy evaluations of recency, frequency, and monetary (RFM) value—a common metric in CRM but enhanced through fuzzification.

In mobile commerce, fuzzy logic has been applied to evaluate and prioritize factors influencing app adoption and continued usage. Studies using fuzzy AHP have assessed criteria such as trust, convenience, interface design, and content quality [19], [35]. These studies show how fuzzy models can account for the subjective and contextual nature of consumer decision-making, particularly in mobile-first environments.

Despite their conceptual strength, many fuzzy personalization systems remain underutilized in real-time environments. There is limited integration with CRM platforms, marketing automation systems, or live data streams, which restricts their application in dynamic, large-scale personalization strategies. Furthermore, most studies focus on model construction rather than validation or long-term performance assessment.

Nonetheless, the reviewed literature strongly supports the value of fuzzy techniques in capturing nuanced consumer behavior, enabling marketers to offer more personalized and

responsive experiences even when faced with vague, incomplete, or linguistically fuzzy data.

4.5 Sentiment, Trust, and Influence Modelling Using Fuzzy Systems

In digital marketing, consumer sentiment, trust, and social influence are critical to brand perception and customer decision-making. However, these factors are inherently subjective and difficult to quantify using traditional logic or statistical models. Fuzzy systems provide a flexible framework to handle this ambiguity, allowing for nuanced interpretation of emotional and perceptual data.

One widely adopted approach is the use of fuzzy inference systems (FIS) for sentiment analysis. These systems allow for linguistic terms—such as “somewhat positive,” “highly negative,” or “neutral”—to be assigned membership values, enabling more granular sentiment classification. Fuzzy classifiers have been applied to analyse online reviews, social media comments, and customer feedback forms where emotional tone and language vagueness make crisp classification ineffective [36].

Fuzzy cognitive maps (FCMs) are another technique used to model the causal relationships between factors like perceived brand authenticity, crisis communication, and consumer trust. For instance, studies during the COVID-19 pandemic used FCMs to simulate how fear, media coverage, and social proof impacted trust in health-related digital marketing campaigns [37].

Additionally, fuzzy logic has been used to assess influencer effectiveness, where variables such as credibility, reach, content resonance, and audience engagement are not easily defined. Fuzzy scoring models allow these soft criteria to be aggregated, compared, and ranked across campaigns and platforms [38].

Despite promising conceptual frameworks, practical implementation in real-time systems remains limited. Few sentiment models based on fuzzy logic have been integrated into enterprise-level tools like social media listening platforms, live campaign monitors, or brand dashboards. Moreover, many models are tested on static datasets without feedback mechanisms or continuous learning capabilities.

Nonetheless, the literature demonstrates that fuzzy systems are well-suited for interpreting non-quantifiable marketing inputs. Their ability to represent shades of meaning makes them ideal for trust-sensitive domains like influencer marketing, reputation management, and consumer sentiment monitoring.

4.6 Platform Evaluation and Service Optimization in Digital Marketing

As digital marketing platforms become more complex and feature-rich, evaluating their performance and optimizing service delivery has become a critical concern. Traditional evaluation methods often fail to capture the nuanced trade-offs between usability, responsiveness, trust, and design features. Fuzzy logic has emerged as a preferred approach to

assess these multi-dimensional, often subjective factors in a more holistic and human-aligned manner.

Fuzzy MCDM techniques, such as fuzzy AHP and fuzzy TOPSIS, are commonly used to compare digital platforms based on a combination of qualitative and quantitative attributes. Studies have applied these models to rank e-commerce websites, mobile apps, and customer service interfaces, evaluating dimensions such as visual appeal, navigation simplicity, content relevance, and perceived trustworthiness [39], [40], [41].

Fuzzy QFD (Quality Function Deployment) and fuzzy Kano models are also widely applied in platform interface evaluation. These methods map vague customer expectations (e.g., "intuitive layout" or "easy checkout") onto technical design requirements, helping marketers and developers prioritize features that align with user satisfaction [42]. For instance, fuzzy Kano models have been used to classify features into categories like "must-haves," "delighters," and "indifferent," based on fuzzy input from user surveys or behavioral analytics.

In the domain of e-commerce logistics, fuzzy time window models and scoring frameworks are employed to manage uncertainty in delivery schedules, consumer availability, and service reliability. These models help businesses adjust last-mile strategies in real time, balancing operational constraints with customer expectations [43], [44], [45].

Despite the potential, many of these fuzzy-based platform evaluation models are developed for isolated scenarios or as part of academic prototypes. Real-world deployment is still limited, with few systems incorporating fuzzy evaluation directly into their analytics pipelines or performance dashboards.

Nevertheless, the reviewed studies underscore fuzzy logic's versatility in addressing platform complexity and consumer heterogeneity. Its ability to model user perceptions and service variability makes it a promising tool for digital marketing operations seeking adaptive, user-centered evaluation systems.

5. Fuzzy in Digital Marketing – Themes

5.1 Managing Subjective Judgments in Strategic Evaluation

One of the most consistent challenges across digital marketing is dealing with decision environments rich in qualitative or conflicting criteria—like vendor trustworthiness, campaign ROI, or multi-platform strategy selection. Fuzzy logic is increasingly applied to these issues through MCDM frameworks (especially fuzzy AHP, TOPSIS, DEMATEL, and VIKOR) [46], [47], [48].

For example, fuzzy AHP has been used to rank key performance criteria for digital platforms based on expert input and behavioural data [49]. Studies like Wang et al. [50] combine fuzzy AHP and TOPSIS to evaluate logistics service providers in Vietnam using criteria such as innovation, customer experience, and environmental performance. Similarly, fuzzy DEMATEL models have mapped causal

links between service features (e.g., responsiveness, speed) and satisfaction outcomes [51].

While these models enhance clarity in ambiguous decision environments, many studies treat them as plug-and-play frameworks without comparing their suitability across cases. The literature lacks reflection on when and why one model may perform better than another—a missed opportunity for methodological insight.

5.2 Fuzzy Logic as a Bridge Between Behavioural Intuition and Quantitative Modelling

Another emerging pattern is the use of fuzzy logic to model behavioural data that is typically linguistic, inconsistent, or incomplete—especially in customer profiling, segmentation, and targeting. This includes the application of fuzzy clustering, fuzzy classification, and fuzzy rule-based systems to group consumers not by static profiles, but by partial behavioural affinities and evolving engagement [52], [53].

For instance, fuzzy C-means clustering has been used to define consumer segments with overlapping preferences and fluid boundaries, offering more adaptable targeting strategies [54]. Similarly, Werro et al. [55] propose a fuzzy-based personalized discount model that tailors offers based on loyalty and purchase behaviour using a relational fuzzy database system.

These approaches are especially relevant in contexts like m-commerce and mobile app marketing, where behaviour is dynamic and difficult to pin down using binary segmentation [56].

However, most models remain theoretical or proof-of-concept, with limited application in real-time CRM or marketing automation platforms. Bridging this gap between fuzzy behavioural modelling and operational deployment represents a critical next step for the field.

5.3 Capturing Soft Constructs: Sentiment, Trust, and Influence

Marketing problems often hinge on "soft" variables such as trust, emotional response, or influencer credibility that cannot be directly measured or clearly defined. Fuzzy logic provides a viable means to encode, manipulate, and interpret such constructs.

Fuzzy Inference Systems (FIS) and Fuzzy Cognitive Maps (FCMs) are widely used to model sentiment in online reviews, social media, and consumer-brand relationships [57]. For instance, during the COVID-19 pandemic, researchers used FCMs to model how fear, communication tone, and public information flows affected trust in brand messaging [58].

In influencer marketing, fuzzy models evaluate perceived authenticity, engagement consistency, and follower alignment, integrating these qualitative dimensions into ranking systems [59]. These models provide a foundation for more transparent decision-making in campaign design and influencer selection. Although conceptually robust, few of these models are implemented in production systems. There remains a practical divide between fuzzy sentiment modelling

and its deployment in tools like sentiment trackers, brand dashboards, or social media analytics.

5.4 Contextualizing Fuzzy Evaluation in Platform and Experience Design

A fourth pattern is the contextual use of fuzzy logic in evaluating platforms, UX design, and digital service performance. In this space, fuzzy methods are not just used for ranking features, but for translating ambiguous user expectations into technical design requirements.

Fuzzy QFD and fuzzy Kano models are particularly prominent in studies assessing user experience. These tools allow businesses to weigh customer voice in interface development by processing linguistic input like “easy to navigate,” “visually clear,” or “trustworthy design” [60].

Additionally, fuzzy scoring models have been applied to logistics and service reliability challenges. For instance, fuzzy time window models optimize delivery strategies under uncertain customer preferences and scheduling constraints [61], while hybrid fuzzy-MCDM frameworks assess e-commerce platform competitiveness across multi-criteria [62].

What unifies these applications is their reliance on human-like interpretation of user input to improve design and operational outcomes. Yet, like other areas, most models are limited to pilot studies, with little integration into agile product cycles or continuous user feedback systems.

5.5 Technical Advancement without Practical Transferability

Across the reviewed themes, the literature consistently highlights a disconnect between the development of fuzzy logic models and their practical integration into real-world digital marketing systems. While many studies demonstrate ambitious modelling efforts, they often lack validation using live data, are developed in isolation from existing marketing ecosystems such as CRM and social media platforms, and fail to provide methodological guidance for tool selection, hybridization, or real-time application. Furthermore, there is a notable scarcity of research addressing cross-cultural variations in fuzzy perception, a critical consideration for global digital brands operating across diverse markets [63], [64]. This thematic synthesis underscores a research field that, while mature in conceptual modelling, remains fragmented and limited in its translation into deployable marketing tools or unified strategic frameworks. These insights lay the groundwork for identifying research gaps and formulating a future research agenda, as discussed in the subsequent section.

5.6 Analysing web marketing and analytics

Effective web marketing and analytics strategies are essential for maximizing online presence and customer engagement. Fuzzy Cognitive Mapping (FCM), hybrid modelling, and fuzzy methodologies such as fuzzy AHP and TOPSIS-Grey have emerged as indispensable tools in this endeavour. The ability of fuzzy methodologies to integrate both qualitative and quantitative data allows for a richer analysis of marketing strategies compared to traditional approaches that often rely

solely on numerical metrics. Studies by [65], [66] demonstrate the efficacy of these methodologies in deciphering complex consumer behaviours, optimizing marketing campaigns, and refining website functionalities to enhance user experiences.

5.7 Leveraging social media platforms for organizational strategies

Social media platforms have become indispensable tools for organizations seeking to enhance their digital marketing strategies. MCDM methodologies, grounded in intercriteria correlation (CRITIC) and Fuzzy TOPSIS approaches, offer actionable insights into social media campaign effectiveness and audience engagement metrics. The application of fuzzy logic in this context allows organizations to navigate the uncertainties of social media interactions, leading to more effective campaign strategies. Studies by [67] underscore the importance of leveraging these methodologies to navigate the dynamic landscape of social media marketing, driving brand awareness, and customer loyalty.

5.8 Analysing live streaming purchase behaviour

Live marketing has emerged as a dynamic avenue for product promotion and customer engagement through real-time broadcasting. The surge in popularity of live streaming platforms has been remarkable, with China alone has 587 million live streaming users in 2020 [68]. In the realm of e-commerce, Zhu and Yang's research delved into the intricacies of customer purchasing behaviour during live streaming sessions. Utilizing fuzzy DEMATEL - ANP methodology, many studies have provided the insights into the significance of fuzzy logic in analysing consumer preferences and decision-making processes within the dynamic context of live streaming commerce. Fuzzy methodologies excel in capturing the complexities of consumer behaviour in this fast-paced environment, enhancing the understanding of audience preferences and purchase triggers. Live streaming platforms have emerged as powerful channels for driving e-commerce sales and enhancing customer engagement. Weighted methods of Fuzzy DEMATEL and Analytical Network Process (ANP) provide valuable insights into live streaming purchase behaviour and audience preferences. Su et al.[69] proposed an interval-valued intuitionistic fuzzy multi-criteria group decision-making approach, emphasizing decision-makers' professionalism in evaluating the risks associated with live-streaming e-commerce platforms. Their method determines decision-makers' weights based on their professionalism and utilizes the technique for order preference by similarity to an ideal solution (TOPSIS) method to rank alternative platforms. This underscores the significance of employing fuzzy logic methodologies in assessing risks and making informed decisions within the realm of live streaming e-commerce. Fuzzy has gained prominence in optimizing live streaming marketing strategies, facilitating seamless transactions, and fostering consumer trust and loyalty.

5.9 Evolution of influencer marketing

Influencer marketing has experienced a significant shift with the advent of social media platforms, challenging the dominance of traditional celebrities. The emergence of social media influencers has become increasingly prominent, reshaping the landscape of marketing strategies [70]. As influencers wield considerable influence over their audience, attributes such as content quality, interaction competence, and relationship authenticity have become pivotal in driving successful influencer marketing campaigns [71]. [72] conducted a survey involving 411 consumers and utilized partial least squares-structural equation modelling (PLS-SEM) and fuzzy set qualitative comparative analysis (fsQCA) to unravel intricate mechanisms underlying influencer-consumer interactions. Fuzzy logic enhances the analytical capabilities in this domain, allowing for a deeper understanding of the nuanced relationships between influencers and their audience.

6. Future Directions

Despite the growing body of literature applying fuzzy logic in digital marketing, a few conceptual, methodological, and operational gaps persist. These gaps limit the practical transferability of fuzzy models and signal underexplored opportunities for further research and innovation. Drawing on the themes synthesized in the previous section, this section outlines the key shortcomings observed in the literature and proposes a targeted agenda for future research.

6.1 Identified Gaps in the Current Literature

6.1.1 Lack of Real-Time and Scalable Implementation

While many fuzzy models demonstrate conceptual rigor, few are implemented in real-world systems or validated using live marketing data. Most studies rely on simulated scenarios, small-scale pilot tests, or static survey inputs [73], [74]. This restricts their utility in dynamic, real-time environments such as CRM systems, marketing automation platforms, or e-commerce analytics dashboards.

6.1.2 Siloed Methodological Practices

The literature shows a heavy reliance on single-method fuzzy MCDM tools like fuzzy AHP or TOPSIS without comparative benchmarking. There is little critical reflection on the strengths or limitations of each approach, and few studies provide guidelines on when to use which model [75], [76]. Hybrid models are occasionally proposed, but their comparative advantage is rarely validated.

6.1.3 Minimal Integration with Artificial Intelligence (AI)

Although some studies mention potential for hybrid fuzzy-AI frameworks, actual integration with deep learning, reinforcement learning, or NLP systems is rare [77], [78]. This limits the ability of fuzzy systems to adapt and scale in data-rich environments.

6.1.4 Limited Focus on Cross-Cultural and Multi-Market Applications

Fuzzy models, particularly those involving consumer sentiment or preference, often assume uniform interpretation of linguistic variables across different regions or cultures. Very few studies explore how fuzzy perception varies

globally, or how localization could improve accuracy in segmentation or trust modeling [79], [80].

6.1.5 Theoretical Fragmentation

A significant number of studies focus on technical modeling without connecting their work to broader marketing or consumer behavior theories. This disconnect limits the theoretical contribution of fuzzy research and weakens its strategic relevance to marketing scholars and practitioners.

6.2 Future Research Agenda

Based on these gaps, the following five research directions are proposed:

6.2.1 Operationalization of Fuzzy Models into Live Systems

Future work should focus on embedding fuzzy models into real-time marketing systems such as integrating fuzzy sentiment engines into social media dashboards or applying fuzzy segmentation within live CRM workflows. This requires collaboration between data scientists, system architects, and marketing professionals.

6.2.2 Comparative Benchmarking of Fuzzy Decision Models

Researchers should design studies that apply multiple fuzzy MCDM models (e.g., AHP, TOPSIS, DEMATEL) to the same decision problem and assess comparative outcomes. This would offer much-needed guidance on model selection and performance trade-offs under varying data conditions and decision contexts.

6.2.3 Development of Hybrid Fuzzy-AI Systems

New work should explore the intersection between fuzzy logic and intelligent systems including the use of fuzzy logic in training deep learning models, enhancing explainability in AI systems, and improving the human interpretability of predictive analytics.

6.2.4 Cross-Cultural Fuzzy Modeling and Language Adaptation

Given fuzzy logic's reliance on linguistic variables, future research should examine how language-specific expressions of satisfaction, trust, or preference affect model outputs. Studies could focus on regional adaptations or conduct comparative modeling across language and cultural groups.

6.2.5 Theory-Driven Fuzzy Research

There is a need to integrate fuzzy logic applications more closely with established marketing and behavioral theories such as the Theory of Planned Behavior, the Technology Acceptance Model, or Customer Experience Theory. Doing so can ground fuzzy models in tested theoretical frameworks and expand their relevance beyond technical optimization.

7. Conclusion

Fuzzy theory has become increasingly relevant in digital marketing, where ambiguity, subjectivity, and complexity are intrinsic to both consumer behaviour and strategic decision-making. This study provided a comprehensive synthesis of 88 scholarly works, examining how fuzzy logic has been applied across the digital marketing landscape. Through thematic

structuring, the review revealed the depth and diversity of current research, while also exposing methodological and practical limitations.

The literature shows a clear concentration of fuzzy-based applications in areas such as multi-criteria decision-making, consumer profiling, trust and sentiment modelling, platform evaluation, and service optimization. These themes reflect how researchers have leveraged fuzzy models to navigate uncertain environments, translate qualitative insights into measurable constructs, and develop decision frameworks that align with the fluid nature of consumer perception and platform performance.

In addition to mapping thematic directions, the review highlighted several recurring challenges: limited integration of fuzzy models into live systems, inconsistent methodological practices, underexplored hybridization with AI, and minimal adaptation for culturally diverse markets. These observations point to a field that is methodologically rich but operationally fragmented.

To advance the field, the study proposed a forward-looking research agenda focused on practical deployment, methodological benchmarking, interdisciplinary fusion, and stronger theoretical integration. By anchoring future research in these areas, scholars and practitioners can increase the strategic utility of fuzzy logic in digital marketing contexts—from real-time customer engagement to adaptive platform analytics.

This review not only consolidates existing knowledge but also contributes a conceptual and methodological scaffold for future inquiry. It demonstrates that fuzzy theory, when applied critically and contextually, holds substantial promise for solving digital marketing problems that conventional models cannot adequately address.

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