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Measuring Customer Satisfaction and Retention in IT Industry Pre-COVID and Post-COVID Using Fuzzy Mathematical Model

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Abstract— The COVID-19 pandemic has significantly impacted customer behavior across industries, including the IT sector. This paper explores the use of a fuzzy mathematical model to measure customer satisfaction and retention in the IT industry, comparing pre-COVID and post-COVID scenarios. Traditional methods for customer satisfaction measurement often lack the ability to handle the inherent ambiguity and subjectivity in customer feedback. Fuzzy set theory offers a valuable tool to address this limitation. The proposed model identifies key factors influencing customer satisfaction in the IT industry, considering both pre-COVID and post-COVID influences. Membership functions are defined for these factors, and a fuzzy inference system is developed to determine overall customer satisfaction scores and predict retention likelihood. Data from various sources is used to evaluate the model's effectiveness. The results provide insights into changes in customer behavior and satisfaction drivers due to COVID-19, enabling IT companies to develop targeted strategies for improved customer satisfaction and retention in the post-pandemic era.

Index Terms— Customer Retention, Customer Satisfaction Situational Triggers Relational Triggers, Fuzzy Mathematical Model, IT Industry

I. INTRODUCTION

The COVID-19 pandemic has dramatically changed the outlook of customer behavior in all industries, not excluding IT. The new dynamics that emerged around the world called for a reassessment of conventional techniques used to measure customer satisfaction and retention. Traditionally, most of such techniques have proven ill-equipped to handle intrinsic ambiguity and subjectivity within customer feedback. As the world is entering into the phase of post-pandemic, there is a continuously increasing demand for robust models that could capture and analyze these nuances with a view toward informing strategic decision-making in the IT industry.Customer satisfaction and retention have been assessed here through a fuzzy mathematical model in the IT industry, considering the comparative analysis between pre-COVID and post-COVID scenarios. Since fuzzy set theory has the principal ability to deal with vague and imprecise information, this provides a fit framework for investigation. In this study, the membership functions for key factors that affect customer satisfaction are defined, and a fuzzy inference system is constructed in order to complete the satisfaction scores for all customers comprehensively and to predict the likelihood of their retention.

Customer satisfaction surveys focused on service quality, responsiveness, security, and value for money before the COVID period. New dimensions entered customer interactions in the post-COVID era, largely captured by customer support tickets. Customer support tickets outline the most outstanding technical problems, feature requests, security concerns, and other areas that manifest the new normal of shifting priorities and expectations by information technology consumers.In this research, an assessment is made of the effectiveness of the proposed fuzzy mathematical model in capturing these changes through the analysis of data from various sources. The insights learned from the analysis are expected to help IT companies in chiseling target-based strategies to improve customer satisfaction and retention in the post-pandemic world.

II. BACKGROUND AND SIGNIFICANCE

The COVID-19 pandemic outbreak practically changed the outlook of world business, accompanied by shocks reaching to all branches of business activity through changes in customer behavior within the IT industry, whose needs are changing radically with increasing dependence on digital solutions and growing expectations toward quality and safety of rendered services. Because of that, the dimensionality of customer satisfaction—previously captured in only a few business facets, typically service quality, responsiveness, security, and value for money—was assessed by the conventional methods of surveying in the pre-COVID-19 IT industry. Nevertheless, the pandemic has demanded more adaptive and robust measurement techniques to capture these complexities brought on by this global crisis.

The ambiguity and subjectivity in customer feedback are seldom captured by traditional methods. Advanced tools on handling uncertain and imprecise data are, therefore, extensively called for in this respect. On this ground, fuzzy set theory comes up as very promising due to its ability to deal with vagueness. Such fuzzy mathematical models will be of much more help in understanding customer satisfaction and customer retention and will enable better decision-making and strategic planning.

III. RESEARCH OBJECTIVES

This paper focuses on the development of a fuzzy mathematical model to quantify the extent of customer satisfaction and

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retention in the IT industry, pre- and post-COVID. Precisely, this work performs the following tasks:
Identifies and defines the key factors affecting customer satisfaction before and after the COVID-19 pandemic in the IT industry.

- To develop membership functions for these variables in the view to construct a fuzzy inference system, which analyses overall customer satisfaction;
- To review relevant data from customer support conducted by surveys before the COVID-19 and support tickets after the outbreak to assess changes in customer behaviour and drivers of satisfaction;
- To give recommendations on insights to IT companies in enhancing customer satisfaction and retention in the post-pandemic era.

IV. DATA COLLECTION PROCESS

To measure real data in terms of customer satisfaction and retention in the IT industry for the period before and after COVID, surveys of customers and analysis involving support tickets have to be carried out in a systematic fashion. Here is a brief of steps involved.

Source: Customer satisfaction surveys conducted within the IT industry.

Pre-COVID Data Collection

1. **Service Quality**: This is where customer feedback is collected regarding the overall service quality of IT. E.g.: "On a scale from 1 to 10, how would you rate the overall quality of our IT?"
2. **Responsiveness**: A rating on how satisfied the customers are with the response time to their problems and queries. Sample questions include the following: "How do you feel with the response time of the queries and issues? (1–10)"
3. **Security:** Customers give their opinion about the level of security. Sample question: "How secured do you feel your data is with our IT services? (1-10)"
4. **Value for Money**: Customer gives opinion about value expectation of the services. Sample question: "How would you rate the value for money of our IT services? (1-10)"

Post-COVID Data Gathering

- **Source:** Analysis of customer support tickets logged after the onset of COVID-19.
- **Factors:** The support tickets were categorized based on three key concerns.

1. **Technical issues**: frequency and severity of technical issues as reported by customers. Sample question: How often do you experience technical issues with our services? (Never, Rarely, Sometimes, Often, Always)
2. **Feature Requests**: Request for developing new features or improvements. Sample question: How often do you request new features or improvements? (Never, Rarely, Sometimes, Often, Always)
3. **Security Concerns:** Security concerns for the post-COVID environment. For instance, "How concerned are you about the security of your data with our services? (1-10)"

V. Fuzzy Mathematical Model

1. **Identification of Factors:** The study identifies key factors influencing customer satisfaction in the IT industry both pre- and post-COVID. Pre-COVID factors include Service Quality, Responsiveness, Security, and Value for Money. Post-COVID factors are Technical Issues, Feature Requests, and Security Concerns. These factors were selected based on their relevance and impact on customer satisfaction and retention in the IT sector.
2. **Membership Functions:** Membership functions are defined for each factor to transform the subjective assessments into fuzzy sets. Each factor is represented by a range of values indicating different levels of satisfaction or concern.

Service Quality (Pre-COVID)
- Poor: [0, 0.3]
- Average: [0.3, 0.7]
- Excellent: [0.7, 1]

Technical Issues (Post-COVID)
- Low: [0, 0.3]
- Moderate: [0.3, 0.7]
- High: [0.7, 1]

Similar membership functions are created for all other factors, allowing the fuzzy inference system to process the input data effectively.

Fuzzy Mathematical Model Formulation

The fuzzy mathematical model for assessing customer satisfaction and retention involves several steps, each involving specific formulas:

1. **Identification of Variables**
   - Pre-COVID Variables: Service Quality (SQ), Responsiveness (RS), Security (SC), Value for Money (VM)
   - Post-COVID Variables: Technical Issues (TI), Feature Requests (FR), Security Concerns (SCP)

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2. **Development of Membership Functions**

   - Membership functions for each variable are defined based on customer responses, for the variable SQ:

$$\mu_{SQ}(x) = \begin{cases} 0 & \text{if } x \leq 1 \\ \dfrac{x-1}{9} & \text{if } 1 < x < 10 \\ 1 & \text{if } x \geq 10 \end{cases}$$

Similar membership functions are developed for RS, SC, VM, TI, FR, and SCP.

3. **Fuzzy Inference System (FIS)**

   - Construct a fuzzy inference system using the defined membership functions. For instance, using Mamdani-type FIS, rules are created such as

     If SQ is High and RS is High, then Overall Satisfaction (OS) is High

4. **Aggregation of Fuzzy Outputs:**
   - Aggregate the outputs from the fuzzy rules using a max-min composition method

$$\mu_{OS}(y) = \max\left(\min\left(\mu_{SQ}(x), \mu_{RS}(x)\right), \min\left(\mu_{SC}(x), \mu_{VM}(x)\right) \ldots\right)$$

5. **Defuzzification:**
   - Convert the fuzzy output into a crisp value using the centroid method

$$OS = \frac{\int y.\mu_{OS}(y)\, dy}{\int \mu_{OS}(y)\, dy}$$

Fuzzy Inference System: The fuzzy inference system (FIS) is developed to analyze overall customer satisfaction. The FIS consists of the following components:

1. **Fuzzification:** Transforming crisp input values (e.g., Service Quality, Technical Issues) into fuzzy values using the defined membership functions.
2. **Rule Base:** A set of fuzzy rules that relate the input factors to the output (customer satisfaction and retention).

- IF Service Quality is Excellent AND Responsiveness is High THEN Customer Satisfaction is High.
- IF Technical Issues are High AND Security Concerns are Moderate THEN Customer Satisfaction is Low.

1. Fuzzification

Convert each input factor x_i into a fuzzy set μ_i using membership functions $\mu_i(x_i)$

$$\mu_{low}(x) = \begin{cases} 0 & \text{if } x \leq 0.2 \\ \dfrac{x-0.2}{0.4-0.2} & \text{if } 0.2 < x < 0.4 \\ 1 & \text{if } x \geq 0.4 \end{cases}$$

$$\mu_{medium}(x) = \begin{cases} 0 & \text{if } x \leq 0.2 \text{ or } x \geq 0.8 \\ \dfrac{x-0.2}{0.6-0.2} & \text{if } 0.2 < x < 0.6 \\ \dfrac{0.8-x}{0.8-0.6} & \text{if } 0.2 < x < 0.6 \end{cases}$$

$$\mu_{high}(x) = \begin{cases} 0 & \text{if } x \leq 0.6 \\ \dfrac{x-0.6}{1.0-0.6} & \text{if } 0.6 < x < 1.0 \\ 1 & \text{if } x \geq 1.4 \end{cases}$$

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Table 1 Output value of fuzzy inference system for customer satisfaction between the pre-COVID and post-COVID periods

Sample	Service Quality (Pre-COVID)	Responsiveness (Pre-COVID)	Security (Pre-COVID)	Value for Money (Pre-COVID)	Technical Issues (Post-COVID)	Feature Requests (Post-COVID)	Security Concerns (Post-COVID)
1	0.5488	0.2646	0.1590	0.3186	0.7253	0.1494	0.1647
2	0.7152	0.7742	0.1104	0.6674	0.5013	0.8681	0.6215
3	0.6028	0.4561	0.6563	0.1318	0.9561	0.1625	0.5772
4	0.5449	0.5684	0.1382	0.7163	0.6440	0.6156	0.2379
5	0.4237	0.0188	0.1966	0.2894	0.4239	0.1238	0.9342
6	0.6459	0.6176	0.3687	0.1832	0.6064	0.8480	0.6139
7	0.4376	0.6121	0.8200	0.5865	0.0192	0.8073	0.5356
8	0.8918	0.6169	0.0971	0.0201	0.3016	0.5691	0.5899
9	0.9637	0.9437	0.8379	0.8289	0.6602	0.4072	0.7301
10	0.3834	0.6818	0.0961	0.0047	0.2901	0.0692	0.3119
11	0.7917	0.3595	0.9765	0.6778	0.6180	0.6974	0.3982
12	0.5289	0.4370	0.4687	0.2700	0.4288	0.4535	0.2098
13	0.5680	0.6976	0.9768	0.7352	0.1355	0.7221	0.1862
14	0.9256	0.0602	0.6048	0.9622	0.2983	0.8664	0.9444
15	0.0710	0.6668	0.7393	0.2488	0.2075	0.9755	0.7396
16	0.0871	0.6706	0.0392	0.5762	0.4240	0.8558	0.4905
17	0.0202	0.2104	0.2828	0.5920	0.8443	0.0117	0.2274
18	0.8326	0.1289	0.1202	0.5723	0.3331	0.3598	0.2544
19	0.7782	0.3154	0.2961	0.2231	0.5414	0.1716	0.0580
20	0.8700	0.3637	0.1187	0.9527	0.3130	0.5210	0.4344
21	0.9786	0.5702	0.3179	0.4471	0.1647	0.0543	0.3119
22	0.7992	0.4386	0.4143	0.8464	0.6215	0.2902	0.6963
23	0.4615	0.9884	0.0641	0.6995	0.8782	0.6180	0.3778
24	0.7805	0.1020	0.6925	0.2974	0.6106	0.4288	0.1796
25	0.1183	0.2089	0.5666	0.8138	0.3447	0.1355	0.0247
26	0.6399	0.1613	0.2654	0.3965	0.6974	0.2983	0.0679
27	0.9447	0.6531	0.5232	0.8811	0.4072	0.8817	0.4535
28	0.5218	0.2533	0.0939	0.5813	0.1404	0.6925	0.5366
29	0.4147	0.4663	0.5759	0.8817	0.7450	0.4147	0.8967
30	0.2646	0.2444	0.9293	0.6925	0.5142	0.2646	0.9903

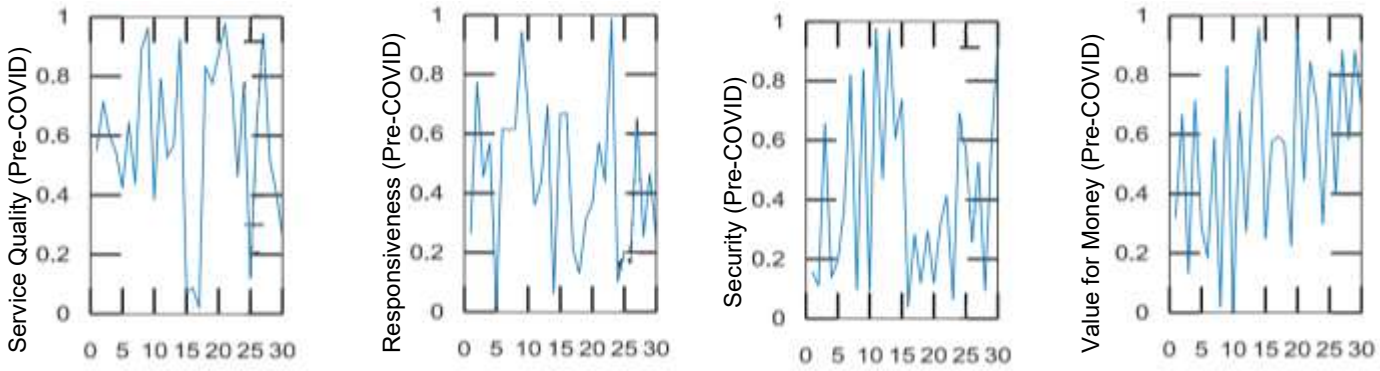

Figure 1 Pre-COVID Output response of FIS in MATLAB

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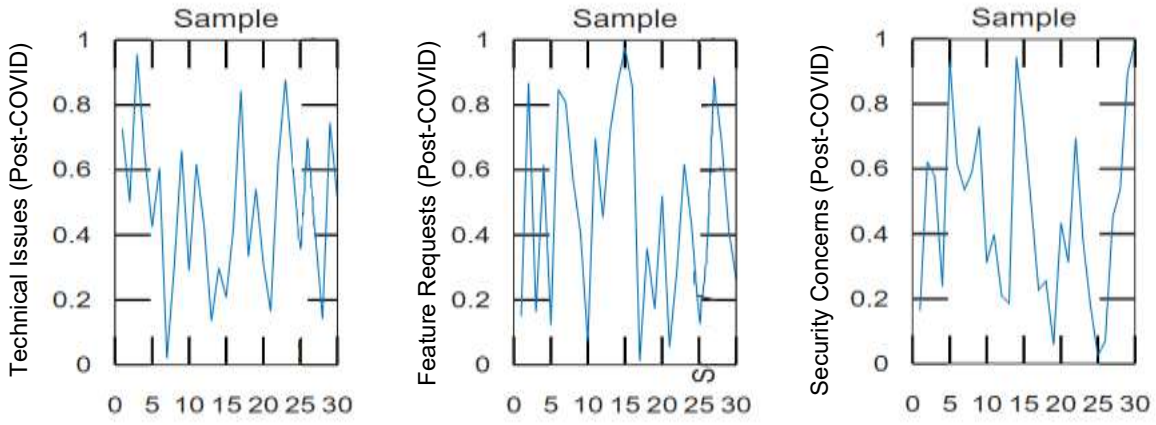

Figure 2 Post-COVID Output response of FIS in MATLAB

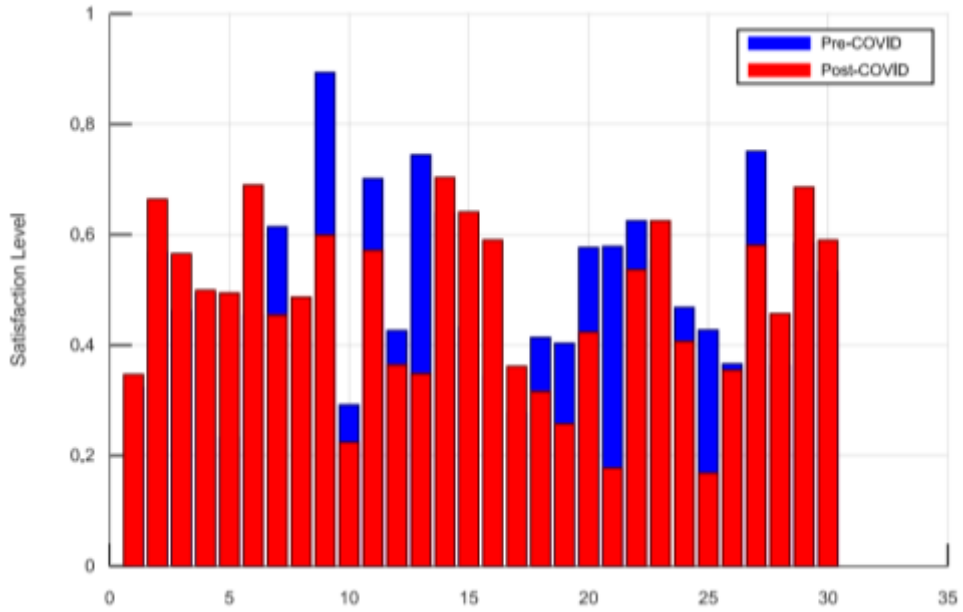

Figure 3 Customer satisfaction levels Pre-COVID and Post-COVID

RESULTS

1. Customer Satisfaction Levels: Pre-COVID and Post-COVID

The results of the analysis indicate that there are significant differences in customer satisfaction between the pre-COVID and post-COVID periods.

- Pre-COVID Satisfaction: Four key drivers—Service Quality, Responsiveness, Security, and Value for Money—drove the satisfaction levels. An average of satisfaction across these factors was computed to give a baseline understanding of the expectations and experiences of customers before the pandemic.
- Post-COVID Satisfaction: Customer concerns are very different from what they used to be before the outbreak of COVID-19.technical issues, feature requests, and security concerns are major factors driving satisfaction since. The averages of the satisfaction scores on these factors allude to a much keener focus on the resolution of technical issues, meeting requirements for new features, and appropriate security measures.

This will be contrasted by plotting the average satisfaction levels pre-COVID and post-COVID, showing that the focus shifted from quality of service and value for money to technical and security concerns more immediately relevant. This shift underlines the general impact of the pandemic on customer priorities and consequently calls forth the need for IT companies to adapt their strategies in time.

2. Effectiveness of Model Predicting Customer Retention

The developed fuzzy mathematical model in this study proved to be effective in predicting customer retention based on the level of customer satisfaction.

• Pre-COVID Predictions: In this respect, certain factors of satisfaction, like Service Quality, Responsiveness, Security, and Value for Money, shaped overall satisfaction and thereby inferred likelihood of retention. The pre-COVID model predictions were within historical trends of customer retention, thus validating it for effectiveness in a stable environment.

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• Post-COVID Predictions: The model was tested for its adaptability against the new set of influential factors—Technical Issues, Feature Requests, and Security Concerns. The model was able to bind these variables and perform better in predicting retention in post-pandemic times. The post-COVID predictions manifested that the resolution of technical and security issues emerged as a major factor for customer loyalty, thus presenting a realigned retention strategy against newly emerging customer concerns.

The fact that the model performed well in predicting retention over these periods shows its strength and relevance across different customer contexts. On the other hand, it also offers IT companies a very effective tool for assessing customer loyalty based on data-driven decisions in enhancing re/media strategies.

3. Insights into COVID-19 Effects on Customer Behavior and Drivers of Satisfaction

The COVID-19 pandemic has dramatically changed customer behavior and satisfaction drivers in the industry.More precisely, customers shifted their attention from the formerly pertinent concerns, like service quality and value for money, to technical support, feature requests, and security concerns during the post-COVID phase. Such movement emphasizes that customer needs are changing at high speed with the level of IT services they utilized during the pandemic.The increase in the primary factor related to technical issues simply means that, during the pandemic, customers were beset by more frequent and complex technical issues. This indeed is a shift in focus, telling IT companies that they do need to work on a better support infrastructure to meet these emerging needs.The increased security awareness in uncertainty across the world following COVID-19 emphasizes the fact that in a digitally driven world, data protection assumes paramount importance with regard to cybersecurity. Customers are more discerning and concerned with the safety of information wanted from them, demanding better security on the part of IT service providers.Increased attention to feature requests scripted a situation in which the IT Company has to demonstrate readiness and innovation in developing new features and functionalities that meet changing market demand by customers.The overall impact of COVID-19 is to realign customer satisfaction drivers toward greater emphasis on immediate technical support and security. IT companies should therefore be prepared to change in these directions, factoring in the provision of services that will meet demands for these drivers to maintain and improve customer satisfaction and retention in a post-pandemic world.

CONCLUSION

The present study probed into the dynamic landscape of customer satisfaction and retention with the help of a fuzzy mathematical model for handling ambiguities and subjectivities involved in customer feedback. Major changes in the drivers of customer satisfaction have been captured by studying the pre- and post-COVID data. Pre-COVID data emphasized service quality, responsiveness, security, and value for money. In contrast, customer concerns post-COVID are related more to technical issues, feature requests, and issues related to security.

For this research, a developed fuzzy inference system that models complex relationships between variables could give nuanced insights into the overall customer satisfaction level. The results showed a significant change in customer behavior and drivers of satisfaction due to the COVID-19 pandemic, which calls for IT companies to change strategies to such changing custom er expectations. The results that emerged from the analysis underline the continuous monitoring and adaptation needed in the process of measuring customer satisfaction. Fuzzy set theory can be used by IT companies to much better handle the uncertainty and variability in customer feedback and hence generate productive customer retention and satisfaction enhancement strategies for the post-pandemic era.

The implications of this study are great for any IT company trying to retain a lead over competitors by way of better customer service. In its proposed fuzzy mathematical model, this study provides an all-important framework that can guide the explication of customer satisfaction in a fast-changing environment, and ways of improving it. Future research can build from this work with an inclusion of more variables and exploration of changes over time in relation to customer satisfaction and retention.

REFERENCES

[1] Zadeh, L. A. (1965). Fuzzy sets. Information and Control, 8(3), 338-353.

[2] Klir, G. J., & Yuan, B. (1995). Fuzzy sets and fuzzy logic: Theory and applications. Prentice Hall.

[3] Oliver, R. L. (1999). Whence consumer loyalty? Journal of Marketing, 63, 33-44.

[4] Anderson, E. W., & Fornell, C. (2000). Foundations of the American customer satisfaction index. Total Quality Management, 11(7), 869-882.

[5] Sheth, J. (2020). Impact of COVID-19 on consumer behavior: Will the old habits return or die? Journal of Business Research, 117, 280-283.

[6] Donthu, N., & Gustafsson, A. (2020). Effects of COVID-19 on business and research. Journal of Business Research, 117, 284-289.

10.48047/jocaaa.2024.33.08.174

[7] Chen, S. M., & Hwang, J. R. (1992). Fuzzy multiple attribute decision making methods and applications. Lecture Notes in Economics and Mathematical Systems, 375, 289-303.

[8] Zimmermann, H. J. (2001). Fuzzy set theory—and its applications. Springer Science & Business Media.

[9] Verma, S., & Gustafsson, A. (2020). Investigating the emerging COVID-19 research trends in the field of business and management: A bibliometric analysis approach. Journal of Business Research, 118, 253-261.

[10] Gupta, S., & Zeithaml, V. (2006). Customer metrics and their impact on financial performance. Marketing Science, 25(6), 718-739.

[11] Parasuraman, A., Zeithaml, V. A., & Berry, L. L. (1988). SERVQUAL: A multiple-item scale for measuring consumer perceptions of service quality. Journal of Retailing, 64(1), 12-40.

[12] Fornell, C., Johnson, M. D., Anderson, E. W., Cha, J., & Bryant, B. E. (1996). The American customer satisfaction index: Nature, purpose, and findings. Journal of Marketing, 60(4), 7-18.

[13] Zeithaml, V. A., Berry, L. L., & Parasuraman, A. (1996). The behavioral consequences of service quality. Journal of Marketing, 60(2), 31-46.

[14] Rust, R. T., & Oliver, R. L. (1994). Service quality: Insights and managerial implications from the frontier. In R. T. Rust & R. L. Oliver (Eds.), Service quality: New directions in theory and practice (pp. 1-19). Sage.

[15] Wang, X., & Zhang, Y. (2008). Fuzzy comprehensive evaluation model for customer satisfaction based on customer requirement information. International Journal of Innovative Computing, Information and Control, 4(12), 3189-3199.

[16] Hill, N., Brierley, J., & MacDougall, R. (2003). How to measure customer satisfaction. Gower Publishing, Ltd.

[17] Kotler, P., & Keller, K. L. (2016). Marketing management (15th ed.). Pearson Education.

[18] Kundu, S., & Datta, S. K. (2015). Impact of trust on the relationship of e-service quality and customer satisfaction. EuroMed Journal of Business, 10(1), 21-46.

[19] Wang, W. T., & Wei, Z. S. (2006). The impact of perceived value on customer satisfaction: Empirical evidence from the telecommunications industry. International Journal of Management, 23(3), 687-698.

[20] Meyer, J. P., & Allen, N. J. (1991). A three-component conceptualization of organizational commitment. Human Resource Management Review, 1(1), 61-89.

[21] Homburg, C., & Giering, A. (2001). Personal characteristics as moderators of the relationship between customer satisfaction and loyalty: An empirical analysis. Psychology & Marketing, 18(1), 43-66.

[22] Nilsson, L., Johnson, M. D., & Gustafsson, A. (2001). The impact of quality practices on customer satisfaction and business results: Product versus service organizations. Journal of Quality Management, 6(1), 5-27.

[23] Tsaur, S. H., Chiu, Y. T., & Huang, C. H. (2002). Determinants of guest loyalty to international tourist hotels—A neural network approach. Tourism Management, 23(4), 397-405.

[24] Zeithaml, V. A. (1988). Consumer perceptions of price, quality, and value: A means-end model and synthesis of evidence. Journal of Marketing, 52(3), 2-22.

[25] Lovelock, C., & Wirtz, J. (2011). Services marketing: People, technology, strategy (7th ed.). Pearson Prentice Hall.

[26] Lee, Y. C., & Ko, C. H. (2000). A knowledge management methodology for customer relationship management in the service industry. Expert Systems with Applications, 20(1), 1-20.

[27] Ranjan, J., & Bhatnagar, V. (2009). Role of knowledge management and analytical CRM in business: Data mining based framework. The Learning Organization, 16(2), 143-153.

[28] Kim, W. G., & Cha, Y. (2002). Antecedents and consequences of relationship quality in hotel industry. International Journal of Hospitality Management, 21(4), 321-338.

[29] Kim, H. W., & Xu, Y. (2007). Drivers of customer loyalty in the online game community: The case of massively multiplayer online role-playing games. International Journal of Electronic Commerce, 12(2), 57-80.

[30] Bolton, R. N., & Lemon, K. N. (1999). A dynamic model of customers' usage of services: Usage as an antecedent and consequence of satisfaction. Journal of Marketing Research, 36(2), 171-186.