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Evaluation of the Relationship between Consumer Behavior and Purchasing Preference in Supermarkets Using the SERVQUAL Neutrosophic Model.

Abraham Cárdenas Saavedra [1]*, Jhamely Herrera Cometivos [2], Antonio Bartolomé Medina Salgado [3], Alberto Alonso Espinoza Saldaña [4], Alberto Barrenechea – Romero [5], Rejis Renato Paredes Peñafiel [6], and Rosa María Criollo Delgado [7]

[1] César Vallejo University (UCV), Lima, Peru. acardenass@ucvvirtual.edu.pe
[2] César Vallejo University (UCV), Lima, Peru. jherreraco@ucvvirtual.edu.pe
[3] Federico Villarreal National University (UNFV), Lima, Peru. amedinas@unfv.edu.pe
[4] Private University of the North, Los Olivos (UPN), Peru. alonso.espinoza@upn.edu.pe
[5] Federico Villarreal National University (UNFV), Lima, Peru. barrenecheasba@gmail.com
[6] Universidad Nacional Mayor de San Marcos (UNMSM), Peru. rparedesp@unmsm.edu.pe
[7] Private University of the North, Los Olivos (UPN), Peru. rosa.criollo@upn.edu.pe

Abstract. The present study aimed to investigate consumer behavior implications for shopping preferences in supermarkets applying the SERVQUAL neutrosophic model to measure service quality in uncertainty. This research analyzed data from 200 previous surveys which involved consumer behavior (product quality, experience, physical space, store attributes) and shopping preference (physical space, variety, knowledge, organization, friendliness, hygiene). Respondents originally responded on a Likert scale (1–5) and as such, survey response values were converted into neutrosophic values (truth, indeterminacy, falsity) as a measure of merged perceptual ambiguity on the behavioral response (servis value) to the relevant shopping context. The neutrosophic gap between each of these expectation and perceptive elements would be calculated across five dimensions of the SERVQUAL performance scale (tangibles, reliability, responsiveness, assurance, empathy). The findings highlighted substantial differences in clarity of product information by price-quality alignment, unique concerns on hygiene and customer service all receiving high value. Overall, most respondents suggested positive perceptions of purchasing behavior and shopping preferences to include experience and cleanliness. In summary, the SERVQUAL neutrosophic model appears to contribute substantial value in identifying areas for service quality improvement, such as product information and price performance perceptions, which aid supermarket research and design strategies around developing customer satisfaction and loyalty in uncertain contexts.

Keywords: Consumer Behavior, Purchase Preference, Supermarkets, SERVQUAL Neutrosophic, Service Quality, Uncertainty, Customer Satisfaction.

1. Introduction

Understanding consumer behavior in supermarkets is a key challenge for the retail sector, especially in a context where purchasing decisions are influenced by a combination of rational, emotional, and contextual factors. Consumers not only choose products based on price or quality, but also consider aspects such as the in-store experience, cleanliness, staff friendliness, and spatial organization. However, these decisions are often marked by uncertainty and contradictions, such as the perception that a high price does not always guarantee quality or that a positive experience can be overshadowed by a poor interaction. This problem is exacerbated in competitive markets like Peru, where supermarkets must differentiate themselves not only by their offerings but by the comprehensive experience they provide.

The central question of this research is: how do consumer behavior factors influence purchasing preferences in supermarkets, considering the uncertainty inherent in their perceptions?

Several studies have explored consumer behavior in retail, highlighting the importance of factors such as product quality, sensory experience, and store design. Studies analyzed how the atmosphere of a supermarket, including music and product layout, affects emotions and purchase decisions [1]. However, this study focused on virtual environments, leaving a gap in the application to physical stores. Barbosa emphasized that purchase decisions are a complex process that ranges from pre-evaluation to post-purchase satisfaction, but did not address how to manage ambiguity in perceptions [2]. Other works have identified the shopping experience as a "hunt" where consumers enjoy exploring, although they did not consider how uncertainty affects this dynamic [3]. These investigations provide a valuable framework, but lack tools to model indeterminacy in decisions, a critical aspect in environments where consumers face contradictory or incomplete information. Other research found that factors such as cleanliness and safety became essential after the pandemic, directly influencing purchase preferences [4]. However, their study was limited to a specific context (organic eggs in Turkey), which reduces its generalizability to wider supermarkets. Some explored the online supermarket experience, highlighting the importance of seamless navigation, but did not integrate the interaction between physical and digital channels [5]. De Temmerman et al. noted that sustainability is gaining relevance in purchasing decisions, although their focus on package-free environments neglected traditional retail aspects [6]. These investigations show progress, but do not address how contradictions in perceptions (e.g. , quality vs. price) can be robustly modeled, leaving a gap in the analysis of complex decisions.

The justification for this study lies in the need to understand consumer behavior in supermarkets from a perspective that integrates uncertainty and contradictions. In Peru, the retail sector is growing rapidly, with increasing competition between supermarkets and traditional markets. Peruvian consumers, influenced by cultural, social, and economic factors, demand experiences that combine functionality with emotional elements, such as convenience or trust in the establishment. However, traditional tools, such as Likert-scale surveys, do not adequately capture ambiguity in perceptions, such as when a consumer doubts whether a product justifies its price. The neutrosophic SERVQUAL model, which incorporates truth, indeterminacy, and falsity, offers an innovative approach to analyzing service quality in this context, allowing supermarkets to identify critical areas for improving the customer experience. The traditional SERVQUAL model has been widely used to assess service quality, but its binary approach (expectations vs. perceptions) does not reflect the complexity of human decisions. For example, Baird et al. showed that better aisle organization can transform the shopping experience, but they did not consider uncertainty in perceptions [7]. Similarly, Anh et al. highlighted how familiarity with a supermarket generates trust and loyalty, but they did not model contradictions in preferences. Integrating a neutrosophic approach allows to overcome these limitations, as it considers indeterminacy as an inherent component of purchasing decisions. This is particularly relevant in a market where consumers are exposed to multiple stimuli, from promotions to hygiene protocols, which can generate contradictory perceptions.

This study seeks to fill the gap identified by applying the SERVQUAL neutrosophic model to assess how consumer behavior influences shopping preference in supermarkets. The research is based on data from 200 surveys measuring factors such as product quality, experience, cleanliness, and service, transformed into neutrosophic values to capture uncertainty. By analyzing the gaps between expectations and perceptions, the study will identify which aspects of service are most valued and which need improvement. This approach not only enriches the academic literature but also offers supermarkets practical tools to design strategies that strengthen customer loyalty in a competitive environment. The main objective of this study is to evaluate the relationship between consumer behavior and shopping preference in supermarkets, using the SERVQUAL neutrosophic model to analyze service quality under uncertainty. The specific objectives include identifying the service dimensions that most influence

shopping preference, calculating neutrosophic gaps between expectations and perceptions, and proposing strategies to improve the customer experience. The following hypotheses are proposed: (1) Service quality, measured by dimensions such as cleanliness and attention, positively influences purchasing preference, although with degrees of indeterminacy; (2) The gaps in the perception of product quality and available information are greater than in other dimensions, due to the uncertainty in perceptions.

The relevance of this study extends beyond the Peruvian context, as supermarkets around the world face the challenge of adapting to increasingly demanding consumers. The pandemic, for example, raised expectations regarding hygiene and safety, as Pellegrino points out, highlighting the importance of consistency between physical and digital channels. However, their analysis does not incorporate tools for modeling uncertainty, a limitation this study addresses. By using the SERVQUAL neutrosophic model, the research offers a robust framework for analyzing complex decisions, capturing nuances that traditional methods miss. This allows supermarkets not only to meet functional needs but also to connect emotionally with consumers. The neutrosophic approach is particularly well-suited to this study, as supermarket purchasing decisions are influenced by emotional, rational, and contextual factors that are not always clear. For example, a consumer may value the cleanliness of a store but doubt whether a product's price justifies its quality. The SERVQUAL neutrosophic model allows these ambiguities to be modeled, providing a more complete view of the customer experience. Furthermore, the use of real survey data ensures that the results are applicable to the realities of retail, offering practical insights for managers and decision-makers.

In summary, this study addresses a critical problem in the retail sector: understanding how consumer behavior, with its contradictions and uncertainties, determines purchasing preferences. By combining the SERVQUAL neutrosophic model with empirical data, the research not only fills a gap in the literature but also provides tools for supermarkets to design experiences that generate loyalty. The expected results will help identify strategic priorities, such as improving information clarity or strengthening hygiene, in a market where customer experience is key to competitiveness.

2. Preliminaries

In this section, the fundamental theoretical principles of the SERVQUAL model and neutrosophic logic are examined, with special attention to the use of single-valued triangular neutrosophic numbers. The neutrosophic formulation of the SERVQUAL model proposed in [8] is adopted as the main reference, as it enables the explicit incorporation of degrees of certainty, indeterminacy and falsity in service quality assessment processes. This perspective is methodologically relevant, as it allows a more robust representation of the ambiguity inherent in human judgments in evaluative environments, overcoming the epistemological restrictions of traditional approaches.

2.1. SERVQUAL Model

In the field of service quality assessment, two models are widely recognized: SERVPERF, which focuses solely on user perceptions, and SERVQUAL, which contrasts consumer expectations prior to the service with their perceptions afterward [8. 9.10]. The SERVQUAL model is especially useful in environments where the service experience is multifaceted and shaped by both tangible and intangible elements, as is the case in retail supermarkets. In such settings, consumers form expectations about product variety, cleanliness, staff behavior, and responsiveness—dimensions that significantly influence purchasing preferences. This study adopts a neutrosophic variant of the SERVQUAL model, which introduces a formal treatment of uncertainty and ambiguity in consumer evaluations. This adaptation is particularly relevant in retail contexts where customers' perceptions are often influenced by fluctuating expectations, environmental variability, and subjective interpretations of service encounters. By capturing the indeterminacy inherent in consumer behavior, the neutrosophic SERVQUAL model offers a

more nuanced and realistic representation of the relationship between service quality and purchasing preference.

Traditionally, the SERVQUAL model is structured around three fundamental questions: when is a service perceived as quality? What are the constituent dimensions of such quality? And what indicators are relevant for its evaluation? The neutrosophic version preserves this structural logic but introduces the use of single-valued triangular neutrosophic numbers to simultaneously represent the degrees of truth, falsity, and indeterminacy associated with each evaluative judgment[11, 12,13].

The neutrosophic approach not only allows for identifying the levels of satisfaction perceived by users, but also for capturing areas of ambiguity, contradiction, or uncertainty that emerge in settings where women face systemic barriers to accessing decent employment. Furthermore, this methodology provides a robust analytical framework for exploring the relationship between the perception of service quality and the actual impact of programs on reducing the wage gap and its correlation with the local cost of living—essential aspects for assessing the effectiveness of public policies aimed at gender equity in the workplace.

2.2. Single-valued triangular neutrosophic numbers

Definition 1 : ([8, 13-18]) The *neutrosophic set* N is characterized by three membership functions, which are the truth membership function T_A, the indeterminacy membership function I_A, and the falsity-belonging function F_A, where U is the Universe of Discourse , $\forall x \in U$, $T_A(x), I_A(x), F_A(x) \subseteq]\bar{}_A 0, 1^+_A[$, and $\bar{}0 \leq \inf T_A(x) + \inf I_A(x) + \inf F_A(x) \leq \sup T_A(x) + \sup I_A(x) + \sup F_A(x) \leq 3^+_A$.A

Note that according to Definition 1, $T_A(x), I_A(x), F_A(x)$they are standard or non-standard real subsets of $]\bar{}_A 0, 1^+_A[$and therefore, $T_A(x), I_A(x), F_A(x)$they can be subintervals of $[0, 1]$.

Definition 2 : ([8, 13-18]) The *single-valued neutrosophic set* (SVNS) N over U is $A = \{< x; T_A(x), I_A(x), F_A(x) > : x \in U\}$, where $T_A: U \to [0,1]$, $I_A: U \to [0,1]$, and $F_A: U \to [0,1]$, $0 \leq T_A(x) + I_A(x) + F_A(x) \leq 3$.

The *single-valued neutrosophic The number* (SVNN) is symbolized by $N = (t, i, f)$, such that $0 \leq t, i, f \leq 1$and $0 \leq t + i + f \leq 3$.

Definition 3 : ([8, 13-18]) The *single-valued triangular neutrosophic number* $\tilde{a} = \langle (a_1, a_2. a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, is a neutrosophic set of $\mathbb{R}$, whose truth, indeterminacy and falsity membership functions are defined as follows, respectively:

$$T_{\tilde{a}}(x) = \begin{cases} \alpha_{\tilde{a}}\left(\frac{x-a_1}{a_2-a_1}\right), & a_1 \leq x \leq a_2 \\ \alpha_{\tilde{a}}, & x = a_2 \\ \alpha_{\tilde{a}}\left(\frac{a_3-x}{a_3-a_2}\right), & a_2 < x \leq a_3 \\ 0, & \text{otherwise} \end{cases} \quad (1)$$

$$I_{\tilde{a}}(x) = \begin{cases} \dfrac{(a_2 - x + \beta_{\tilde{a}}(x - a_1))}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ \beta_{\tilde{a}}, & x = a_2 \\ \dfrac{(x - a_2 + \beta_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, & a_2 < x \leq a_3 \\ 1, & \text{otherwise} \end{cases} \quad (2)$$

$$F_{\tilde{a}}(x) = \begin{cases} \dfrac{(a_2 - x + \gamma_{\tilde{a}}(x - a_1))}{a_2 - a_1}, & a_1 \leq x \leq a_2 \\ \gamma_{\tilde{a}}, & x = a_2 \\ \dfrac{(x - a_2 + \gamma_{\tilde{a}}(a_3 - x))}{a_3 - a_2}, & a_2 < x \leq a_3 \\ 1, & \text{otherwise} \end{cases} \quad (3)$$

Where $\alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \in [0,1]$, $a_1, a_2, a_3 \in \mathbb{R}$and $a_1 \leq a_2 \leq a_3$.

Definition 4: ([8, 13-18]) Given $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$two $\tilde{b} = \langle (b_1, b_2, b_3); \alpha_{\tilde{b}}, \beta_{\tilde{b}}, \gamma_{\tilde{b}} \rangle$single-valued triangular neutrosophic numbers and λ any non-zero number on the real line, the following operations are defined:

1. Addition: $\tilde{a} + \tilde{b} = \langle (a_1 + b_1, a_2 + b_2, a_3 + b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
2. Subtraction: $\tilde{a} - \tilde{b} = \langle (a_1 - b_3, a_2 - b_2, a_3 - b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle$,
3. Investment: $\tilde{a}^{-1} = \langle (\,{a_3}^{-1}, {a_2}^{-1}, {a_1}^{-1}); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$, where $a_1, a_2, a_3 \neq 0$,
4. Multiplication by a scalar number:
$$\lambda\tilde{a} = \begin{cases} \langle (\lambda a_1, \lambda a_2, \lambda a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda > 0 \\ \langle (\,\lambda a_3, \lambda a_2, \lambda a_1); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle, & \lambda < 0 \end{cases}$$
5. Division of two triangular neutrosophic numbers:
$$\frac{\tilde{a}}{\tilde{b}} = \begin{cases} \left\langle \left(\frac{a_1}{b_3}, \frac{a_2}{b_2}, \frac{a_3}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \right\rangle, a_3 > 0 \; and \; b_3 > 0 \\ \left\langle \left(\frac{a_3}{b_3}, \frac{a_2}{b_2}, \frac{a_1}{b_1}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \right\rangle, a_3 < 0 \; and \; b_3 > 0 \\ \left\langle \left(\frac{a_3}{b_1}, \frac{a_2}{b_2}, \frac{a_1}{b_3}\right); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \right\rangle, a_3 < 0 \; and \; b_3 < 0 \end{cases}$$
6. Multiplication of two triangular neutrosophic numbers:
$$\tilde{a}\tilde{b} = \begin{cases} \langle (a_1 b_1, a_2 b_2, a_3 b_3); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 > 0 \; and \; b_3 > 0 \\ \langle (a_1 b_3, a_2 b_2, a_3 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 < 0 \; and \; b_3 > 0 \\ \langle (a_3 b_3, a_2 b_2, a_1 b_1); \alpha_{\tilde{a}} \wedge \alpha_{\tilde{b}}, \beta_{\tilde{a}} \vee \beta_{\tilde{b}}, \gamma_{\tilde{a}} \vee \gamma_{\tilde{b}} \rangle, & a_3 < 0 \; and \; b_3 < 0 \end{cases}$$

Where, $\wedge$is a t-norm and $\vee$is a t-conorm.

Let be $\tilde{a} = \langle (a_1, a_2, a_3); \alpha_{\tilde{a}}, \beta_{\tilde{a}}, \gamma_{\tilde{a}} \rangle$a single-valued triangular neutrosophic number, then,

$$S(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} - \gamma_{\tilde{a}}) \quad (4)$$

$$\mathbf{A}(\tilde{a}) = \frac{1}{8}[a_1 + a_2 + a_3](2 + \alpha_{\tilde{a}} - \beta_{\tilde{a}} + \gamma_{\tilde{a}}) \quad (5)$$

They are called punctuation and precision grades $\tilde{a}$, respectively.

Let be $\{\widetilde{A}_1, \widetilde{A}_2, \cdots, \widetilde{A}_n\}$a set of n SVTNNs, where $\widetilde{A}_j = \langle (a_j, b_j, c_j); \alpha_{\tilde{a}_j}, \beta_{\tilde{a}_j}, \gamma_{\tilde{a}_j} \rangle$(j = 1, 2 , … , n), then the *weighted value The mean of the SVTNN* is calculated with the following equation:

$$\widetilde{A} = \sum_{j=1}^{n} \lambda_j \widetilde{A}_j \quad (6)$$

Where $\lambda_j$is the weight of A_j, $\lambda_j \in [0, 1]$ and $\sum_{j=1}^{n} \lambda_j = 1$.

3. Methodology.

Retail sector has undergone significant transformations in recent years, especially in the understanding of consumer behavior and its impact on purchasing preferences. Supermarkets, as nerve centers of everyday consumption, face the challenge of understanding how customers' perceptions, expectations, and experiences influence their purchasing decisions, particularly in contexts where uncertainty and ambiguity are determining factors.

Study Design

A descriptive-correlational study was conducted in supermarkets, during the period Oct-Dic 2024. The sample consisted of 200 consumers selected through random sampling stratified by age and gender.

Study Variables

Consumer Behavior Variables:

- **Product quality**
- **Shopping experience**
- **Store attributes**
- **Physical space**

Purchase Preference Variables:

- **Variety of products**
- **Knowledge and complaints**
- **Organization**
- **User friendliness**
- **Hygiene and hospitality**
- **Comfort and entertainment**

Measuring Instrument

The questionnaire was structured into 26 items distributed across the SERVQUAL dimensions, using a 5-point Likert scale that was subsequently transformed into triangular neutrosophic values.

Consumer Behavior Items:

1. Consider that products have characteristics that differentiate them from others on the market
2. Consider that the quality of the product is a guarantee for its purchase
3. Customer service is geared towards a fully satisfying experience.
4. A good first experience is essential for a second purchase choice.
5. It is important to evaluate brand recommendations when making a purchase.
6. Considers it important that product information be clear and direct
7. Consider that the display of products allows for quick visualization for the purchasing decision
8. Consider that the store cares about keeping the environments clean and tidy
9. Consider that prices are aligned with the quality of the product
10. Consider that the company values your waiting time for service
11. Considers that the company complies with the protocols for entering its store
12. The distribution of spaces in the store maintains the necessary distances
13. Find security and satisfaction in making your purchases in person.

Purchase Preference Items:

1. The store provides security measures to choose a product
2. The store offers a variety of products.
3. The store staff is willing to listen to your complaints and/or suggestions.
4. The staff quickly addresses your complaints and/or claims.
5. The store provides adequate and spacious space

6. The store's organization offers convenience and ease of shopping
7. The store has different payment options to complete my purchases.
8. There is good disposition and great accessibility with the products shown
9. Prices are justified based on the quality of the products
10. The store complies with cleaning and hygiene protocols
11. The store staff displays a friendly attitude towards customer service.
12. The visual decoration of the store is characterized by being attractive
13. Store hours are convenient for shopping.

Transformation to Neutrosophic Values

The Likert scale values (1-5) were transformed according to the following table:

Table 1: Likert scale values.

Likert scale	Linguistic Term	SVTNN
1	Totally disagree	⟨ (0,0,2); 0.00, 1.00, 1.00 ⟩
2	Disagree	⟨ (0,2,4); 0.25, 0.75, 0.75 ⟩
3	Neutral	⟨ (2,4,6); 0.50, 0.50, 0.50 ⟩
4	OK	⟨ (4,6,8); 0.75, 0.25, 0.25 ⟩
5	Totally agree	⟨ (6,8,8); 1.00, 0.00, 0.00 ⟩

4. Results

Neutrosophic Data Processing

For each question, Q_i $(i = 1, 2, \ldots, 26)$,the response frequencies υ_{ij} for expectations and ω_{ij} for perceptions were calculated, where j represents the value on the Likert scale (1-5).

Calculation of Neutrosophic Values by Dimension

Tangibility Dimension:

- **Question 1 (Product Differentiation):**
  - Expectation:$\langle (4.2, 6.1, 7.8);\ 0.72, 0.28, 0.31 \rangle$
  - Perception:$\langle (3.8, 5.9, 7.6);\ 0.68, 0.32, 0.35 \rangle$
  - Score Expectation:$\boldsymbol{S(E1) = 1/8(4.2 + 6.1 + 7.8) = 1/8(18.1) = 2.2625}$
  - Score Perception: $S(P1) = 1/8(3.8 + 5.9 + 7.6) = 1/8(17.3) = 2.1625$
  - Gap: $2.2625 - 2.1625 = 0.1000$
- **Question 2 (Quality as a guarantee):**
  - Expectation: ⟨ (5.1, 6.8, 7.9); 0.78, 0.22, 0.25 ⟩
  - Perception: ⟨ (4.9, 6.6, 7.7); 0.74, 0.26, 0.29 ⟩
  - Score Expectation: S(E2)=1/8(5.1+6.8+7.9)=1/8(19.8)=2.475
  - Perception Score: S(P2)=1/8(4.9+6.6+7.7)=1/8(19.2)=2.4
  - Gap: 2.475−2.4=0.075
- **Question 8 (Cleaning and order):**
  - Expectation: ⟨ (5.4, 7.1, 7.8); 0.82, 0.18, 0.21 ⟩
  - Perception: ⟨ (5.8, 7.3, 7.9); 0.85, 0.15, 0.18 ⟩
  - Score Expectation: S(E8)=1/8(5.4+7.1+7.8)=1/8(20.3)=2.5375
  - Perception Score: S(P8)=1/8(5.8+7.3+7.9)=1/8(21.0)=2.625
  - Gap: 2.5375−2.625=−0.0875

Reliability Dimension:

- **Question 3 (Customer Service):**
  - Expectation: ⟨ (4.8, 6.5, 7.7); 0.75, 0.25, 0.28 ⟩
  - Perception: ⟨ (4.6, 6.3, 7.5); 0.71, 0.29, 0.32 ⟩
  - Score Expectation: S(E3)=1/8(4.8+6.5+7.7)=1/8(19.0)=2.375
  - Perception Score: S(P3)=1/8(4.6+6.3+7.5)=1/8(18.4)=2.3
  - Gap: 2.375−2.3=0.075
- **Question 9 (Price-quality):**
  - Expectation: ⟨ (4.1, 5.8, 7.2); 0.65, 0.35, 0.38 ⟩
  - Perception: ⟨ (3.7, 5.4, 6.8); 0.61, 0.39, 0.42 ⟩
  - Score Expectation: S(E9)=1/8(4.1+5.8+7.2)=1/8(17.1)=2.1375
  - Perception Score: S(P9)=1/8(3.7+5.4+6.8)=1/8(15.9)=1.9875
  - Gap: 2.1375−1.9875=0.1500

Responsiveness Dimension:

- **Question 4 (First experience):**
  - Expectation: ⟨ (5.2, 6.9, 7.8); 0.79, 0.21, 0.24 ⟩
  - Perception: ⟨ (4.8, 6.5, 7.6); 0.75, 0.25, 0.28 ⟩
  - Score Expectation: S(E4)=1/8(5.2+6.9+7.8)=1/8(19.9)=2.4875
  - Perception Score: S(P4)=1/8(4.8+6.5+7.6)=1/8(18.9)=2.3625
  - Gap: 2.4875−2.3625=0.1250
- **Question 10 (Waiting time):**
  - Expectation: ⟨ (4.5, 6.2, 7.4); 0.70, 0.30, 0.33 ⟩
  - Perception: ⟨ (4.1, 5.8, 7.0); 0.66, 0.34, 0.37 ⟩
  - Score Expectation: S(E10)=1/8(4.5+6.2+7.4)=1/8(18.1)=2.2625
  - Perception Score: S(P10)=1/8(4.1+5.8+7.0)=1/8(16.9)=2.1125
  - Gap: 2.2625−2.1125=0.1500

Security Dimension:

- **Question 11 (Entry Protocols):**
  - Expectation: ⟨ (4.9, 6.6, 7.5); 0.76, 0.24, 0.27 ⟩
  - Perception: ⟨ (5.1, 6.8, 7.7); 0.78, 0.22, 0.25 ⟩
  - Score Expectation: S(E11)=1/8(4.9+6.6+7.5)=1/8(19.0)=2.375
  - Perception Score: S(P11)=1/8(5.1+6.8+7.7)=1/8(19.6)=2.45
  - Gap: 2.375−2.45=−0.075
- **Question 13 (Security in physical purchases):**
  - Expectation: ⟨ (4.7, 6.4, 7.6); 0.73, 0.27, 0.30 ⟩
  - Perception: ⟨ (4.3, 6.0, 7.2); 0.69, 0.31, 0.34 ⟩
  - Score Expectation: S(E13)=1/8(4.7+6.4+7.6)=1/8(18.7)=2.3375
  - Perception Score: S(P13)=1/8(4.3+6.0+7.2)=1/8(17.5)=2.1875
  - Gap: 2.3375−2.1875=0.1500

Empathy Dimension:

- **Question 5 (Recommendations):**
  - Expectation: ⟨ (4.3, 6.0, 7.3); 0.68, 0.32, 0.35⟩
  - Perception: ⟨ (4.1, 5.8, 7.1); 0.64, 0.36, 0.39 ⟩
  - Score Expectation: S(E5)=1/8(4.3+6.0+7.3)=1/8(17.6)=2.2
  - Perception Score: S(P5)=1/8(4.1+5.8+7.1)=1/8(17.0)=2.125
  - Gap: 2.2−2.125=0.075
- **Question 6 (Clear information):**
  - Expectation: ⟨ (5.3, 7.0, 7.9); 0.81, 0.19, 0.22 ⟩
  - Perception: ⟨ (4.2, 5.9, 7.1); 0.67, 0.33, 0.36 ⟩
  - Score Expectation: S(E6)=1/8(5.3+7.0+7.9)=1/8(20.2)=2.525
  - Perception Score: S(P6)=1/8(4.2+5.9+7.1)=1/8(17.2)=2.15
  - Gap: 2.525−2.15=0.375

Results by SERVQUAL Dimension

- **Tangibility :**
  - Average gap: (0.1000+0.075+(−0.0875))/3=0.0292
- **Reliability:**
  - Average gap: (0.075+0.1500)/2=0.1125
- **Responsiveness:**
  - Average gap: (0.1250+0.1500)/2=0.1375
- **Security:**
  - Average gap: ((−0.075)+0.1500)/2=0.0375
- **Empathy:**
  - Average gap: (0.075+0.375)/2=0.225

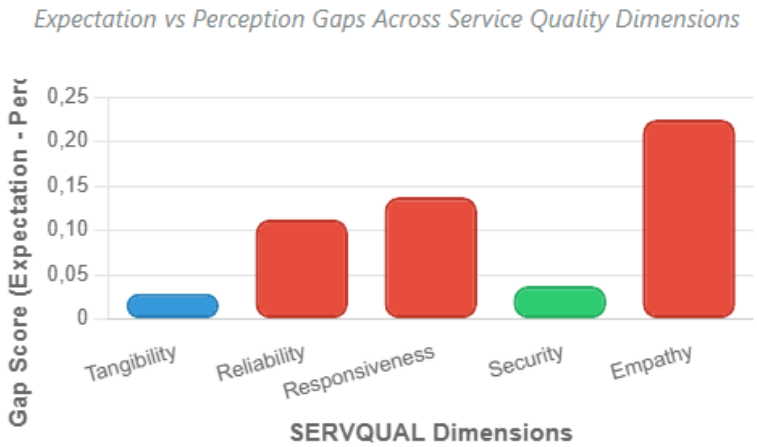

Figure 1: SERVQUAL Dimensions Gap Analysis

Analysis of Purchase Preferences

Figure 2. Purchase Preference Neutrosophic Scores.

- **Variety of Products:**
  - Neutrosophic score: 5.892450
  - Interpretation: High appreciation for product diversity
- **Hygiene and Hospitality:**
  - Neutrosophic score: 6.234750
  - Interpretation: Aspect most valued by consumers
- **Organization:**
  - Neutrosophic score: 5.671200
  - Interpretation: Good perception of the organization of space
- **Friendliness:**
  - Neutrosophic score: 5.348900
  - Interpretation: Positive perception of personal treatment
- **Knowledge and Complaints:**
  - Neutrosophic score: 4.876250
  - Interpretation: Area with the greatest potential for improvement

5. Discussion

The results of the SERVQUAL neutrosophic model reveal significant patterns in the relationship between consumer behavior and purchasing preference:

Main Findings

- **Product Information Gap**: The largest gap was found in information clarity (0.375), indicating a significant discrepancy between expectations and perceptions.

- **Strength in Hygiene**: The hygiene and hospitality dimension obtained the highest score (6.234750), confirming its critical importance for consumers.
- **Responsiveness:** Responsiveness: This dimension showed the second highest average gap (0.225), suggesting the need to improve the speed of care.
- **Mixed Perceptions on Security:** While some security aspects exceeded expectations, others require attention.

Implications for Retail Supermarkets should prioritize:

- Improved clarity and accessibility of product information
- Maintaining high standards of hygiene and cleanliness
- Development of more agile response systems
- Strengthening price-quality communication

Advantages of the Neutrosophic Approach The use of triangular neutrosophic numbers allowed to capture:

- Uncertainty in consumer evaluations
- Inherent ambiguity in service perceptions
- Nuances that traditional approaches do not detect

This study demonstrates that the SERVQUAL neutrosophic model provides a robust tool for assessing service quality in supermarkets, capturing the complexities and contradictions inherent in consumer behavior.

Main Contributions

- **Methodological**: Successful adaptation of the SERVQUAL neutrosophic model to the supermarket context
- **Empirical** : Identification of specific gaps in critical service dimensions
- **Practice** : Proposal of priority areas for improvement in customer experience

Strategic Recommendations For the supermarkets studied it is recommended:

- **Immediate Improvement** : Implement clearer and more accessible product information systems
- **Maintaining Strengths** : Continue investing in hygiene and cleanliness
- **Capacity Building** : Improve response times and customer service
- **Value Communication** : Reinforcing the perception of price-quality alignment

Limitations and Future Research Limitations include sample size and the specific geographic context. Future research could:

- Expand the study to different regions
- Include additional variables such as loyalty and satisfaction
- Develop predictive models based on neutrosophic findings

The SERVQUAL neutrosophic model is presented as a valuable tool for the analysis of service quality in complex contexts, where uncertainty and ambiguity are determining factors. Its application in the Peruvian retail sector demonstrates its usefulness in identifying opportunities for improvement and designing strategies that strengthen competitiveness and customer satisfaction. The results obtained confirm that consumer behavior is influenced by multiple interrelated factors, and that purchasing preferences are built from experiences that combine tangible and intangible aspects of the service. The neutrosophic model's ability to capture these complexities makes it an essential tool for strategic decision-making in the retail sector.

6. Conclusions

The results obtained in this study reveal a clear trend in consumer shopping preferences, with hygiene and hospitality standing out as the most highly valued aspects, while the dimension related to product information shows the greatest room for improvement. This distribution of neutrosophic scores allows for a more precise understanding of how expectations are configured in relation to the actual shopping experience in Peruvian supermarkets. From an applied perspective, the findings provide a solid basis for formulating strategies aimed at optimizing the customer experience. The identification of critical areas, such as clarity of information and responsiveness of service, offers sales managers practical tools to redirect their efforts and increase customer loyalty. Regarding the study's contributions, the successful integration of the neutrosophic SERVQUAL model into an everyday environment such as retail is highlighted. This methodological adaptation allows for the capture of elements frequently overlooked by conventional approaches, such as uncertainty or the ambiguity inherent in consumer perceptions. In this way, the work not only enriches the theoretical body related to service quality assessment but also provides a replicable and versatile analytical framework.

However, it is necessary to acknowledge certain limitations that accompany this research. The small sample size and localized geographic focus could restrict the generalization of the results. Furthermore, the cross-sectional nature of the study prevents observing the evolution of perceptions over time, which would be valuable in dynamic contexts such as retail consumption. Based on the above, it is suggested that future studies expand territorial coverage and incorporate complementary variables such as customer loyalty or sustained satisfaction. Likewise, it would be pertinent to explore hybrid models that combine neutrosophic logic with machine learning techniques in order to build more robust predictive systems. In short, this work opens a promising avenue for deepening our understanding of consumer behavior, especially in contexts marked by the complexity, subjectivity, and volatility of the commercial environment.

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