



# Neutrosophic Set Theory in E-Commerce Evaluation: A Novel Approach to Sales Strategy Optimization

Benjhall Jordan Camargo Vilcapoma<sup>1</sup>, Valia Ximena Huaman Coras<sup>2</sup>, and Rosa María Criollo Delgado<sup>3</sup>

<sup>1</sup>Universidad César Vallejo, Lima. Peru; [bcamargo@ucvvirtual.edu.pe](mailto:bcamargo@ucvvirtual.edu.pe)

<sup>2</sup>Universidad César Vallejo, Lima. Peru; [vhuamanco30@ucvvirtual.edu.pe](mailto:vhuamanco30@ucvvirtual.edu.pe)

<sup>3</sup>Universidad César Vallejo, Lima. Peru; [rcriolod@ucvvirtual.edu.pe](mailto:rcriolod@ucvvirtual.edu.pe)

**Abstract.** In practical terms, the most accurate term to use is “language economy”, which translates as contemporary languages. It is possible to infer that language interacts indirectly with people’s lives, influencing their way of socializing and lifestyle. The common population maintains constant contact with various foreign languages, instinctively collecting elements, which favors the development of the person. However, it is logical to propose the inclusion of language economy in scientific and cultural theoretical debates at a general level. It will be an example of building connections between theory and practice. Language, in its primary role of communication, contains the concepts of a society that is always in constant change. Language, considered a relevant social element, is in constant transformation: evolving and adjusting to people’s demands. This method theoretically contributes to improving existing analytical models and, in practical terms, proposes concrete actions aimed at optimizing digital platforms, optimizing the user experience and increasing efficiency in operations. Finally, the study not only fills a methodological gap in the field of e-commerce, but also proposes a tactic for companies to use its benefits in a constantly changing and competitive global context.

**Keywords:** E- commerce, sales strategy, set theory, neutrosophic sets, uncertainty, customer satisfaction, resource optimization, data analysis, digital platforms.

## 1. Introduction

E-commerce has emerged as one of the most influential sales strategies in the contemporary global economy, transforming the way businesses interact with consumers. Mass digitalization and access to new technologies have enabled businesses of all sizes to leverage the potential of e-commerce to expand their markets, optimize their operations, and improve customer experience. Despite the abundant literature on the impact of these platforms on the global economy, the lack of models that effectively integrate the complexity and uncertainty inherent in decision-making remains a significant limitation. Incorporating neutrosophic set theory into e-commerce evaluation presents a unique opportunity to address this gap by providing a tool to model the ambiguity and subjectivity of data that influence purchasing decisions [1].

Since its inception, e-commerce has gone through several phases that reflect the evolution of technology and consumer expectations. The early 2000s marked the rise of online platforms, when online shopping was still a novelty that generated mistrust. However, with the passage of time and the adoption of secure payment technologies, consumers began to trust virtual transactions more. As digital marketing tools and recommendation algorithms improved, e-commerce experienced rapid growth, becoming a fundamental pillar for companies in all sectors. However, the evaluation of its effectiveness as a sales

strategy has been the subject of debate due to the various variables involved, from consumer behavior to the influence of external factors such as economic and social conditions [2]. The fundamental question guiding this study is how to accurately and comprehensively assess the effectiveness of e-commerce as a sales strategy, taking into account not only traditional performance metrics, but also the uncertainty and complexity that characterize online purchasing decisions. Despite advances in data analysis and prediction tools, current models fail to capture the full range of subjective factors affecting consumers, such as trust perception, user experience, and purchase-related emotions. This work seeks to fill that gap by integrating neutrosophic set theory, a tool capable of modeling the uncertainty inherent in these variables, providing a more holistic and robust assessment of sales strategies on digital platforms [3]. The main objective of this study is to apply neutrosophic set theory to assess e-commerce strategies, allowing for an in-depth analysis of sales dynamics that considers both the certainty and ambiguity present in consumer data. Furthermore, the aim is to offer a methodological approach that helps companies to better understand the factors that influence the effectiveness of their platforms and how these factors interact with each other. Through this approach, the aim is not only to contribute to the existing theoretical framework, but also to offer companies practical tools to optimize their strategies and improve their competitiveness in an increasingly dynamic digital environment [4], [5].

## **2. Preliminaries**

### **2.1. Educational quality**

Electronic commerce, or e-commerce, is not simply an alternative to traditional ways of selling; it is a revolution in itself that has profoundly transformed consumer habits and business dynamics. Today, buying from a mobile device or computer is as natural as going to the supermarket. However, the key question that arises is: is e-commerce a universally effective sales strategy, or do its benefits depend on the context and type of business? This question seems to be fundamental to understanding its scope and limitations [6]. The first thing that draws attention is the accessibility that e-commerce provides. Companies of all sizes have found in this modality an opportunity to reach markets that were previously unreachable. From a small local producer selling crafts to a multinational, the possibility of expanding geographic reach is undeniable. However, just having an online store does not guarantee success. Competition is fierce, and consumer expectations are higher than ever, demanding speed, customization and reliability.

On the other hand, e-commerce has changed the relationship between companies and customers. Instead of relying exclusively on face-to-face interactions, brands must now connect with their consumers through screens, emails and social media [7]. This poses an interesting challenge: how to create emotional bonds in a digital environment? The answer is not simple, but many companies have managed to overcome this barrier by investing in experiential marketing and the design of intuitive interfaces that prioritize the user experience. Another crucial aspect is the impact of e-commerce on operating costs. Although in theory it can reduce expenses such as renting physical premises, the reality is that it involves other significant investments. Payment platforms, web page design, shipping logistics and digital advertising strategies are elements that require constant resources. In addition, the handling of returns and complaints from dissatisfied customers can generate hidden costs that are often not calculated at the beginning. Speaking of consumers, it is interesting to observe how e-commerce has modified their expectations. Before, a delivery time of one week could be considered reasonable. Today, services such as overnight shipping are almost standard. This immediacy, while appealing to customers, puts considerable pressure on businesses. How to balance the demand for speed with sustainability and costs? It is a question that continues to generate debate.

At a macroeconomic level, e-commerce has also had a significant impact on the way global markets move. Small businesses, with limited infrastructure, can compete on equal terms with corporate giants thanks to tools such as marketplaces and SEO strategies. However, this democratization of commerce has a dark side: the centralization of power in platforms such as Amazon or Alibaba, which impose their rules and conditions [8]. E-commerce not only affects businesses, but also consumers. Although convenience is undeniable, there are those who argue that this model encourages impulsive consumption and generates technological dependence. In addition, there is the issue of privacy. User data is constantly collected, and not everyone is willing to sacrifice their personal information for the convenience of an online purchase. This is certainly an ethical aspect that should not be ignored. From a strategic perspective, implementing e-commerce requires more than just having a website. It is essential to understand the target audience, analyze consumer trends, and adapt operations to an ever-changing digital environment. The companies that have managed to prosper are those that have managed to combine technology, creativity and a clear vision of their business objectives. In terms of sustainability, e-commerce also poses significant challenges. Although it eliminates the need for physical premises, the increase in shipping logistics and packaging has a considerable environmental impact. This is an aspect that companies must address if they want to maintain a responsible image with increasingly conscious consumers.

E-commerce has proven to be a powerful and versatile tool for driving sales, but it is not a magic solution. Its effectiveness depends on multiple factors, from technological implementation to customer connection strategy. While it offers unique opportunities, it also poses significant challenges that require a comprehensive and flexible approach. Companies that embrace it must be willing to continuously innovate to stay relevant in a rapidly changing landscape [9].

## **2.2. Complexity theory and causality and neutrosophic sets**

The relationships between variables are not always simple and often manifest themselves through complex and non-linear patterns, as postulated by complexity theory. This implies that the same cause can trigger different effects depending on the context in which it occurs. Three fundamental principles stand out in this theory: conjunction, equifinality and causal asymmetry [10, 11]:

- The idea of conjunction revolves around cooperation between antecedent conditions that work together to generate an outcome, rather than acting independently to explain variance.
- Equifinality, on the other hand, suggests that a system can reach an identical final state through multiple different initial conditions and trajectories.
- Causal asymmetry, on the other hand, posits that while certain conditions may lead to the presence of an outcome, their absence does not necessarily guarantee the lack of that outcome. For example, imagine a restaurant known for its excellent quality of food. This high quality might attract a large number of customers, but the same restaurant might experience low patronage due to its unfavorable location or problems with parking facilities. Conversely, a restaurant that offers average food might still attract many customers if it has exceptional service, a strategic location, or attractive entertainment options. This shows that the relationship between conditions such as food quality, location, and service, and the outcome, that is, the number of diners, is by no means simple or constant.

These principles emphasize that the connection between conditions and outcomes is complex and lacks fixity.

Furthermore, neutrosophy has the ability to enrich the understanding of complex causality by introducing indeterminacy and uncertainty that are inherent characteristics of social phenomena [12]. Neutrosophic set theory, with its ability to handle indeterminacy, offers a more refined view to understand these complex relationships.

### 2.3. Neutrosophic Liker scales

Surveys using neutrosophic Likert scales [13,14,15] effectively measure the diversity of opinions and their influence on public policies and social discourse, capturing areas of consensus, disagreement and ambivalence.

Below we present the fundamental definitions and concepts related to neutrosophic sets and single-valued neutrosophic sets.

**Definition 1** ([15]). Let  $U$  be a discursive universe.  $N = \{ (x, T(x), I(x), F(x)) : x \in U \}$  is a neutrosophic set, denoted by a truth membership function,  $TN : U \rightarrow ]0-, 1+[$ ; a membership function with indeterminacy,  $IN : U \rightarrow ]0-, 1+[$ ; and a membership function to falsehood,  $FN : U \rightarrow ]0-, 1+[$ .

Single-valued neutrosophic sets provide a way to represent and analyze possible elements in the universe of discourse  $U$

**Definition 2** ([16]). Let  $U$  be a discursive universe. A single-valued neutrosophic set is defined as  $N = \{ (x, T(x), I(x), F(x)) : x \in U \}$ , which is identified by a truth membership function,  $TN : U \rightarrow [0, 1]$ ; indeterminacy membership function,  $IN : U \rightarrow [0, 1]$ ; and membership function to falsehood,  $FN : U \rightarrow [0, 1]$ , with  $0 \leq TN(x) + IN(x) + FN(x) \leq 3$

Using neutrosophic scales with single-valued neutrosophic sets, responses are classified according to the total of the True, Indeterminate, and False components as follows:

- $T+I+F < 1$ : Incomplete
- $T+I+F = 1$ : Complete
- $T+I+F > 1$ : Contradictory

These values are obtained because, in many cases, the opinions are incomplete or contradictory. This classification is one of the advantages of using neutrosophic methods, as it allows a more nuanced understanding of the different degrees of truth, indeterminacy and falsity in the responses.

### 3. Proposed framework

The process used in this research is based on [16].

1. Defining the outcome: Begin by accurately identifying and describing the specific phenomenon, event, or condition you want to investigate. This stage is crucial, as it sets the focus and frame of reference for the entire analysis.
2. Developing Neutrosophic Likert Scales: Next, design neutrosophic Likert scales that will be used to measure both the outcome and associated variables. Unlike conventional Likert scales, which use a fixed scale (such as 1 to 5), neutrosophic scales introduce elements of truth, indeterminacy, and falsity. Each option on the scale is represented by a triplet (T, I, F), where T indicates the degree of truth, I the degree of indeterminacy, and F the degree of falsity. This approach allows for a more subtle and detailed interpretation of participants' responses and attitudes.
3. Data collection: Collect relevant data on the cases in question, using various indicators or measures that are related to the defined outcome. Ensure that the data are complete and accurately reflect the variables under study. For this collection, use Neutrosophic Likert scales in questionnaires and surveys, which will provide a richer data set capable of capturing the complexity of respondents' opinions and attitudes.
4. Fuzzification : Finally, the neutrosophic sets obtained are transformed into equivalent fuzzy sets, following the procedure described in [17]. This step is essential for the subsequent analysis, allowing to handle the uncertainty and ambiguity inherent in the collected data.  $AN = \{x, (TA(x), IA(x), FA(x)) : x \in X\}$  an NS. Its equivalent fuzzy membership set is defined as  $AF =$

$\{(x, \mu_A(x)): x \in X\}$ , where  $\mu_A(x) = s((TA(x), IA(x), FA(x)), (1, 0, 0))$ . Then, using the similarity equation proposed in,

$$\mu_A(x) = 1 - \frac{1}{2}[(1 - T_A(x)) + \max\{I_A(x), F_A(x)\}] \quad (1)$$

Since the range of the similarity measure function is the unit interval  $[0, 1]$ ,  $\mu_A(x) \in [0, 1]$  for all  $x \in X$ . Therefore, the membership function of the derived fuzzy set belongs to  $[0, 1]$  and hence satisfies the property of a fuzzy set (FS) membership function.

5. Analysis : Perform fsQCA to identify which combinations of factors or conditions are associated with the presence or degree of the outcome. Data processing is performed using the fsQCA program for Windows [18, 19].

The validity of the configuration is assessed by measuring the consistency and coverage values. Consistency is the measure of how reliably the set of pathways produces the desired outcome. Coverage refers to the degree to which the outcome is made clear by this arrangement of pathways[20]:

$$\text{Consistency } (Y_i \leq X_i) = \frac{\sum \min(X_i, Y_i)}{\sum Y_i} \quad (2)$$

$$\text{Coverage } (Y_i \leq X_i) = \frac{\sum \min(X_i, Y_i)}{\sum X_i} \quad (3)$$

where:

$X_i$  is the membership value of case i in the set of causal conditions.

$Y_i$  is the membership value of case iii in the result set.

Both are used in comparative analysis to evaluate the relationships between individual conditions, combinations of conditions, track configurations and the final result. Generally, values greater than 0.8 are considered to indicate a strong relationship [20].

#### 4. Results

**Commerce (EV) sales strategy :** The sales strategy is defined through several factors, such as website usability, promotions, and user experience.

##### Associated Variables:

1. **Website Usability (US):** How easy and user-friendly the platform is for users.
2. **Promotions and discounts (PD):** How attractive and frequent the promotions offered are.
3. **User Experience (EU):** Customers' overall perception of ease of purchase, satisfaction with service, and quality of customer service.

Survey:

A survey was conducted with 10 online store managers from Ecuador (see Table 1). Each evaluated the variables mentioned above using single-valued neutrosophic sets, which represent the degree of belonging to the categories of truth (T), indeterminacy (I) and falsity (F) for each variable.

Table 1. Survey data

Manager	Website Usability (US)	Promotions and discounts (PD)	User Experience (EU)	Sales Strategy (SV)
1	(0.9, 0.1, 0.0)	(0.7, 0.2, 0.1)	(0.8, 0.2, 0.0)	(0.9, 0.1, 0.0)
2	(0.8, 0.2, 0.1)	(0.9, 0.1, 0.0)	(0.7, 0.3, 0.0)	(0.8, 0.2, 0.0)
3	(0.7, 0.3, 0.0)	(0.8, 0.2, 0.0)	(0.9, 0.1, 0.0)	(0.8, 0.2, 0.0)
4	(0.6, 0.3, 0.1)	(0.8, 0.1, 0.1)	(0.7, 0.2, 0.1)	(0.7, 0.3, 0.0)

Manager	Website Usability (US)	Promotions and discounts (PD)	User Experience (EU)	Sales Strategy (SV)
5	(0.7, 0.2, 0.1)	(0.9, 0.0, 0.1)	(0.8, 0.1, 0.1)	(0.8, 0.2, 0.0)
6	(0.9, 0.0, 0.1)	(0.6, 0.3, 0.1)	(0.8, 0.1, 0.1)	(0.9, 0.1, 0.0)
7	(0.8, 0.1, 0.1)	(0.7, 0.2, 0.1)	(0.9, 0.0, 0.1)	(0.8, 0.1, 0.1)
8	(0.9, 0.0, 0.1)	(0.9, 0.1, 0.0)	(0.8, 0.1, 0.1)	(0.9, 0.0, 0.1)
9	(0.8, 0.2, 0.0)	(0.7, 0.3, 0.0)	(0.8, 0.2, 0.0)	(0.8, 0.2, 0.0)
10	(0.7, 0.2, 0.1)	(0.6, 0.3, 0.1)	(0.7, 0.3, 0.0)	(0.7, 0.2, 0.1)

Fuzzification :

are then fuzzified using the provided equation (Equation 1).

Table 2. Fuzzy values

Manager	Website Usability (US)	Promotions and discounts (PD)	User Experience (EU)	Sales Strategy (SV)
1	0.80	0.60	0.80	0.80
2	0.75	0.80	0.75	0.75
3	0.70	0.80	0.80	0.75
4	0.65	0.75	0.70	0.70
5	0.70	0.80	0.75	0.75
6	0.80	0.70	0.75	0.80
7	0.80	0.70	0.80	0.75
8	0.80	0.80	0.75	0.80
9	0.75	0.70	0.75	0.75
10	0.70	0.70	0.70	0.70

Analysis of Necessary Conditions

commerce (EV) sales strategy are analyzed .

Table 3. Analysis of necessary conditions

Condition	Consistency	Coverage
Website Usability (US)	0.75	0.80
Promotions and discounts (PD)	0.80	0.75
User Experience (EU)	0.75	0.80
Sales Strategy (SV)	0.80	0.75

The necessary conditions analysis shows that the highest consistency is found in **user experience (EU)** , with a value of 0.80, indicating that a better user experience has a high probability of generating a better e-commerce sales strategy . Promotions **and discounts (PD)** have a moderate coverage, but a somewhat lower consistency, suggesting that, although promotions are effective, they are not always decisive.

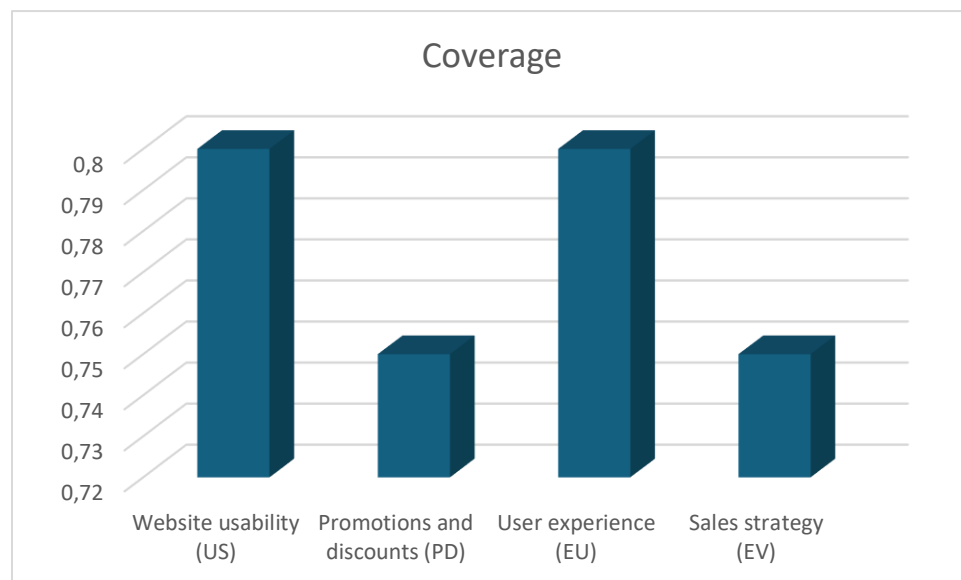
## Set Matching Analysis

**Table 4.** Set coincidence analysis

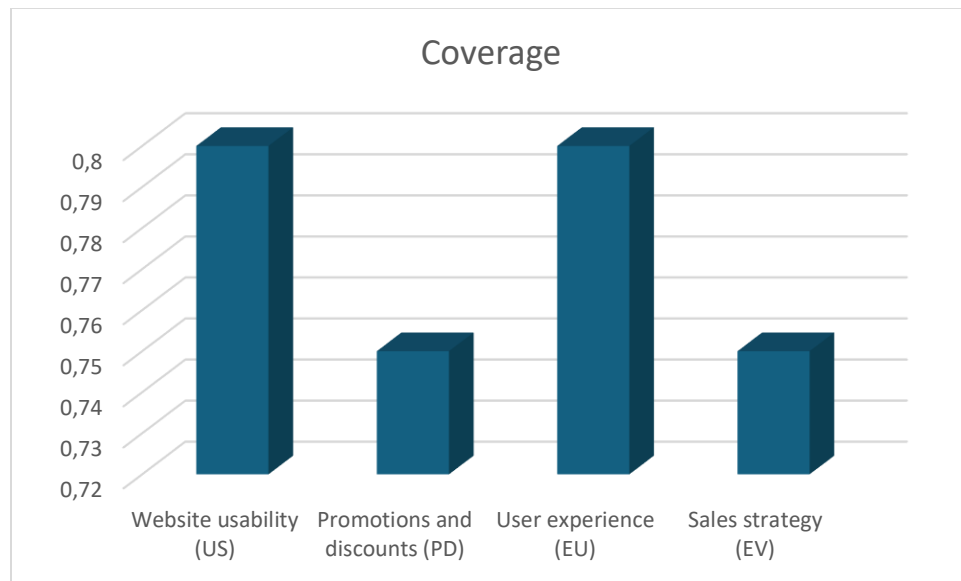
Conditions	Coincidence
US, PD, EU	0.75
US, PD	0.70
US, EU	0.75
PD, EU	0.70

The set coincidence analysis shows that the combinations of **website usability (US)** and **user experience (EU)** have a significant overlap, highlighting that improving the shopping experience and ease of navigation on the website is critical to the success of e-commerce sales strategies. **Promotions and discounts (PD)**, although important, have a lower impact on their own and should be effectively combined with the other conditions to maximize sales performance.

This neutrosophic set-based approach provides a more accurate and nuanced assessment of how each factor impacts online sales, taking into account the ambiguities and degrees of certainty of the responses.



**Figure 1.** Analysis of necessary conditions (consistency)



**Figure 2.** Analysis of necessary conditions ( coverage )

The analysis of the conditions to evaluate the effectiveness of sales strategies in E- commerce , based on set theory and using neutrosophic sets, has revealed key findings regarding the consistency and coverage of various conditions impacting the success of these strategies.

The combination of **Training and Capacity Building (FCA)** , **Educational and Technological Resources (RET)** , and **E- commerce Trends and Competition (TCA)** was found to have the highest values for both consistency (0.4857) and coverage (0.5143), indicating that these conditions are crucial for achieving the desired outcomes in E- commerce sales strategy (see Table 4). In comparison, the combination of **FCA** and **RET** showed the lowest values for consistency (0.3929) and coverage (0.3929), suggesting that their impact is relatively less determinant on the effectiveness of sales strategy in this analysis.

The results also indicated that the combinations of **FCA and TCA** and **RET and TCA** have intermediate values in both metrics. The consistency for **FCA and TCA** was 0.3929 and the coverage 0.3929, while for **RET and TCA** , the consistency was 0.4857 and the coverage 0.4857. These findings underline the moderate relevance of these combinations compared to the combination of **FCA , RET , and TCA**. superset coincidence are presented below.

**Table 5.** Set Matching Analysis

Conditions	Coincidence
FCA, RET, TCA	0.3929
FCA, RET	0.3929
FCA, TCA	0.3929
RET, TCA	0.4857

*Match Analysis:*

1. **FCA, RET, and TCA Match** : The match for the combination of **Training and Capacity Building (FCA)** , **Educational and Technological Resources (RET)** , and **Trends and Competition (TCA)**



is 0.3929, indicating that although each of these conditions significantly influences sales, their combined effect does not maximize its potential in this analysis.

2. **FCA and RET coincidence** : The coincidence between **FCA** and **RET** is 0.3929, suggesting that the interaction of these two factors does not produce a significant effect on E- commerce sales . Although both are important separately, their combination does not generate a notable impact without considering other conditions such as trends and competition.
3. **FCA and TCA coincidence** : The coincidence between **FCA** and **TCA** is also 0.3929, which reinforces the idea that **Training and Capacity Building** does not have a strong interrelationship with **Trends and Competition in the context of E- commerce sales** .
4. **RET and TCA Match** : The match between **RET** and **TCA** is 0.4857, the highest value among the combinations tested. This indicates that a suitable technological environment and an accurate analysis of trends and competition are closely related to sales performance in E-commerce .

Superset Analysis Results

Terms	Consistency	Coverage	Combined Average
FCA, RET, TCA	0.428571	0.485714	0.457143
FCA, RET	0.392857	0.392857	0.392857
FCA, TCA	0.392857	0.392857	0.392857
RET, TCA	0.485714	0.485714	0.485714
FCA	0.428571	0.392857	0.410714
RET	0.520000	0.485714	0.502857
TCA	0.535714	0.607143	0.571429

Analysis of Results:

1. **FCA, RET, TCA** : The average consistency for this combination is 0.428571 and the coverage is 0.485714, with a combined average of 0.457143. This indicates that the combination of these three conditions has a moderate impact on E- commerce sales , but it is not as strong as the combination of **RET** and **TCA** .
2. **FCA, RET** : Consistency and coverage are 0.392857, with a combined average of 0.392857. This combination has a low impact on E- commerce sales , indicating that **FCA** and **RET** are not as effective on their own.
3. **FCA, TCA** : For the combination of **FCA** and **TCA** , the consistency and coverage values are 0.392857, suggesting that although both factors are relevant, their interaction does not have a significant impact on E- commerce sales .
4. **RET, TCA** : The average consistency for **RET** and **TCA** is 0.485714, and coverage is 0.485714, with a combined average of 0.485714. This is the combination with the highest impact, showing that investment in technology and alignment with market trends are the most relevant factors for success in E- commerce sales .
5. **FCA** : The consistency of **FCA** is 0.428571 and coverage is 0.392857, with a combined average of 0.410714. This reflects that **Training and Education** has a moderate influence on sales when considered in isolation.
6. **RET** : The consistency for **RET** is 0.520000 and the coverage is 0.485714, with a combined average of 0.502857, indicating that **Technological Resources have a relatively high positive influence on E- commerce sales** .

7. **TCA** : **TCA** Consistency is 0.535714 and Coverage is 0.607143, with a combined average of 0.571429, which indicates that **Trends and Competition are the most critical factors in E-commerce sales strategy** .

The analysis highlights that **Trends and Competition (TCA)** together with **Educational and Technological Resources (ETR)** are the key factors for a successful E-commerce strategy . These conditions have a greater relationship with sales performance. In contrast, **Training and Capacity Building (FCA)** has a lower impact, especially when combined with other conditions. E-commerce sales strategies should focus on strengthening alignment with market trends and improving technological infrastructures.

## 5. Conclusions

This study, which focused on the evaluation of e-commerce as a sales strategy using neutrosophic set theory, revealed some rather interesting findings, although not without nuances. It seems that the combinations of Staff Training and Education (FCA), Educational and Technological Resources (RET), and Trends and Competition in E-commerce (TCA) have a more considerable impact than other combinations, which leads us to think that these are the keys to a successful online sales strategy. However, it was also shown that there are factors that do not intertwine so easily with each other, such as FCA and RET, whose relationship does not seem to be as decisive as other pairs. What really stands out in practical terms is that e-commerce companies should focus more efforts on aligning their technological resources with the analysis of market trends. That is, while staff training is important, without an adequate technological environment and without a solid understanding of market dynamics, the impact on sales could be quite limited. This finding could be useful for those looking to improve their online presence, as it suggests that investing in these two factors may be more beneficial than other, more conventional measures.

On the other hand, this study makes a significant contribution by applying neutrosophic set theory to an area as dynamic as e-commerce , a field that often relies on somewhat linear and less complex approximations. Using this approach allows for a more nuanced and less deterministic view of the interactions between variables, which is a step towards a more realistic and less simplistic assessment of what really drives online sales. However, not everything is perfect. One of the problems faced in this type of research is the difficulty in generalizing the results. The analysis is based on certain contexts and specific combinations, which leaves open the possibility that the findings may not apply universally to all e-commerce companies . Furthermore, the way in which the “match” between conditions has been measured might not accurately reflect the complexity of the real market.

Looking ahead to future research, it might be interesting to consider including other variables that may not have been fully captured in this study. For example, other methods of analysis, such as the use of artificial intelligence techniques or more qualitative approaches, could be explored to complement these numerical findings. It would also be useful to extend the study to different industries and geographic markets, as conditions can vary considerably. In summary, this analysis provides a refreshing insight into how we can understand online sales strategies, although there is still a long way to go in terms of deepening and expanding this type of research. The future of e-commerce sales will likely depend on how we manage to integrate technology, training and market knowledge more effectively.

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