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# Factors Affecting the Selection of B2C E-Commerce Website in Vietnam: A Fuzzy AHP Analysis

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**Abstract:** The burgeoning B2C e-commerce landscape in Vietnam necessitates a deeper understanding of customer selection criteria to ensure sustained satisfaction and trust. This study addresses this gap by employing a Fuzzy Analytic Hierarchy Process (FAHP) to evaluate B2C e-commerce platforms in Vietnam. The FAHP facilitates the identification of critical factors and sub-factors influencing online customer satisfaction and website selection. We leverage a comprehensive literature review to establish a framework encompassing five main factors and twenty-three sub-factors. Our FAHP analysis unveils "Privacy and Security," particularly "Secure transactions," as the most influential factor for Vietnamese consumers. "Website design and usability," with an emphasis on "Website responsiveness," takes the second-highest priority. These results provide valuable insights for e-commerce businesses, enabling them to optimize resource allocation based on the relative importance of these factors. Furthermore, this research contributes to the limited body of knowledge on B2C e-commerce website selection, particularly within the Vietnamese context.

**Keywords:** B2C, E-Commerce Website, Selection, Influential Factors, FAHP

## Introduction

The e-commerce industry is experiencing rapid growth worldwide, becoming an essential and cutting-edge method of shopping. As e-commerce continues to surge, it is driving significant changes in modern society. Within e-commerce platforms, several primary business models emerge, including Business-To-Business (B2B), Business-To-Consumer (B2C), Consumer-To-Consumer (C2C), Consumer-To-Business (C2B), and Business-To-Government (B2G). The B2C model, where enterprises offer online shopping platforms for consumers, is particularly crucial. With the advancement of the modern knowledge economy and network economy, B2C is increasingly appealing to both enterprises and consumers, intensifying market competition. Online shopping empowers customers with expanded choices and cost savings, granting them greater agency in business interactions. To boost customer satisfaction and loyalty, enterprises must deliver personalized, satisfactory products and services, ultimately aiming for increased profitability. Concurrently, numerous B2C e-commerce platforms are emerging, leading to intense competition and the potential phasing out of less successful websites (Abdalla and Wang, 2021).

Despite the prevalence of e-commerce systems, not all websites succeed in converting visitors into customers due to various challenges. Common issues faced by e-commerce websites include poor usability, limited user support, inadequate transaction implementation, data security concerns, and failure to cater to individual customer needs. Therefore, effectively evaluating websites has emerged as a significant concern for both practitioners and researchers.

In Vietnam, B2C e-commerce has experienced significant growth, driven by increasing internet penetration, smartphone usage, and a burgeoning middle class with rising disposable income. The swift expansion of the B2C commercial model in Vietnam has introduced challenges concerning customer satisfaction and trust. Consequently, there is a need to assess B2C e-commerce platforms to understand the impact of various criteria on customer satisfaction and identify the most satisfactory websites. This study aims to address the following research questions: (1) What factors and sub-factors affect the selection of B2C e-commerce websites? and (2) What is the rank of importance for these factors and sub-factors?

Assessing e-commerce platforms presents a complex challenge that requires the use of Multi-Criteria Decision-Making (MCDM) techniques. Traditional MCDM methods, including the analytic hierarchy process (AHP), Technique for Ordering Preference by Similarity to Ideal Solution (TOPSIS), Preference Ranking Organization Method for Enrichment Evaluation (PROMETHEE), and Elimination and Choice Translating Reality (ELECTRE), have been extensively applied in various contexts. Among these methods, AHP is particularly recognized for its ability to address intricate decision-making problems through pairwise comparisons. However, AHP often falls short when it comes to handling uncertainty within the decision-making process. To overcome this limitation, the Fuzzy Analytic Hierarchy Process (FAHP) was introduced, integrating fuzzy logic to better manage ambiguity and improve decision accuracy.

Since its inception, the Fuzzy Analytic Hierarchy Process (FAHP) has been extensively utilized by researchers to tackle a wide range of decision-making challenges across multiple disciplines. For instance (Li *et al*., 2023) proposed a FAHP-based framework to analyze factors in green finance (Khandelwal and Barua, 2024) and employed FAHP to rank barriers in the plastic industry in India. These studies demonstrate the merits of FAHP in addressing decision-making problems.

Our research employs FAHP to identify and rank factors affecting the selection of B2C e-commerce websites in Vietnam, ensuring fair and objective attribute weights. This study is significant both theoretically and practically. Theoretically, it contributes to the literature by providing a comprehensive understanding of the factors influencing B2C e-commerce website selection in Vietnam. From a managerial perspective, the findings offer valuable insights for improving e-commerce platforms based on user preferences and expectations.

## *Literature Review*

To evaluate B2C e-commerce effectively, it is crucial to identify the primary influential factors by examining prior research. Given the increasing complexity and competition within the e-commerce landscape, it is essential to define customer expectations. Consequently, considering customers' perspectives becomes pivotal in assessing service quality to enhance both customer satisfaction and service standards. In crafting the B2C website evaluation index, this study opts for factors from two angles. From the standpoint of website development, two factors are chosen: Website design and usability and Privacy and Security. Simultaneously, considering user engagement with the website, three additional factors are incorporated: Product quality, Fulfillment, and Service quality. The discussion of the factors is presented as follows.

Website design and usability: The design and usability of a B2C website refer to how the website is visually structured and how easy it is for users to navigate, interact with, and understand its features and content. Design encompasses elements such as layout, color schemes, typography, imagery, and overall visual aesthetics, whereas usability emphasizes functionality, user interface components, ease of use, and accessibility. Fundamentally, a well-designed and highly usable B2C website integrates a visually appealing interface with intuitive navigation, enhancing the user experience and enabling seamless interaction for customers.

In the context of a B2C website, "product" refers to the goods or services that are offered for sale to consumers. These products can vary widely depending on the nature of the business, but they typically include tangible items like clothing, electronics, household goods, and groceries, as well as intangible services such as digital downloads, subscriptions, or online courses. The product section of a B2C website typically includes detailed descriptions, pricing information, and availability, all aimed at enticing consumers to make a purchase. Additionally, features like quality and variety may also be included to help customers make informed buying decisions.

In the context of a B2C website, "fulfillment" refers to the process of completing and delivering orders to customers in a timely and satisfactory manner. Fulfillment encompasses various aspects of the post-purchase experience, including packaging, billing shipping cost delivery, and flexible return.

The aspect of "Privacy and security" in a B2C website pertains to measures taken to protect customers' personal information and ensure the security of their online transactions. This aspect is crucial for fostering trust and confidence among consumers, particularly when handling sensitive data such as payment details and personal identifiers.

Service quality encompasses various elements aimed at enhancing the overall customer experience and ensuring that customers receive high-quality service and support. The important elements are Customer service support, Order processing speed, Order status tracking, and Payment alternatives. The factors and sub-factors affecting the selection of B2C e-commerce websites are exhibited in Table (1) and Fig. (1).

**Table 1:** Factors and sub-factors affecting the selection of B2C e-commerce website

| Factor | Sub-factor | Definition | Source |
|---|---|---|---|
| Website design and usability (F1) | Website responsiveness (F11) | The ability of a website to adapt and display appropriately across various devices and screen sizes | Afzali (2022); Iqbal *et al*. (2020); Morsi (2023) |
| | Ease of navigation (F12) | How easily users can move around and find information on a website | Afzali (2022); Yu *et al*. (2011); Zhao (2011) |
| | Website layout (F13) | The arrangement and presentation of visual elements on a web page | Afzali (2022); Morsi (2023); Yu *et al.* (2011) |
| | Up-to-date information (F14) | Content, data, or resources that are current, accurate, and relevant to the website's audience. | Afzali (2022); Rekik (2021); Ziemba (2021) |
| | Multilingual (F15) | The website offers content in more than one language, allowing users from different linguistic backgrounds to access the information in a language they understand. | Rekik (2021) |
| Product (F2) | Price (F21) | The monetary value assigned to the product | Afzali (2022); Morsi (2023); Rekik (2021); Yu *et al*. (2011); Zhao (2011) |
| | Quality (F22) | The ability to meet or exceed customer expectations and satisfy their needs or requirements | Morsi (2023) |
| | Detail (F23) | The specific information, features, specifications, and attributes that describe its characteristics, functionalities, and benefits in depth | Rekik (2021); Zhao (2011) |
| | Availability (F24) | The accessibility and readiness for purchase by consumers | Morsi (2023) |
| | Variety (F25) | The range of different options, styles, variations, or versions available within a product category or product line | Morsi (2023); Yu *et al*. (2011) |
| Fulfillment (F3) | On-time delivery (F31) | The ability of a fulfillment center or logistics provider to successfully ship orders and have them arrive at their destination within the agreed-upon timeframe | Afzali (2022); Zhao (2011) |
| | Billing and shipping cost (F32) | The charges associated with processing orders, packaging products, and delivering them to customers | Afzali (2022) |
| | Packaging (F33) | The process of preparing products for shipment to customers | Afzali (2022) |
| | Flexible return (F34) | Policies and processes that allow customers to return purchased items with ease and convenience | Afzali (2022)<br>Afzali (2022) |
| Privacy and Security (F4) | Secure transactions (F41) | The protection of sensitive information exchanged between the user and the website during online transactions | Afzali (2022); Iqbal *et al*. (2020); Rekik (2021); Yu *et al*. (2011); Zhao (2011); Ziemba (2021) |
| | Legal compliance (F42) | Ensuring that the website and its operations adhere to relevant laws, regulations, and industry standards | Rekik (2021) |
| | Authentication and authorization (F43) | The aspects of website security that help control access to resources and protect sensitive information | Iqbal *et al*. (2020) |
| | Data collection and usage (F44) | The processes by which websites gather, store, and utilize information about users, visitors, and their interactions with the site | Rekik (2021) |
| | User participation (F45) | The involvement, engagement, and interaction of visitors or users with the content, features, and functionalities offered by the website. Providing users with options to manage their privacy preferences. Allowing users to opt out of certain data collection or marketing communications | Author |

| Factor | Sub-factor | Definition | Source |
|---|---|---|---|
| Service quality (F5) | Customer service support (F51) | The provision of assistance, guidance, and resolution of issues or inquiries encountered by users while interacting with the website or its products and services | Afzali (2022); Morsi (2023); Rekik (2021); Zhao (2011) |
| | Order processing speed (F52) | The time it takes for the website to process and fulfill customer orders is from the moment they are placed to the moment they are shipped or delivered to the customer. | Zhao (2011) |
| | Order status tracking (F53) | Order status tracking on an e-commerce website allows customers to monitor the progress of their orders from the moment they are placed until they are delivered. | Afzali (2022); Morsi (2023); Zhao (2011) |
| | Payment alternatives (F54) | Payment alternatives for an e-commerce website refer to the various methods that customers can use to make purchases and complete transactions online. | Iqbal *et al*. (2020); Morsi (2023); Zhao (2011) |

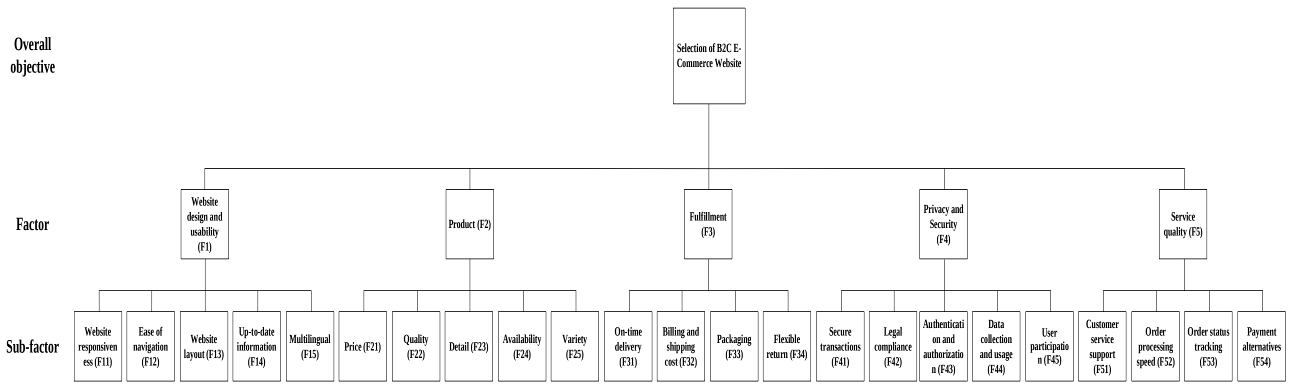


**Fig. 1:** The hierarchy of factors and sub-factors affecting the selection of a B2C e-commerce website

## Materials

The materials used in this study comprised a structured survey instrument and data from domain experts in the Vietnamese e-commerce industry. The study employed a questionnaire designed based on the Fuzzy Analytic Hierarchy Process (FAHP) framework, targeting five primary factors influencing B2C e-commerce website selection: Website Design and Usability, Product, Fulfillment, Privacy and Security, and Service Quality.

The questionnaire was distributed to 66 experts with over ten years of experience in various roles within the e-commerce sector, including Chief Information Officers (CIOs), database administrators, IT managers, help desk technicians, computer support specialists, and cybersecurity analysts. After filtering responses for consistency, data from 63 valid respondents were used for analysis.

The experts' feedback was essential for generating pairwise comparison matrices and assigning weights to 23 sub-factors grouped under the main factors. The survey adopted a linguistic scale (ranging from "equally important" to "absolutely important"), which was converted into triangular fuzzy numbers for computational purposes.

The materials ensured the study's robustness by drawing on expert insights, a clear hierarchical framework, and validated decision-making techniques, enabling precise identification and ranking of the factors influencing Vietnamese consumer preferences in B2C e-commerce.

## Methodology

### *Fuzzy Sets*

Fuzzy set theory, introduced by Zadeh (1975), was developed to address uncertainty arising from imprecision or vagueness (Zadeh, 1975). A fuzzy set $\tilde{A} = \{(x, \mu_{\tilde{A}}(x)) | x \in X\}$ consists of ordered pairs, where $X$ is a subset of the real numbers $R$ and $\mu_{\tilde{A}}(x)$ is the membership function. This function assigns a membership grade to each element $x$, ranging from 0-1. Since its inception, fuzzy set theory has been widely applied to address real-world problems requiring the analysis and interpretation of imprecise information by decision-makers. A special case of a convex normalized fuzzy set is referred to as a fuzzy number (Zimmermann, 1996). Depending on the context, various types of fuzzy numbers can be employed. To handle the inherent

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ambiguity in evaluating the performance of alternatives against specific criteria, triangular and trapezoidal fuzzy numbers are commonly utilized. A Triangular Fuzzy Number (TFN) represents a specific form of a trapezoidal fuzzy number where the two most likely values coincide. Due to its simplicity and computational efficiency, the TFN is a widely used membership function in numerous applications. It is frequently applied to model the uncertainty associated with decision-making criteria. n decision-making processes, TFNs use boundary values rather than precise numbers to reflect the fuzziness inherent in pairwise comparison matrices. A triangular fuzzy number, denoted as $\tilde{A} = (l, m, u)$, is defined by its membership function, which characterizes the degree of fuzziness within a given context:

$$\mu_{\tilde{A}}(x) = \begin{cases} (x-l)/(m-l); \ l \le x \le m \\ (u-x)/(u-m); \ m \le x \le u \\ 0; \ otherwise \end{cases} \quad (1)$$

A triangular fuzzy number $\tilde{A}$, as depicted in Fig. (2), is characterized by three parameters: $m$, $l$, and $u$. The parameter $m$ represents the most likely or central value, while $l$ and $u$ denote the minimum and maximum possible values, respectively, thereby defining the range of potential evaluations. When $l = m = u$, the triangular fuzzy number simplifies into a crisp, non-fuzzy value. The triplet $(l, m, u)$ effectively describes a fuzzy event.

For two triangular fuzzy numbers $\widetilde{A_1}$ and $\widetilde{A_2}$, where $\widetilde{A_1} = (l_1, m_1, u_1)$ and $\widetilde{A_2} = (l_2, m_2, u_2)$, their fundamental operational laws are defined by Gupta and Kaufmann (1985) These laws provide the framework for performing arithmetic operations on triangular fuzzy numbers.

Addition:

$$\widetilde{A_1} \oplus \widetilde{A_2} = (l_1 + l_2, m_1 + m_2, u_1 + u_2) \quad (2)$$

Multiplication:

$$\widetilde{A_1} \otimes \widetilde{A_2} = (l_1 . l_2, m_1 . m_2, u_1 . u_2) \ for \ l_i > 0, m_i > 0, u_i > 0, i = 1,2 \quad (3)$$

Division:

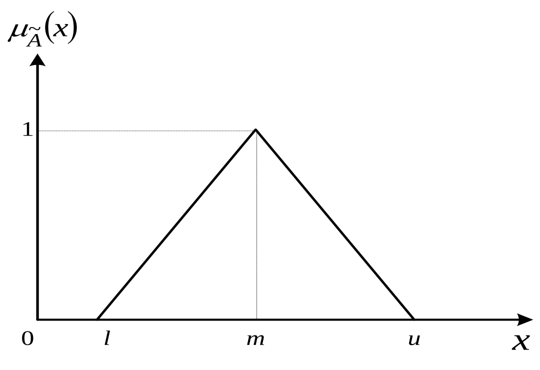


**Fig. 2:** A triangular fuzzy number, $\tilde{A} = (l, m, u)$

$$\frac{\widetilde{A_1}}{\widetilde{A_2}} = \left(\frac{l_1}{u_2}, \frac{m_1}{m_2}, \frac{u_1}{l_2}\right) \ for l_i > 0, m_i > 0, u_i > 0, i = 1,2 \quad (4)$$

Reciprocal:

$$\tilde{A}_1^{-1} \approx \left(\frac{1}{u_1}, \frac{1}{m_1}, \frac{1}{l_1}\right) \ for \ l_1 > 0, m_1 > 0, u_1 > 0 \quad (5)$$

### *Fuzzy AHP*

The fuzzy Analytic Hierarchy Process (AHP) methodology is proposed primarily due to its capability to address both quantitative and qualitative criteria effectively. Furthermore, it has been successfully applied and validated in numerous complex, real-world scenarios. Additionally, the methodology simplifies intricate problems by organizing them into a clear hierarchical structure, ensuring transparency in the decision-making process. Its straightforward approach and comprehensible hierarchical framework make it accessible at operational levels. Moreover, it facilitates group decision-making by enabling a better understanding of the complex interrelationships among the components of the problem. Lastly, the incorporation of fuzzy theory allows the method to manage uncertainty arising from unquantifiable, incomplete, or unobtainable information, as well as partial ignorance. The fuzzy AHP methodology consists of four key components: (1) Representing the relative importance in pairwise comparisons, (2) Aggregating fuzzy sets for group decision-making and weight determination, (3) Defuzzifying fuzzy sets into crisp values for final comparisons and (4) Assessing the consistency of judgments (Liu *et al*., 2020). A detailed explanation of the fuzzy AHP process is provided below.

A fuzzy pairwise comparison matrix is constructed as follows:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \vdots & \tilde{a}_{2n} \\ \vdots & \cdots & \cdots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} \quad (6)$$

Here, $\tilde{a}_{ij} = \left(l_{ij}, m_{ij}, \ and \ u_{ij}\right)$ represent the fuzzy comparison value of criterion $i$ relative to criterion $j$.

The fuzzy weights for each criterion are calculated using the following formula:

$$\tilde{r}_i = (\widetilde{a_{i1}} \otimes \widetilde{a_{i2}} \otimes \ldots \otimes \widetilde{a_{in}})^{1/n} \ for \ i = 1,2, \ldots, n \quad (7)$$

$$\widetilde{w_i} = \frac{\tilde{r}_i}{\tilde{r}_1 \oplus \tilde{r}_2 \ldots \oplus \widetilde{r_n}} \ for \ i = 1,2, \ldots, n \quad (8)$$

In these equations, $\tilde{r}_i$ represents the geometric mean of the fuzzy comparison values for criterion I relative to all other criteria, while $\widetilde{w}_i$ is the fuzzy weight of the $i^{th}$ criterion.

The fuzzy weight vector is expressed as:

$$\widetilde{W} = (\widetilde{w}_1, \widetilde{w}_2, \ldots, \widetilde{w}_n)^T \quad (9)$$

The proposed framework, based on the fuzzy AHP methodology, is designed to rank the factors influencing the selection of B2C e-commerce websites and comprises the following steps.

*Step 1: Development of a Hierarchical Structure*

The hierarchical structure is constructed based on the identified factors and sub-factors. The top level represents the overall goal, while subsequent levels encompass the factors and sub-factors. During this stage, the problem is decomposed into components according to their shared characteristics. As noted by Miller (1956), decision-makers generally cannot effectively process more than seven to nine elements simultaneously when making decisions.

*Step 2: Formation of a Decision-Making Group*

A panel of decision-makers is formed, consisting of experts with substantial knowledge and experience related to the research problem. These decision-makers are tasked with determining the relative importance or weights of each factor and sub-factor within the hierarchical structure.

*Step 3: Identification of Linguistic Variables and Fuzzy Conversion Scales*

The decision-makers conduct pairwise comparisons of factors to evaluate their relative importance or preference. These comparisons are expressed as linguistic variables through questionnaires. A linguistic variable is defined as a variable whose values are words or phrases from natural or artificial language (Zadeh, 1975). For this study, linguistic terms such as "equally important," "weakly important," "fairly important," "strongly important," and "absolutely important" are used to capture subjective pairwise comparisons. These linguistic values are subsequently converted into fuzzy numbers using triangular fuzzy conversion scales, following the methodology proposed by Kahraman *et al*. (2006), as illustrated in Fig. (3) and Table (2).

*Step 4: Constructing Comparison Matrices*

For a single-level problem with $n$ factors, the relative weights of factors $i$ and $j$ are represented as triangular fuzzy numbers $\widetilde{a_{ij}} = (l_{ij}, m_{ij}, u_{ij})$. For instance, if a decision-maker considers factor $i$ significantly more important than factor $j$, they may assign $a_{ij} = (1,3,5)$. Conversely, if factor $j$ is considered strongly more important than $i$, the pairwise comparison might be represented as $a_{ij} = (1/5,1/3,1)$. Following the principles of traditional AHP, a fuzzy comparison matrix $\tilde{A} = \{\widetilde{a_{ij}}\}$ is constructed as:

$$\tilde{A} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ \tilde{a}_{21} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ \tilde{a}_{n1} & \tilde{a}_{n2} & \cdots & 1 \end{bmatrix} = \begin{bmatrix} 1 & \tilde{a}_{12} & \cdots & \tilde{a}_{1n} \\ 1/\tilde{a}_{12} & 1 & \cdots & \tilde{a}_{2n} \\ \vdots & \vdots & \vdots & \vdots \\ 1/\tilde{a}_{1n} & 1/\tilde{a}_{2n} & \cdots & 1 \end{bmatrix} \quad (10)$$

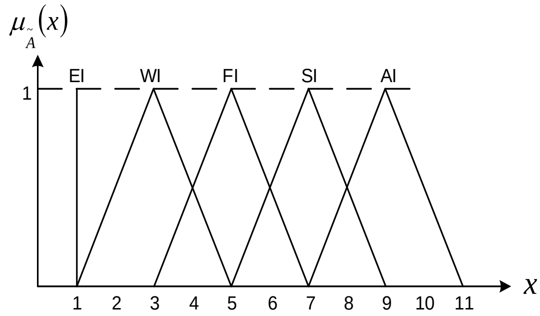


**Fig. 3:** Linguistic scale for relative importance

**Table 2:** Linguistic scales and fuzzy scales for importance

| Linguistic scale for importance | Triangular fuzzy scale | Triangular fuzzy reciprocal scale |
|---|---|---|
| Equally Important (EI) | (1, 1, 1) | (1,1,1) |
| Weakly Important (WI) | (1, 3, 5) | (1/5, 1/3, 1) |
| Fairly Important (FI) | (3, 5, 7) | (1/7, 1/5, 1/3) |
| Strongly Important (SI) | (5, 7, 9) | (1/9, 1/7, 1/5) |
| Absolutely Important (AI) | (7, 9, 11) | (1/11,1/9, 1/7) |

*Step 5: Evaluating the Consistency Index and Consistency Ratio*

To ensure decision quality, it is essential to assess the consistency of evaluations. Saaty (1980) introduced the Consistency Index (CI) as a measure for evaluating the consistency of pairwise comparison matrices. For fuzzy comparison matrices, defuzzification is required to transform fuzzy numbers into crisp values (Huang *et al*., 2008). Among various defuzzification methods, this study adopts the approach proposed by Lee and Li (1988), which effectively represents decision-makers perceptions of fuzziness.

To defuzzify a triangular fuzzy number $\widetilde{a_{ij}} = (l_{ij}, m_{ij}, u_{ij})$ into a crisp value, the following formula is applied:

$$\left(a_{ij}^{\alpha}\right)^{\lambda} = \left[\lambda . l_{ij}^{\alpha} + (1-\lambda) . u_{ij}^{\alpha}\right], 0 \le \lambda \le 1, 0 \le \alpha \le 1 \quad (11)$$

where, $l_{ij}^{\alpha} = (m_{ij} - l_{ij}).\alpha + l_{ij}$ is the left-end value of the $\alpha$-cut for $\widetilde{a_{ij}}$ and $u_{ij}^{\alpha} = u_{ij} - (u_{ij} - m_{ij}).\alpha$ is the right-end value for the $\alpha$-cut operation.

The parameters α and λ capture environmental stability and decision-maker optimism, respectively. Higher α values indicate more stable decision environments, with $\alpha = 0$ representing maximum uncertainty. For λ, a value of 0 indicates an optimistic decision-maker, while 1 denotes a pessimistic one. The defuzzified comparison matrix is expressed as:

$$\lfloor (A^{\alpha})^{\lambda} \rfloor = \lfloor (a_{ij})^{\lambda} \rfloor = \begin{bmatrix} 1 & (a_{12}^{\alpha})^{\lambda} & \cdots & (a_{1n}^{\alpha})^{\lambda} \\ (a_{21}^{\alpha})^{\lambda} & 1 & \cdots & (a_{2n}^{\alpha})^{\lambda} \\ \vdots & \vdots & \vdots & \vdots \\ (a_{n1}^{\alpha})^{\lambda} & (a_{n2}^{\alpha})^{\lambda} & \cdots & 1 \end{bmatrix} \quad (12)$$

**Table 3:** Random Index (RI) of random matrices

| $n$ | 3 | 4 | 5 | 6 | 7 | 8 | 9 |
|---|---|---|---|---|---|---|---|
| *RI(n)* | 0.58 | 0.9 | 1.12 | 1.24 | 1.32 | 1.41 | 1.45 |

The Consistency Index (CI) of the matrix is calculated as:

$$CI = \frac{\lambda_{max} - n}{n-1} \quad (13)$$

where, $\lambda_{max}$ is the largest eigenvalue of the comparison matrix and $n$ is its dimension.

The Consistency Ratio (CR), as defined by Davies (1994), is the ratio of the matrix's CI to the CI of a random matrix:

$$CR = \frac{CI}{RI(n)} \quad (14)$$

where, $RI(n)$ is the random index corresponding to the matrix size $n$, as shown in Table (3).

A comparison matrix is considered acceptable if its Consistency Ratio (CR) is less than or equal to 0.1. If the CR exceeds this threshold, it is recommended that the decision-maker revisit and refine the pairwise comparisons to improve consistency.

### *Step 6: Constructing the Representative Matrix for Group Decision-Making*

To achieve consensus among decision-makers, it is necessary to aggregate individual judgments, as each judgment matrix reflects the perspective of a single decision-maker. Traditional AHP employs two primary methods for synthesizing individual preferences into a collective group preference: The Aggregation of Individual Judgments (AIJ) and the Aggregation of Individual Priorities (AIP) (Forman and Peniwati, 1998). These approaches can also be adapted for use in Fuzzy AHP (FAHP).

In the AIJ method, the group judgment matrix is derived by combining individual judgment matrices, resulting in a consolidated group matrix. This approach conceptualizes the group as a "new individual," whose preferences are represented as a unified judgment matrix. Conversely, the AIP method involves each group member independently deriving individual priorities from their respective judgment matrices. The group priorities are subsequently calculated by aggregating these individual priorities.

The choice between AIJ and AIP depends on the complexity of the required fuzzy arithmetic operations. In this study, the AIJ method is employed to aggregate group decisions, as it effectively consolidates individual perspectives into a single representative group judgment matrix.

Consider a group of $K$ decision-makers involved in the study, who are tasked with performing pairwise comparisons of nnn criteria. From these comparisons, a set of $K$ matrices $\tilde{A}_k = \{\tilde{a}_{ijk}\}$ is generated, where $\tilde{a}_{ijk} = (l_{ijk}, m_{ijk}, u_{ijk})$ represents the relative importance of criterion $i$ in comparison to criterion $j$, as evaluated by expert $k$. The triangular fuzzy numbers in the group judgment matrix can be determined using the following equation, as proposed by Büyüközkan and Feyzioğlu (2004):

$$l_{ij} = \min_{k=1,2,\ldots,K} (l_{ijk})$$

$$m_{ij} = \sqrt[K]{\prod_{k=1}^{K} m_{ijk}} \quad (15)$$

$$u_{ij} = \max_{k=1,2,\ldots,K} (u_{ijk})$$

### *Step 7: Determining the Weights of Criteria and Sub-Criteria*

The weights of the factors and sub-factors are subsequently calculated through the application of the extended FAHP method. This approach allows for a more comprehensive analysis, incorporating fuzzy logic to derive the relative importance of each criterion and sub-criterion.

### *Data Collection*

To collect data, a team of 66 key domain experts was formed for the decision-making panel, which includes seven Chief Information Officers (CIOs), 12 database administrators, seven IT Managers, 27 help desk technicians, nine computer support specialists, and four cyber security analysts who work in the e-commerce sector in Vietnam and have more than ten years of expertise in the field. The finalized list of 23 sub-factors affecting the selection of B2C e-commerce websites has been grouped into five key groups based on the research framework after several phases of discussion with experts. These are Website design and usability, Product, Fulfillment, Privacy and Security, and Service quality. Finally, the factors and sub-factors are completely depicted and introduced in Table (1).

The questionnaire instrument was designed using the primary attributes of the FAHP method's factor comparison and a scale of 1-5 for each comparison between factors. In March 2024, the questionnaire was distributed to experts who were involved in the previous step of factor investigation and had roles and responsibilities that might provide a holistic view of the Website design and usability, Product, Fulfillment, Privacy, and Security and Service quality factors during the study. After the experts' comparison matrices of factors and sub-factors are formed, then the Consistency Ratios (CRs) are calculated using Eqs. (13-14). Three questionnaires had inappropriate answers among the returned responses. As a result, their feedback was removed from the analysis. Sixty-three respondents have CR values that are all less than 0.1. As a result, the outcomes of this study are based on the viewpoints of 63 experts.

## Results and Discussion

The FAHP method is used to determine the ranking of the influence of factors and sub-factors affecting the selection of B2C e-commerce websites. The calculation is done according to the hierarchy that has been formed in the theoretical framework which consists of website design and usability, product, fulfillment, privacy and security, and service quality criteria. After receiving and accepting the questionnaire results, calculations are performed using Eq. (15) to form the group judgment matrix for each website design and usability, product, fulfillment, privacy and security and service quality factor and sub-factor; then the consistency ratio of each pairwise comparison matrix is calculated; then calculate the weight of each factor and sub-factor to determine the local ranking and global ranking. To calculate the global weight of sub-factors and global rank, multiply the weight of each factor by the weight of the sub-factor. The results of consensus pairwise comparison matrices, global weights, and ranks are found in Tables (4-16). Figure (4) shows the rank of sub-factors influencing the selection of a B2C e-commerce website.

Taking the matrix in Table (4) as an example, we can utilize Eq. (7) to obtain the following:

$$\tilde{r}_1 = \left(\begin{matrix}(1,1,1)\otimes(1,1.71,7)\otimes(1,1.913,9)\otimes(0.2,0.433,1)\\ \otimes(0.111,0.831,9)\end{matrix}\right)^{1/5} = (0.467,1.033,3.554)$$

$$\tilde{r}_2 = \left(\begin{matrix}(0.143,0.585,1)\otimes(1,1,1)\otimes(1,1.191,5)\otimes(0.2,1.11,5)\\ \otimes(1,2.31,5)\end{matrix}\right)^{1/5} = (0.491,1.123,2.627)$$

$$\tilde{r}_3 = \left(\begin{matrix}((0.111,0.523,1)\otimes(0.2,0.84,1)\otimes(1,1,1)\otimes(0.2,1.567,7)\\ \otimes(1,3.408,7)\end{matrix}\right)^{1/5} = (0.339,1.186,2.178)$$

$$\tilde{r}_4 = \left(\begin{matrix}(1,2.31,5)\otimes(0.2,0.901,5)\otimes(0.143,0.638,5)\otimes(1,1,1)\\ \otimes(1,4.404,9)\end{matrix}\right)^{1/5} = (0.491,1.424,4.076)$$

$$\tilde{r}_5 = \left(\begin{matrix}(0.111,1.204,9)\otimes(0.2,0.433,1)\otimes(0.143,0.293,1)\\ \otimes(0.111,0.227,1)\otimes(1,1,1)\end{matrix}\right)^{1/5} = (0.204,0.511,1.552)$$

$$\tilde{r}_1\oplus\tilde{r}_2\oplus\tilde{r}_3\oplus\tilde{r}_4\oplus\tilde{r}_5 = (1.992,5.276,13.986)$$

Applying Eq. (8), we obtain the following:

$$\tilde{w}_1 = \frac{\tilde{r}_1}{\tilde{r}_1\oplus\tilde{r}_2\oplus\tilde{r}_3\oplus\tilde{r}_4\oplus\tilde{r}_5} = \frac{(0.467,1.033,3.554)}{(1.992,5.276,13.986)} = (0.033,0.196,1.784)$$

$$\tilde{w}_2 = \frac{\tilde{r}_2}{\tilde{r}_1\oplus\tilde{r}_2\oplus\tilde{r}_3\oplus\tilde{r}_4\oplus\tilde{r}_5} = \frac{(0.491,1.123,2.627)}{(1.992,5.276,13.986)} = (0.035,0.213,1.319)$$

$$\tilde{w}_3 = \frac{\tilde{r}_3}{\tilde{r}_1\oplus\tilde{r}_2\oplus\tilde{r}_3\oplus\tilde{r}_4\oplus\tilde{r}_5} = \frac{(0.339,1.186,2.178)}{(1.992,5.276,13.986)} = (0.024,0.225,1.093)$$

$$\tilde{w}_4 = \frac{\tilde{r}_4}{\tilde{r}_1\oplus\tilde{r}_2\oplus\tilde{r}_3\oplus\tilde{r}_4\oplus\tilde{r}_5} = \frac{(0.491,1.424,4.076)}{(1.992,5.276,13.986)} = (0.035,0.270,2.046)$$

$$\tilde{w}_5 = \frac{\tilde{r}_5}{\tilde{r}_1\oplus\tilde{r}_2\oplus\tilde{r}_3\oplus\tilde{r}_4\oplus\tilde{r}_5} = \frac{(0.204,0.511,1.552)}{(1.992,5.276,13.986)} = (0.015,0.097,0.779)$$

Using Eq. (9), the fuzzy weights of the factors are obtained as shown in Table (5). Note that the addition, multiplication, division, and reciprocal for the above calculations are conducted as specified in Eqs. (2-5).

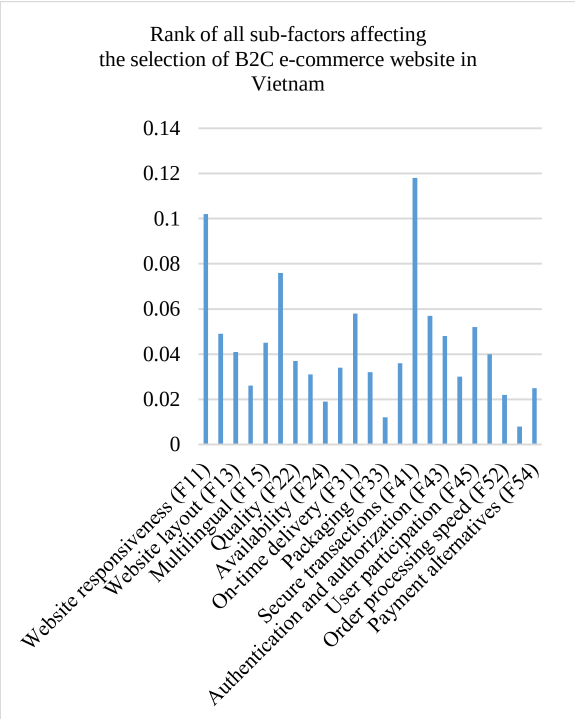


**Fig. 4:** Rank of sub-factors affecting the selection of B2C e-commerce website

**Table 4:** Aggregate comparison matrix of factor

| | F1 | F2 | F3 | F4 | F5 |
|---|---|---|---|---|---|
| F1 | (1,1,1) | (1,1.71,7) | (1,1.913,9) | (0.2,0.433,1) | (0.111,0.831,9) |
| F2 | (0.143,0.585,1) | (1,1,1) | (1,1.191,5) | (0.2,1.11,5) | (1,2.31,5) |
| F3 | (0.111,0.523,1) | (0.2,0.84,1) | (1,1,1) | (0.2,1.567,7) | (1,3.408,7) |
| F4 | (1,2.31,5) | (0.2,0.901,5) | (0.143,0.638,5) | (1,1,1) | (1,4.404,9) |
| F5 | (0.111,1.204,9) | (0.2,0.433,1) | (0.143,0.293,1) | (0.111,0.227,1) | (1,1,1) |

Similarly, the weights in Tables (7, 9, 11, 13 and 15) are calculated from the corresponding matrices in Tables (6, 8, 10, 12 and 14), respectively. Using Eq. (11), the crisp values in Table (16) are obtained by defuzzifying the corresponding equivalent fuzzy values.

As shown in Table (16), privacy and security (F4) is the highest-ranked success factor, followed by website design and usability (F1) in second place, product (F2) in third place, and fulfillment (F3) in fourth place.

Table (16) and Fig. (4), the secure transactions (F41) sub-factor became the greatest weight (0.118) in the selection of a B2C e-commerce website. Secure transactions are fundamental to the success of e-commerce websites, as they protect both customers and businesses from various security threats and risks associated with online transactions. Implementing robust security measures not only ensures compliance with regulations but also enhances trust, credibility, and customer satisfaction.

**Table 5:** Fuzzy weights of factor

| Sub-factor | Fuzzy weights |
|---|---|
| F1 | (0.033,0.196,1.784) |
| F2 | (0.035,0.213,1.319) |
| F3 | (0.024,0.225,1.093) |
| F4 | (0.035,0.27,2.046) |
| F5 | (0.015,0.097,0.779) |

**Table 6:** Aggregate comparison matrix of sub-factors within website design and usability (F1)

| | F11 | F12 | F13 | F14 | F15 |
|---|---|---|---|---|---|
| F11 | (1,1,1) | (1,1.894,7) | (1,2.164,9) | (1,4.426,9) | (0.111,0.912,9) |
| F12 | (0.143,0.528,1) | (1,1,1) | (1,1.191,5) | (0.2,1.054,5) | (1,2.52,5) |
| F13 | (0.111,0.462,1) | (0.2,0.84,1) | (1,1,1) | (1,2.911,7) | (1,3.873,7) |
| F14 | (0.111,0.226,1) | (0.2,0.949,5) | (0.143,0.344,1) | (1,1,1) | (0.111,0.245,1) |
| F15 | (0.111,1.097,9) | (0.2,0.397,1) | (0.143,0.258,1) | (1,4.085,9) | (1,1,1) |

**Table 7:** Fuzzy weights of sub-factor within website design and usability (F1)

| Sub-factor | Fuzzy weights |
|---|---|
| F11 | (0.046,0.318,2.598) |
| F12 | (0.035,0.201,1.237) |
| F13 | (0.033,0.244,1.026) |
| F14 | (0.014,0.081,0.65) |
| F15 | (0.022,0.155,1.134) |

**Table 8:** Aggregate comparison matrix of sub-factor within Product (F2)

| | F21 | F22 | F23 | F24 | F25 |
|---|---|---|---|---|---|
| F21 | (1,1,1) | (1,1.71,7) | (1,1.913,9) | (1,4.332,9) | (0.111,0.712,9) |
| F22 | (0.143,0.585,1) | (1,1,1) | (1,1.277,5) | (0.2,1.211,5) | (1,2.52,5) |
| F23 | (0.111,0.523,1) | (0.2,0.783,1) | (1,1,1) | (1,2.818,7) | (1,3.873,7) |
| F24 | (0.111,0.231,1) | (0.2,0.825,5) | (0.143,0.355,1) | (1,1,1) | (0.111,0.24,1) |
| F25 | (0.111,1.405,9) | (0.2,0.397,1) | (0.143,0.258,1) | (1,4.173,9) | (1,1,1) |

**Table 9:** Fuzzy weights of sub-factor within product (F2)

| Sub-factor | Fuzzy weights |
|---|---|
| F21 | (0.046,0.291,2.598) |
| F22 | (0.035,0.216,1.237) |
| F23 | (0.033,0.247,1.026) |
| F24 | (0.014,0.08,0.65) |
| F25 | (0.022,0.165,1.134) |

**Table 10:** Aggregate comparison matrix of sub-factor within Fulfillment (F3)

| | F31 | F32 | F33 | F34 |
|---|---|---|---|---|
| F31 | (1,1,1) | (1,3.642,11) | (1,4.984,11) | (0.091,0.862,5) |
| F32 | (1,0.275,1) | (1,1,1) | (1,2.64,7) | (1,3.497,7) |
| F33 | (0.091,0.201,1) | (0.143,0.379,1) | (1,1,1) | (0.111,0.457,1) |
| F34 | (0.2,1.159,11) | (0.143,0.286,1) | (1,2.19,9) | (1,1,1) |

**Table 11:** Fuzzy weights of sub-factor within fulfillment (F3)

| Sub-factor | Fuzzy weights |
|---|---|
| F31 | (0.047,0.432,2.301) |
| F32 | (0.085,0.274,1.228) |
| F33 | (0.017,0.094,0.464) |
| F34 | (0.035,0.2,1.464) |

**Table 12:** Aggregate comparison matrix within Privacy and security (F4)

| | F41 | F42 | F43 | F44 | F45 |
|---|---|---|---|---|---|
| F41 | (1,1,1) | (1,1.71,7) | (1,1.913,9) | (1,4.332,9) | (0.111,0.712,9) |
| F42 | (0.143,0.585,1) | (1,1,1) | (1,1.277,5) | (0.2,1.211,5) | (1,2.52,5) |
| F43 | (0.111,0.523,1) | (0.2,0.783,1) | (1,1,1) | (1,2.818,7) | (1,3.873,7) |
| F44 | (0.111,0.231,1) | (0.2,0.825,5) | (0.143,0.355,1) | (1,1,1) | (0.111,0.24,1) |
| F45 | (0.111,1.405,9) | (0.2,0.397,1) | (0.143,0.258,1) | (1,4.173,9) | (1,1,1) |

**Table 13:** Fuzzy weights of sub-factor within Privacy and security (F4)

| Sub-factor | Fuzzy weights |
|---|---|
| F41 | (0.046,0.291,2.598) |
| F42 | (0.035,0.216,1.237) |
| F43 | (0.033,0.247,1.026) |
| F44 | (0.014,0.08,0.65) |
| F45 | (0.022,0.165,1.134) |

**Table 14:** Aggregate comparison matrix of sub-factor within service quality (F5)

| | F51 | F52 | F53 | F54 |
|---|---|---|---|---|
| F51 | (1,1,1) | (1,3.642,11) | (1,4.984,11) | (0.091,0.862,5) |
| F52 | (1,0.275,1) | (1,1,1) | (1,2.64,7) | (1,3.497,7) |
| F53 | (0.091,0.201,1) | (0.143,0.379,1) | (1,1,1) | (0.111,0.457,1) |
| F54 | (0.2,1.159,11) | (0.143,0.286,1) | (1,2.19,9) | (1,1,1) |

**Table 15:** Fuzzy weights of sub-factor within service quality (F5)

| Sub-factor | Fuzzy weights |
|---|---|
| F51 | (0.047,0.432,2.301) |
| F52 | (0.085,0.274,1.228) |
| F53 | (0.017,0.094,0.464) |
| F54 | (0.035,0.2,1.464) |

**Table 16:** Global weight and rank of factors and sub-factors

| Factor/Sub-factor | Factor/sub-factor weight in relation to the factor weight | Sub-factor global weight | Normalized sub-factor global weight (crisp value) | Rank |
|---|---|---|---|---|
| Website design and usability (F1) | (0.033,0.196,1.784) | | 0.241 | 2 |
| Website responsiveness (F11) | (0.046,0.318,2.598) | (0.002,0.062,4.636) | 0.102 | 2 |
| Ease of navigation (F12) | (0.035,0.201,1.237) | (0.001,0.039,2.208) | 0.049 | 7 |
| Website layout (F13) | (0.033,0.244,1.026) | (0.001,0.048,1.831) | 0.041 | 10 |
| Up-to-date information (F14) | (0.014,0.081,0.65) | (0,0.016,1.16) | 0.026 | 18 |
| Multilingual (F15) | (0.022,0.155,1.134) | (0.001,0.03,2.024) | 0.045 | 9 |
| Product (F2) | (0.035,0.213,1.319) | | 0.194 | 3 |
| Price (F21) | (0.046,0.291,2.598) | (0.002,0.062,3.426) | 0.076 | 3 |
| Quality (F22) | (0.035,0.216,1.237) | (0.001,0.046,1.632) | 0.037 | 12 |
| Detail (F23) | (0.033,0.247,1.026) | (0.001,0.053,1.353) | 0.031 | 16 |
| Availability (F24) | (0.014,0.08,0.65) | (0.001,0.017,0.857) | 0.019 | 21 |
| Variety (F25) | (0.022,0.165,1.134) | (0.001,0.035,1.496) | 0.034 | 14 |
| Fulfillment (F3) | (0.024,0.225,1.093) | | 0.171 | 4 |
| On-time delivery (F31) | (0.047,0.432,2.301) | (0.001,0.097,2.516) | 0.058 | 4 |
| Billing and shipping cost (F32) | (0.085,0.274,1.228) | (0.002,0.062,1.342) | 0.032 | 15 |
| Packaging (F33) | (0.017,0.094,0.464) | (0,0.021,0.507) | 0.012 | 22 |
| Flexible return (F34) | (0.035,0.2,1.464) | (0.001,0.045,1.6) | 0.036 | 13 |
| Privacy and Security (F4) | (0.035,0.27,2.046) | | 0.286 | 1 |
| Secure transactions (F41) | (0.046,0.291,2.598) | (0.002,0.078,5.316) | 0.118 | 1 |
| Legal compliance (F42) | (0.035,0.216,1.237) | (0.001,0.058,2.532) | 0.057 | 5 |
| Authentication and authorization (F43) | (0.033,0.247,1.026) | (0.001,0.067,2.099) | 0.048 | 8 |
| Data collection and usage (F44) | (0.014,0.08,0.65) | (0.001,0.022,1.33) | 0.03 | 17 |
| User participation (F45) | (0.022,0.165,1.134) | (0.001,0.045,2.321) | 0.052 | 6 |
| Service quality (F5) | (0.015,0.097,0.779) | | 0.108 | 5 |
| Customer service support (F51) | (0.047,0.432,2.301) | (0.001,0.042,1.793) | 0.04 | 11 |
| Order processing speed (F52) | (0.085,0.274,1.228) | (0.001,0.027,0.957) | 0.022 | 20 |

| Factor/Sub-factor | Factor/sub-factor weight in relation to the factor weight | Sub-factor global weight | Normalized sub-factor global weight (crisp value) | Rank |
|---|---|---|---|---|
| Order status tracking (F53) | (0.017,0.094,0.464) | (0,0.009,0.362) | 0.008 | 23 |
| Payment alternatives (F54) | (0.035,0.2,1.464) | (0.001,0.019,1.14) | 0.025 | 19 |

Website responsiveness (F11) stands second in the sub-factors affecting the selection of B2C e-commerce websites. Website responsiveness is essential for e-commerce websites to deliver an optimal user experience, improve search engine visibility, drive conversions, and maintain a competitive edge in the digital marketplace. Investing in responsive design not only benefits your business in the short term but also sets the foundation for long-term success and growth.

Price (F21) holds the third position among the factors influencing the selection of a B2C e-commerce website. Price is a critical factor in influencing consumers' decisions when selecting a B2C e-commerce website. Consumers often compare prices across different e-commerce websites to ensure they are getting the best deal. Websites that offer competitive prices are more likely to attract and retain customers. Moreover, the mentioned factors are not the only ones to consider, as other elements such as on-time delivery, legal compliance, and user participation also play significant roles.

Some suggested solutions to enhance the quality of B2C e-commerce websites are as follows. To ensure secure transactions on your B2C e-commerce website, it is imperative to implement several measures. Firstly, utilize Secure Sockets Layer (SSL) encryption to safeguard data transmission between users' browsers and your server, particularly during the checkout process. Secondly, maintain Payment Card Industry Data Security Standard (PCI DSS) compliance to protect cardholder information effectively. Thirdly, integrate trusted payment gateways such as PayPal, Stripe, or Authorize.Net to process transactions securely. Additionally, offers two-factor authentication options to enhance user account security. Lastly, conduct regular security audits and vulnerability assessments to proactively identify and address potential security risks. By implementing these practices, you can ensure a robust and secure transaction environment for your customers.

To enhance website responsiveness, several strategies can be employed. Firstly, prioritize mobile optimization to ensure seamless browsing across various devices like smartphones and tablets. Secondly, optimize loading times by compressing images, leveraging browser caching, and minimizing HTTP requests to improve user experience and reduce bounce rates. Thirdly, streamline navigation with clear menus, categories, and search functionality to facilitate quick and easy product discovery for users. Additionally, maintain a clutter-free design focusing on essential elements like product images, descriptions, and calls to action to minimize distractions and guide users towards making purchases. Lastly, utilize A/B testing to experiment with different layouts, designs, and features to identify the most effective strategies for improving website responsiveness and resonating with the target audience.

In managing price, adopt various strategies to optimize competitiveness and appeal to customers. Begin with a competitive pricing approach, conducting thorough market research to align prices with industry standards, ensuring competitiveness. Employ dynamic pricing algorithms to adjust prices dynamically, considering factors like demand, competitor pricing, and inventory levels. Implement regular special offers, discounts, and loyalty programs to entice purchases and attract price-sensitive consumers. Emphasize price transparency by clearly displaying product prices, inclusive of taxes, shipping fees, and discounts, fostering trust and transparency with customers. Additionally, offer a price matching policy to guarantee customers the best deal, assuring them of competitive pricing even if they discover lower prices elsewhere.

While our study identifies "secure transactions" and "Website responsiveness" as the most critical factors for Vietnamese B2C e-commerce customers, a nuanced understanding necessitates comparison with prior research. Integrating findings from studies in similar contexts, particularly those within Southeast Asia, could reveal regional variations in customer priorities. Additionally, a deeper analysis of the relationships between these factors can illuminate their combined influence on website selection. For instance, exploring how "Secure transactions" interact with factors like "Product variety" or "Fulfillment speed" could provide actionable insights for B2C e-commerce businesses in Vietnam.

## Conclusion

In conclusion, this study employed a Fuzzy Analytic Hierarchy Process (FAHP) to identify and prioritize factors influencing Vietnamese B2C e-commerce website selection. By leveraging a comprehensive literature review and expert panel insights, we identified five key factors encompassing 23 sub-factors. The FAHP analysis revealed "Privacy and Security," particularly "Secure transactions," as the most critical factor, followed by

"Website design and usability" with an emphasis on "Website responsiveness."

These findings offer valuable practical implications for Vietnamese B2C e-commerce businesses. Prioritizing secure transaction systems fosters trust and reduces customer abandonment. Additionally, optimizing website responsiveness across devices enhances user experience and potentially increases conversion rates. By strategically allocating resources toward these high-impact factors, e-commerce businesses can gain a competitive edge in the Vietnamese market.

Future research directions can expand on this study in several ways. Firstly, replicating the study with a broader geographically diverse sample could reveal regional variations in customer priorities within Vietnam. Secondly, investigating the potential interdependence between factors, such as how "Secure transactions" interact with "Product variety" or "Fulfillment speed," could provide deeper insights into holistic website optimization strategies. Finally, exploring alternative decision-making methodologies that relax the assumption of factor independence could further refine the model's applicability in real-world scenarios.

This research contributes to the growing body of knowledge on B2C e-commerce website selection, particularly within the under-researched Vietnamese context. By providing actionable insights for practitioners and highlighting avenues for future research, this study aims to empower the continued development and success of Vietnam's B2C e-commerce landscape.

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## Author’s Contributions

**Quang Hung Do:** Participated in all the experiments, including data collected and analysis.

**Duong Quang Khanh:** Written, reviewed, and edited.

**Nguyen Thai Son:** Participated in data curation, investigation, and validation.

## Ethics

The content presented here is the author's original research and has not been published elsewhere.

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