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Shaping Virtual Retail: Identifying Key Influences in Metaverse Shopping with Fuzzy DEMATEL

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***Abstract*—The Metaverse is significantly transforming e-commerce by providing immersive and interactive virtual shopping environments. This study explores the qualitative aspects and user interactions that shape customer experiences on Metaverse platforms. The research uses the Fuzzy DEMATEL (FDEMATEL) technique to identify and prioritize 11 key factors influencing digital shopping experiences, derived from literature and expert opinions. The FDEMATEL approach effectively examines causal relationships among these factors, reducing the bias associated with imprecise human judgments. The study reveals that flow, immersion, and ease of use are prominent factors, while informativeness, media richness, and risk are critical cause factors for successful retail platforms. These findings offer valuable insights for managers and platform developers to enhance Metaverse shopping experiences. The study uniquely identifies and analyzes the causal relationships of critical success factors, providing a comprehensive understanding that can drive the success of Metaverse retail environments.**

***Keywords*—Metaverse Shopping, MCDM, Fuzzy DEMATEL, Retail platform**

I. INTRODUCTION

The metaverse represents a significant leap in the digital revolution and offers a persistent, immersive, and interactive future version of the Internet [1-3]. Metaverse platforms like Roblox Sandbox, decentraland, Zepeto, and Upland provide users with rich, engaging experiences that mirror real-world interactions and activities, seamlessly blending the virtual and physical realms. [4-6]. Among its most promising applications, Metaverse shopping is revolutionizing e-commerce, allowing consumers to purchase products for both their virtual avatars and real-world use, thereby offering a highly engaging and immersive retail experience [7-9].

This transformation has driven substantial market growth. By 2030, the Metaverse economy is projected to reach $936.57 billion, with the global Metaverse e-commerce market expected to expand by 37.91% to $210.3 billion [10, 11]. Major technology companies such as Meta, Microsoft, and Google, as well as various brands, from fashion giants such as Adidas, Gucci, Hermes, Nike, and Vans to other industry leaders such as Hyundai, Samsung, and Sunsilk, are actively investing in metaverse commerce, launching virtual storefronts and digital assets and digital assets to enhance customer engagement [12-14]. For instance, Vans, and Adidas launched their virtual retail space where users can explore and purchase digital fashion items (Figures I and II).

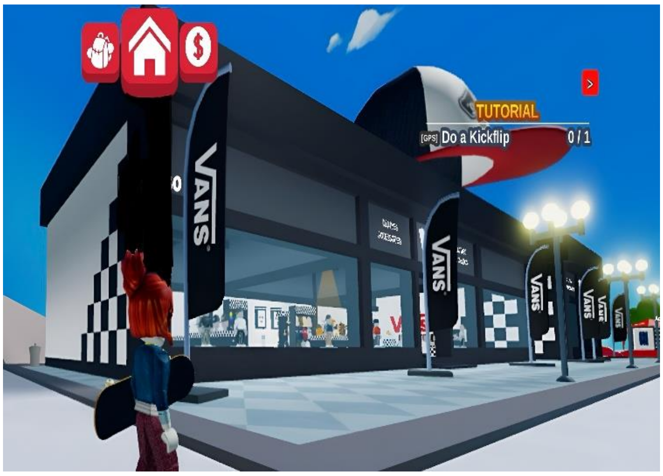

FIGURE I. VANS STORE IN THE METAVERSE [19]

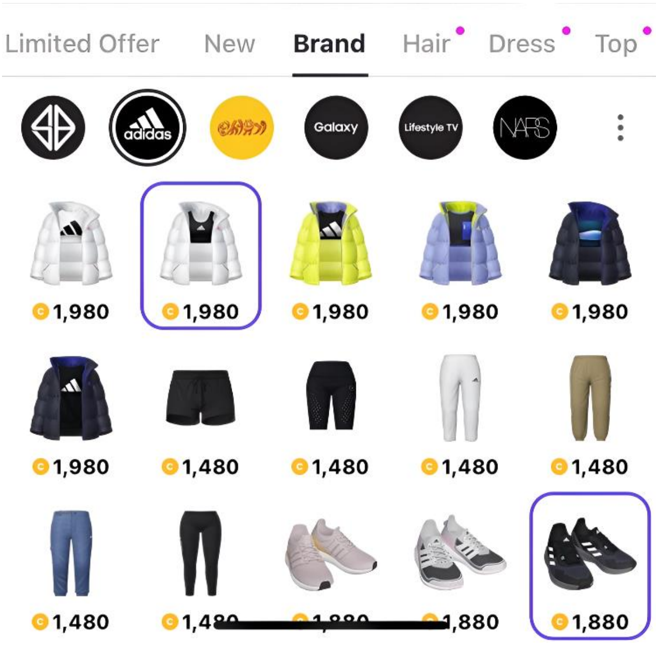

FIGURE II. VIRTUALLY WEARABLE PRODUCTS IN THE METAVERSE [20]

In addition, research suggests that consumer interest in buying goods related to Metaverse is increasing, with physical clothing being the most sought-after product category [15].

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Despite these advancements, understanding the key factors influencing Metaverse shopping experiences remains a critical challenge due to the complex and interdependent nature of technological, behavioral, and experiential factors. Existing studies primarily focus on specific theoretical models such as technology adoption and consumer behavior frameworks, often from a customer-centric perspective [16-18].

Although these studies provide valuable insights, they lack a holistic approach that takes into account the interwoven relationships between multiple influencing factors. There is therefore an urgent need for a comprehensive method that not only identifies key determinants but also uncovers their cause-and-effect relationships and provides deeper insights into consumer behavior in this evolving environment. To address this gap, this study applies the Fuzzy Decision-Making Trial and Evaluation Laboratory (FDEMATEL), a method specifically designed to analyze interdependencies, identify causal relationships, and manage uncertainty in expert evaluations. Metaverse shopping involves multiple interacting factors, making it essential to prioritize key influences while understanding how they affect one another [21].

Although, DEMATEL has been widely applied across various business domains [22-25] and in contexts such as the automobile industries [26], climate issues [27], and marine machinery system [28]. Its application within the Metaverse context remains largely unexplored [29]. Moreover, recent studies have applied innovative decision-making approaches such as the spherical fuzzy decision-making method to prioritize sustainable business investments in the Metaverse [30]. However, these approaches have yet to receive adequate attention in metaverse shopping experiences.

To fill in these gaps, the study aims to address the following research questions are addressed in this study:

- What are the key factors driving the success of Metaverse shopping platforms?
- How do these factors interact with each other regarding cause-and-effect relationships?
- Which factors should be prioritized to enhance and improve the overall shopping experience in the Metaverse?

This study adds to the body of knowledge already available in the field and offers useful advice to developers and companies who want to improve customer adoption and engagement in the metaverse retail setting. The findings present significant theoretical and practical implications. Theoretically, it underscores the need to refine existing frameworks by incorporating context-specific variables related to the metaverse. Practically, it offers valuable guidelines for metaverse developers and content creators, enabling them to improve their offerings effectively.

II. Literature Review

This section examines the metaverse concept and how it affects shopping and retail. It investigates the influential factors in the context of successful online shopping experiences on metaverse platforms.

A. *Metaverse and Shopping*

The emergence of the metaverse, a synthesis of virtual, augmented, and physical realities, has profoundly transformed how we approach shopping and commerce [17]. It is anticipated that the metaverse will drastically alter how customers engage with the digital world and alter the retail industry. Customers will be able to move through immersive virtual environments and engage with other avatars, such as those of other customers and store employees, while frequently utilizing digital avatars of themselves [8,31-32]. Like e-commerce, retailers who are successful in creating a metaverse presence can reach a wider audience by enabling customers from far-off places to visit [33]. Thus, it is anticipated that the metaverse market will grow to a value of $800 billion by 2024, prompting retailers to contemplate how they can modify their business plans to remain competitive in the "virtual" retail space. As early adopters of this new retail landscape, some trailblazing stores have already started working with metaverse developers to create highly immersive and captivating shopping experiences that conflate the real and virtual worlds [14, 34-35].

The integration of the metaverse into the retail landscape offers numerous opportunities, but it also presents a complex array of challenges. Retailers need to maneuver through this complex terrain, balancing the potential benefits against the inherent uncertainties of this technological frontier [7, 36]. Understanding the factors that influence successful shopping experiences on metaverse platforms is crucial for effective integration. Consequently, it is crucial to identify these factors. The following factors have been found to contribute to positive metaverse platform shopping experiences.

B. *Factors Influencing Shopping on Metaverse Platforms*

After reviewing the literature on Metaverse shopping experiences, initially, a total of 20 variables were identified. These factors were then validated through expert opinion. Later, 9 variables were found to be redundant or encompassed by others, such as security, fraud being covered under the broader factor of risk, and aspects of fun and joy falling under enjoyment. As a result, a final set of 11 factors was selected for further analysis and exploration. The complete list of final factors has been provided in Table I.

- Ease of use (EU): According to [37], the attitude and behavioral intention towards using a specific technology are determined by two factors: perceived ease of use and perceived usefulness. EU implies that technology is more likely to be accepted when users perceive it as easy to use. In the context of the metaverse, many researchers have demonstrated the positive impact of ease of use on the acceptance of this platform across various fields, including education [38-39], healthcare [40], human resources [41], and banking [42]. A study by [43] showed that shopping on metaverse platforms can provide an experience comparable to or even better than traditional shopping. Specifically, by focusing on EU i.e. user-centered design principles like intuitive navigation, clear instructions, and seamless integration of augmented and virtual reality features, one can enhance user satisfaction and drive adoption of your platform.

- Enjoyment (EN): EN enhances users' experiences by providing positive interactions within the platform that lead to a sense of self-fulfillment [44]. Fun or enjoyment serves as intrinsic drivers of platform usage, contributing to users' internal motivations and desires to interact with the platform. These hedonic elements go beyond practical usefulness, enhancing user experiences and encouraging more in-depth interaction with the system. Past studies have indicated metaverse retailing as an evolution of traditional online channels, emphasizing heightened elements of EN [45]. The hedonic gratification strongly influences young consumers to explore the metaverse for shopping [46]. [9] similarly observed that EN positively influences consumer adoption of metaverse shopping platforms.
- Social Influence (SI): According to Social Influence Theory, SI emphasizes the impact of others' opinions and behaviors on an individual's actions [47]. In the metaverse, social influence can affect users' decisions to shop based on recommendations, reviews, and social presence [48]. SI is not limited to instances where consumers actively interact with others but also in passive scenarios where other people are present physically but don't engage with the main consumer [32]. A study by [49] depicts SI has a positive impact on how useful people perceive the metaverse platform to be. Furthermore, satisfaction, usage intention, purchase intention, and word-of-mouth intention were all markedly elevated by SI of the metaverse platform [50].
- Informativeness (INF): Providing precise and thorough product information in the metaverse can improve user satisfaction and shopping decision-making [51]. The incorporation of INF within metaverse platforms significantly enhances customer experiences and contributes to their sustained usage over time [52-53]. In a study, [54] discovered that the metaverse attribute of informativeness has a major impact on the flow experience on the platforms, encouraging users to visit the destination physically and demonstrating the fundamentals of INF.
- Media Richness (MR): MR posits that communication effectiveness is enhanced by the richness of the media used [55]. In metaverse shopping, rich media (e.g., 3D product views, and virtual try-ons) can improve user engagement and satisfaction. Previous research has highlighted the positive impact of MR on ease of use and participation intention in the metaverse [56], while also indicating that MR in tourism content, particularly through virtual reality in the metaverse, significantly increases perceived usefulness and enjoyment [57]. In terms of retail, the richness of media in the metaverse cultivates cognitive and affective trust, subsequently shaping purchase intention toward metaverse shopping [58].
- Risk (RK): Perceived risks (RK) in online transactions (e.g., privacy, security, financial) can deter users [2, 9]. Past studies suggest that the RK negatively impacts the intention to shop on the platform [59], diminishing decision confidence and overall satisfaction with the shopping experience [60]. In terms of luxury shopping in the metaverse, reducing perceived risk improves results, as brands must effectively convey their aesthetics and ensure high-quality experiences [61-62].
- Technological Anxiety (TA): TA addresses users' apprehension or fear of using computers and technology [9]. High levels of technological anxiety can negatively impact users' willingness to shop in the metaverse, making it crucial to design user-friendly and supportive interfaces. Previous research indicates that TAs make consumers less likely to want to switch to metaverse platforms [63]. Hence, TA negatively influences consumers' use of the metaverse platform [64].
- Immersion (IM): IM is one of the distinct features of the metaverse shopping platform. High levels of immersion in the metaverse can create a sense of presence, making the shopping experience more realistic and engaging [8]. Previous research has indicated that IM has a positive effect on the intention to use metaverse retail in a variety of sectors including banking [65], education [1] and commerce [66-67]. IM enhances the metaverse platform's shopping experiences positively [9].
- Flow (FL): Flow is a psychological state, where a person becomes fully absorbed and engaged in an activity, experiencing a sense of enjoyment, and focus [68]. Here, it refers to total absorption in the shopping process, which results in a smooth and pleasurable metaverse shopping experience [69]. In past literature, flow and immersion have been used interchangeably but both are different. Flow involves deep engagement and enjoyment in an activity, while immersion pertains to feeling enveloped by sensory experiences within a virtual environment [69]. The flow has a significant influence on consumers' intention to purchase on the Metaverse platforms [4-70].
- Avatar's Self-Congruence (ASC): Self-Congruity Theory proposes that consumers prefer products that are congruent with their self-image [71]. In the metaverse, avatars that accurately represent users' identities can enhance satisfaction and engagement [72]. Recent research also demonstrates that ASC has a positive impact on consumers' intentions to make purchases when using virtual marketplaces [73, 4].
- Synchronicity (SY): Media Synchronicity Theory proposed by [74], suggests that communication processes that are synchronous (real-time) can improve coordination and understanding. Synchronous interactions during metaverse shopping have a positive effect on customers' perceptions of brand trust, brand knowledge, and brand attachment [5]. These factors then influence the customers' active engagement with the brand and their propensity to purchase the product [31].

TABLE I. FACTORS AND THEIR REFERENCES

S.No	Factor	Definition	References
1	Ease of Use (EU)	The degree to which a user finds the metaverse shopping platform easy to navigate and use, including the intuitiveness of its interface and the simplicity of shopping tasks.	[75-76, 43]
2	Enjoyment (EN)	The extent to which users derive pleasure and satisfaction from their shopping experiences in the metaverse influences their engagement and likelihood of repeat visits.	[46, 9]
3	Social Influence (SI)	The impact of peer opinions, social networks, and community interactions on a user's shopping behavior and decisions within the metaverse environment.	[32, 50, 47, 77]
4	Informativeness (INF)	The quality, relevance, and comprehensiveness of the information provided about products and services within the metaverse, helping users make informed purchasing decisions.	[51-52, 54]
5	Media Richness (MR)	The degree to which the metaverse platform provides engaging and sensory-rich multimedia content, such as high-quality images, videos, and interactive elements.	[55, 58]
6	Risk (RK)	The perceived security and privacy concerns associated with shopping in the metaverse, including fears of data breaches, fraud, and the safety of personal information.	[61 -62, 78]
7	Technological Anxiety (TA)	The level of discomfort or apprehension users feel when interacting with new or complex technological features in the metaverse shopping platform.	[63, 9]
8	Immersion (IM)	The extent to which users feel absorbed and present in the virtual shopping environment, leads to a more engaging and realistic experience.	[79-80, 8]
9	Flow (FL)	The seamlessness and continuity of the user experience while shopping in the metaverse, are characterized by an effortless progression through different shopping activities.	[68-69, 81]
10	Avatar's Self-Congruence (ASC)	The alignment and representation of a user's real identity through their virtual avatar, contribute to a more personalized and relatable shopping experience.	[4, 72]
11	Synchronicity (SY)	The real-time responsiveness and interaction capabilities of the metaverse platform, allow for instant communication, updates, and feedback during the shopping experience.	[5,74]

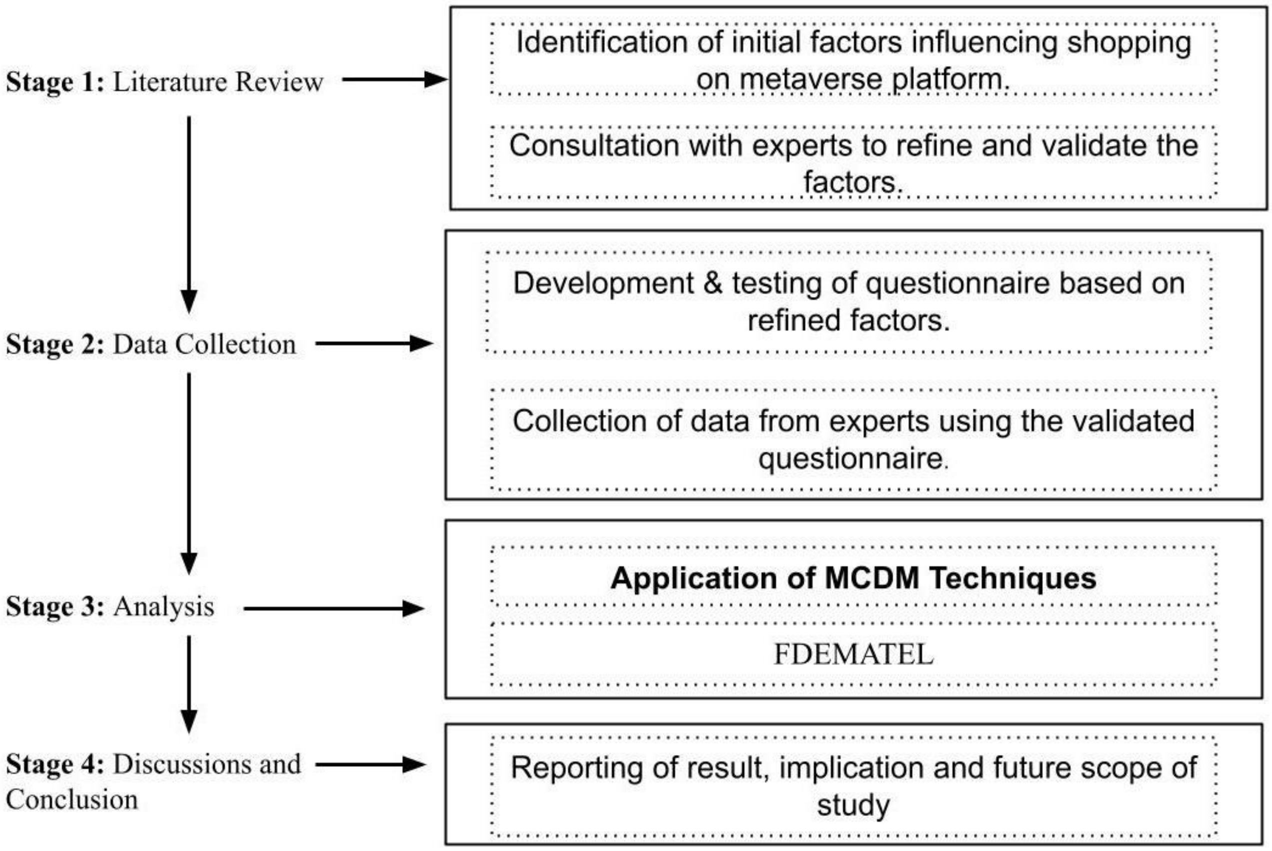

FIGURE III. APPLIED RESEARCH FRAMEWORK FOR THIS STUDY

III. Research Methodology

After finalizing the factors in section two factors linked to successful metaverse shopping experiences. However, it remains challenging to determine the importance and causal relationships among these factors. There is a lack of empirical evidence to comprehend the crucial factors. To address this, the FDEMATEL method is employed to provide a systematic and quantitative examination of the influencing factors. This section also discusses the expert data collection process and related methodologies used to identify and evaluate these factors. There are four steps involved in the entire analysis (See Figure III).

A. The Fuzzy DEMATEL Method

The Decision-Making Trial and Evaluation Laboratory (DEMATEL) method is a powerful analytical tool designed to analyze complex problems with intricate interrelationships [21]. DEMATEL is based on graph theory and matrix tools and uses expert knowledge to visually represent causal relationships between various factors, which makes it particularly valuable for structured decisions [23,24]. Despite its strengths, the traditional DEMATEL is based on clear numerical values and is therefore less effective in dealing with uncertainties when expert opinions are subjective. To address this, fuzzy logic is integrated into DEMATEL to accommodate imprecise expert judgments, improving the reliability of causal analysis [22, 23]

While various MCDM methods exist, not all are suitable for analyzing interdependent factors in Metaverse shopping. The Analytic Hierarchy Process (AHP) assumes independent criteria, limiting its applicability [82]. Although the Analytic Network Process (ANP) takes dependencies into account, it remains computationally complex and does not explicitly represent causal effects [83]. TOPSIS (Technique for Order Preference by Similarity to Ideal Solution) focuses on ranking alternatives but does not assess how factors influence each other, which limits their suitability for cause-and-effect analyses [84]. Similarly, interpretive structure modeling (ISM) identifies relationships between variables but does not quantify the strength of influence between them. In contrast, Fuzzy DEMATEL captures both the direction and intensity of causal effects and thus enables a deeper understanding of factor interactions [85].

Given these limitations, Fuzzy DEMATEL is the most suitable approach as it provides a structured evaluation of critical Metaverse shopping determinants. By incorporating fuzzy linguistic scales, it enhances the accuracy of causal diagrams and prioritization of influential factors, making it particularly effective for understanding the complex interplay of technology, user experience, and social influence in Metaverse shopping.

Step 1: Selecting the Team of Experts and the Fuzzy Linguistic Scale

To address the fuzziness in expert evaluations, the experts selected for the study came from academia, industry, and experienced users of metaverse platforms. The detailed list of experts is provided in Table II. The sample size was determined based on previous research, which suggests that a group of 10-15 experts is sufficient to obtain reliable results and achieve saturation in a homogeneous sample, particularly for the DEMATEL method [86]. This approach is in line with studies by [87] and [88], in which expert assessments were carried out with twelve and ten respondents, respectively. Given that similar studies have successfully used sample sizes within this range, a group of fifteen experts was considered adequate to ensure rigorous and reliable findings.

TABLE II. DEMOGRAPHIC PROFILE OF EXPERTS

Demographics	**Category**	**Sample Size (N=15)**	**Percentage**
Gender	Male	9	60
	Female	6	40
Age	21-30	3	20
	31-40	5	33
	41-50	5	33
	Above 50	2	14
Field	**Academia:**	11	73
	Retail	5	
	Immersive technologies	6	
	Industry:	4	27
	Retail	2	
	Immersive technologies	2	
Total Experience	Less than 5 years	4	27
	5-10 years	5	33
	Above 10 years	6	40

Each expert provided qualitative input on various factors influencing the adoption of metaverse shopping platforms. Their judgments regarding the mutual impact of identified factors were collected using a pairwise comparison matrix and linguistic variables. A five-point fuzzy linguistic scale was employed to enable experts to assess the interrelationships among the factors (Table III).

TABLE III. FUZZY LINGUISTIC SCALE ADOPTED FROM [21]

Linguistic Variable	Influence Score	Corresponding Triangular Fuzzy Numbers (TFNs)
No influence	0	(0, 0.1, 0.3)
Very low influence	1	(0.1, 0.3, 0.5)
Low influence	2	(0.3, 0.5, 0.7)
High influence	3	(0.5, 0.7, 0.9)
Very high influence	4	(0.7, 0.9, 1.0)

Step 2: De-fuzzifying the Triangular Fuzzy Numbers (TFNs) to a Crisp Value

A fuzzy aggregation method was applied to address the uncertainty in human judgment. The fuzzy linguistic data were converted into TFNs (Table IV), which were then defuzzified to obtain crisp values. This process involves several sub-steps:

Step 2.1: Standardization of Fuzzy Numbers

$$x_{ij}^{lk} = \frac{l_{ij}^{k} - \min_{l \le k \le K} l_{ij}^{k}}{D_{\max\min}} \quad (1)$$

$$x_{ij}^{mk} = \frac{m_{ij}^{k} - \min l \le k \le K l_{ij}^{k}}{D_{\max\min}} \quad (2)$$

$$x_{ij}^{rk} = \frac{r_{ij}^{k} - \min l \le k \le k l_{ij}^{k}}{D_{\max\min}} \quad (3)$$

Where $D_{max\ min} = max\ r_{ij}^{k} - min\ l_{ij}^{k}$

These equations represent the standardization of the lower, middle, and upper values of the Triangular Fuzzy Numbers (TFNs). Each component ($x_{ij}^{lk}, x_{ij}^{mk}, x_{ij}^{rk}$) is obtained by normalizing the respective fuzzy values against the range $D_{max\ min}$. This step transforms the fuzzy data into a standardized form, facilitating further analysis while preserving the relative differences in the original fuzzy inputs.

Step 2.2: Calculate Left and Right Normalized Values

$$x_{ij}^{lsk} = \frac{x_{ij}^{mk}}{1 + x_{ij}^{mk} - x_{ij}^{lk}} \quad (4)$$

$$x_{ij}^{rsk} = \frac{x_{ij}^{rk}}{1 + x_{ij}^{rk} - x_{ij}^{mk}} \quad (5)$$

The left and right normalized values represent the proportions of the middle and upper fuzzy values relative to their spreads, indicating the skewness on both sides.

Step 2.3: Calculate the Total Normalized Value

$$x_{ij}^{k} = [x_{ij}^{lsk}\left(1 - x_{iy}^{lsk}\right) + x_{ij}^{rs\,k}][1 + x_{ij}^{lsk} - x_{ij}^{ls\,k}] \quad (6)$$

Here, it integrates both the left and right normalized values to produce a total normalized value. It combines the impact of left and right spreads to offer a comprehensive normalization of the TFN.

Step 2.4: Compute the Crisp Value

$$CV_{ij}^{k} = min\ l_{ij}^{k} + x_{ij}^{k} D_{max\ min} \quad (7)$$

This equation calculates the crisp value by adding the minimum lower fuzzy value to the product of the total normalized value and the range $D_{max\ min}$. This step converts the standardized fuzzy data into a single crisp value, suitable for analysis.

Step 3: Combined Scores and DEMATEL Analysis

In the last step, the combined crisp scores from all expert opinions were calculated (Table V), followed by DEMATEL analysis in R using the Dematel package. This facilitated the visualization and analysis of causal relationships, highlighting key factors influencing metaverse shopping experiences.

TABLE IV. TRIANGULAR FUZZY NUMBERS (TFNS)

	EU	EN	SI	INF	MR	RK	TA	IM	FL	ASC	SY
EU	1,1,1	0.3,0.5,0.7	0.5,0.7,0.9	0.3,0.5,0.7	0.5,0.7,0.9	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7
EN	0.3,0.5,0.7	1,1,1	0.7,0.9,1	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.5,0.7,0.9	0.5,0.7,0.9	0.5,0.7,0.9	0.7,0.9,1
SI	0.5,0.7,0.9	0.7,0.9,1	1,1,1	0.5,0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7
INF	0.5,0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	1,1,1	0.7,0.9,1	0.7,0.9,1	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7
MR	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.7,0.9,1	1,1,1	0.3,0.5,0.7	0.3,0.5,0.7	0.7,0.9,1	0.7,0.9,1	0.7,0.9,1	0.7,0.9,1
RK	0.3,0.5,0.7	0.3,0.5,0.7	0.1,0.3,0.5	0.5,0.7,0.9	0.3,0.5,0.7	1,1,1	0.5,0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7
TA	0.1,0.3,0.5	0.3,0.5,0.7	0.5,0.7,0.9	0.5,0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	1,1,1	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7
IM	0.1,0.3,0.5	0.7,0.9,1	0.5,0.7,0.9	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	1,1,1	0.7,0.9,1	0.7,0.9,1	0.3,0.5,0.7
FL	0.1,0.3,0.5	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.7,0.9,1	1,1,1	0.5,0.7,0.9	0.3,0.5,0.7
ASC	0.1,0.3,0.5	0.7,0.9,1	0.5,0.7,0.9	0.3,0.5,0.7	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.7,0.9,1	0.7,0.9,1	1,1,1	0.3,0.5,0.7
SY	0.1,0.3,0.5	0.7,0.9,1	0.3,0.5,0.7	0.3,0.5,0.7	0.5,0.7,0.9	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	0.3,0.5,0.7	1,1,1

Note: Triangular Fuzzy Numbers (TFNs) derived from linguistic data provided by Expert 1

IV. RESULT

This study applied the Fuzzy DEMATEL (FDEMATEL) method to understand the factors influencing successful metaverse experiences, experts provided their insights on causal relationships between various attributes. These relationships were quantified by assessing the level of influence one attribute exerts on another. By taking the average (arithmetic mean) of these expert opinions which was normalized, we obtained an initial directed-relation matrix (Table V). Table VI presents the final total relation matrix, derived from the normalized relationships matrix through DEMATEL analysis in R. This analysis establishes a threshold of 0.368 to pinpoint the most impactful factors influencing successful metaverse experiences.

The analysis yields three major outcomes: identification of Prominent factors, determination of causal factors, and classification of effect factors, which are discussed below.

A. Prominent Factors

As given in Table VII, R+D represents the overall prominence of each factor. A higher value indicates a more significant role in the system which are as follows: FL> IM> EU> EN> MR> ASC> SY> TA> INF> SI> RK. It is evident that with R+D= 9.84, FL has the highest prominence, indicating that it is the most important factor in the platform and must be present for it to function properly overall. Close to it are IM and EU with 9.40 and 9.25 respectively, playing key roles in overall metaverse dynamics and significantly impacting user experience. Further, EN (8.81), MR (8.47), and ASC (8.43) also show high prominence, indicating their substantial influence on the platform's effectiveness and user satisfaction. These factors collectively highlight the critical elements that need to be prioritized to enhance user engagement and ensure a seamless and enriching experience in the digital environment.

TABLE V. INITIAL DIRECTED-RELATION MATRIX

	EU	EN	SI	INF	MR	RK	TA	IM	FL	ASC	SY
EU	0.800	0.533	0.178	0.312	0.332	0.258	0.429	0.509	0.507	0.256	0.428
EN	0.321	0.666	0.334	0.143	0.368	0.137	0.245	0.479	0.533	0.395	0.403
SI	0.122	0.196	0.777	0.167	0.122	0.200	0.189	0.173	0.185	0.220	0.226
INF	0.512	0.245	0.269	0.723	0.395	0.322	0.269	0.393	0.390	0.235	0.281
MR	0.472	0.516	0.271	0.300	0.754	0.281	0.266	0.480	0.495	0.406	0.440
RK	0.335	0.294	0.322	0.091	0.223	0.748	0.523	0.268	0.283	0.186	0.328
TA	0.361	0.281	0.284	0.078	0.185	0.363	0.722	0.369	0.393	0.300	0.231
IM	0.390	0.502	0.405	0.205	0.259	0.191	0.242	0.678	0.537	0.480	0.464
FL	0.469	0.531	0.414	0.234	0.332	0.181	0.216	0.543	0.707	0.456	0.431
ASC	0.385	0.433	0.382	0.156	0.275	0.207	0.217	0.515	0.529	0.748	0.360
SY	0.313	0.283	0.381	0.230	0.347	0.198	0.215	0.380	0.453	0.296	0.751

Note: Initial directed-relation matrix derived by averaging the normalized expert opinions.

TABLE VI. TOTAL RELATION MATRIX

	EU	EN	SI	INF	MR	RK	TA	IM	FL	ASC	SY
EU	0.554	0.512	0.378	0.279	0.374	0.295	0.379	0.529	0.550	0.402	0.472
EN	0.399	0.489	0.374	0.214	0.342	0.234	0.297	0.469	0.500	0.392	0.419
SI	0.209	0.233	0.343	0.139	0.171	0.163	0.181	0.239	0.252	0.217	0.233
INF	0.447	0.397	0.356	0.345	0.351	0.283	0.310	0.449	0.466	0.351	0.391
MR	0.495	0.521	0.411	0.284	0.475	0.307	0.349	0.536	0.561	0.447	0.487
RK	0.351	0.352	0.325	0.171	0.267	0.345	0.333	0.363	0.382	0.293	0.349
TA	0.361	0.355	0.319	0.170	0.261	0.261	0.373	0.391	0.412	0.324	0.331
IM	0.438	0.479	0.413	0.241	0.337	0.262	0.315	0.537	0.528	0.432	0.457
FL	0.472	0.503	0.428	0.257	0.366	0.270	0.321	0.527	0.582	0.441	0.466
ASC	0.426	0.454	0.398	0.224	0.331	0.259	0.302	0.492	0.514	0.480	0.423
SY	0.377	0.383	0.367	0.224	0.322	0.238	0.277	0.424	0.457	0.349	0.473

Note: The total relation matrix, obtained through DEMATEL analysis in R, identifies the strength of relationships between factors. A threshold of 0.368

TABLE VII. FINAL RESULT OF FDEMATEL ANALYSIS

	R	D	R+D (Importance)	R-D (Role)	Rank
EU	4.72	4.53	9.25	0.19	3
EN	4.13	4.68	8.81	-0.55	4
SI	2.38	4.11	6.49	-1.73	10
INF	4.15	2.55	6.69	1.6	9
MR	4.87	3.6	8.47	1.28	5
RK	3.53	2.92	6.45	0.61	11
TA	3.56	3.44	7	0.12	8
IM	4.44	4.96	9.4	-0.52	2
FL	4.63	5.2	9.84	-0.5`7	1
ASC	4.3	4.13	8.43	0.18	6
SY	3.89	4.5	8.39	-0.61	7

B. Cause and Effect Factors

In our analysis (Table VI), the highest cause factor is INF with a value of 1.6. Informativeness significantly enhances the system by providing valuable and relevant content, greatly increasing user engagement and satisfaction. Following closely is MR with a value of 1.28, which improves user satisfaction through a richer media experience. Other positive influencers include RK at 0.61, TA with a value of 0.12, and ASC at 0.18. EU with a value of 0.19 also positively influences the system by making it more user-friendly.

On the other hand, the highest effect factor is SI with a value of -1.73, indicating it is significantly impacted by other factors. EN, at -0.55, is influenced by various elements including EU and INF. IM at -0.52, FL at -0.57, and SY, with a value of -0.61, are influenced by a wide range of factors including EU and EN. Figure IV illustrates the cause-and-effect relationship between causal factors and their resulting factors.

Further, Figure V represents the factors based on their role and importance. The X-axis (R+D) represents the overall importance of each factor, while the Y-axis (R-D) distinguishes between influencing (cause) factors and influenced (effect) factors. It can be seen from the above diagram that the factors FL, IM, EN, and SY are the most important influenced factors while SI is the least. On the other hand, EU, MR & ASC are the important influencing factors while INF, RK, and TA are less important influencing factors.

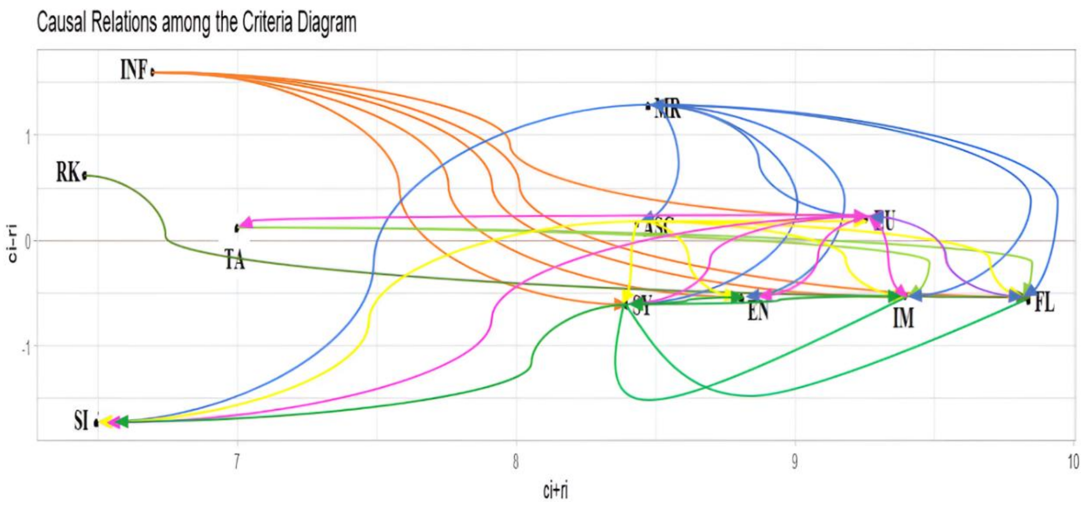

FIGURE IV. DIGRAPH OF CAUSAL RELATIONS AMONG THE FACTORS

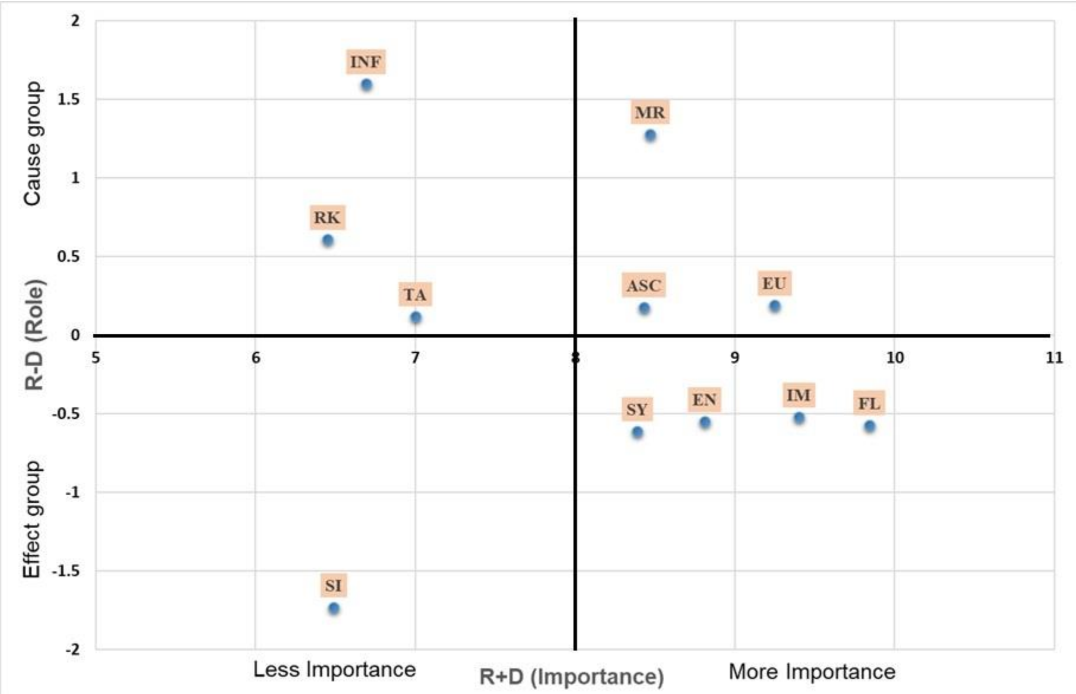

FIGURE V. REGIONS OF FACTORS OF THE METAVERSE PLATFORM

C. *Sensitivity Analysis*

The results may suffer from biases due to the varying backgrounds and levels of expertise of the experts selected for the study [23]. A sensitivity analysis was carried out to confirm the accuracy of the discovered cause-and-effect relationships. The findings of the sensitivity analysis indicate that the rankings of the factors are not significantly affected by modifications to the weights.

This stability shows that, despite possible expert biases, the rankings are not very sensitive to changes in the input data, suggesting that the findings are robust and reliable.

V. DISCUSSIONS

In our study, the most critical factor identified in the success of the metaverse shopping platform is INF. Informativeness influences ease of use, enjoyment, immersion, flow, and synchronicity because valuable and relevant content enhances user experience and engagement. However, it is not affected by any other factor, making it the most outcome-oriented variable due to its role as a key content quality metric. The findings are in line with earlier studies where informativeness (INF) is a significant factor in metaverse adoption [50]. The prominence of media richness (MR) in fostering immersive metaverse experiences also resonates with recent literature that underscores its importance in creating realistic virtual environments that engage users effectively [89].

Avatar self-congruence (ASC) was identified as another important factor influencing user satisfaction and engagement in the metaverse. This finding supports existing studies highlighting the role of avatar self-identity alignment in enhancing user experience and immersion [4, 90]. conversely, the influence of risk perceptions (RK) on user engagement suggests a nuanced understanding of how perceived risks can affect user intention and adoption within virtual platforms, in line with previous findings or theories that may emphasize other factors in virtual environment adoption [9, 62].

Synchronicity (SY) was found to enhance user experience through real-time interactions, consistent with literature emphasizing the importance of dynamic and responsive virtual environments [5]. Technological anxiety (TA) impacts attitudes toward shopping intention in the metaverse [9].

Overall, the study adds to the body of knowledge by offering empirical insights into the intricate interactions between variables affecting user engagement in metaverse retail settings. Future research could further explore these dynamics across different demographic and cultural contexts to enrich our understanding of user behavior and preferences in virtual retail settings.

VI. Implications

A. Theoretical Contribution

While traditional theoretical frameworks typically employ a standardized approach, the relationships among variables show significant changes when contextualized within the dynamics of the metaverse.

In traditional TAM, perceived ease of use (EU) is considered a key independent variable affecting both attitude and behavioural intention [75]. However, this study demonstrates that in the metaverse, EU is both influenced by and influences several key factors, including informativeness (INF), media richness (MR), immersion (IM), flow (FL), avatar self-congruence (ASC), and synchronicity (SY). This reciprocal relationship suggests that TAM should be extended to account for bidirectional influences rather than assuming the EU as a purely independent factor. This shift underscores the need for a more dynamic and interaction-based TAM model for the metaverse.

Similarly, HMSAM states that enjoyment (EN) is influenced by EU and affects immersion (IM) [91]. However, in the metaverse, EN not only influences EU and IM but is also shaped by them, forming a feedback loop rather than a unidirectional relationship. The immersive and engaging nature of the metaverse enhances user satisfaction and perceived ease of use, which, in turn, deepens immersion and further amplifies enjoyment. This study suggests that HMSAM should be extended to incorporate bidirectional interactions, as user engagement in the metaverse is driven by an ongoing reinforcement cycle rather than a linear process.

In Computer Anxiety Theory, technological anxiety (TA) is assumed to negatively impact ease of use (EU) [92]. However, this study finds that in the metaverse, EU reduces TA, meaning that as users find the platform easier to navigate, their anxiety decreases. This reversal challenges the traditional perspective and suggests that TA should be considered a dynamic factor that evolves with user experience, rather than a static barrier to adoption.

These findings indicate that traditional theoretical models require modifications when applied to the metaverse context. Instead of treating variables as static and unidirectional, models should be revised to accommodate bidirectional influences, dynamic relationships, and user-driven experiences. Future research should explore these extensions further to refine theoretical frameworks for understanding consumer behaviour in immersive digital environments.

B. Managerial Implications

The DEMATEL analysis provides a prioritized list of factors crucial for enhancing Metaverse shopping experiences, highlighting specific actions for developers and marketers according to their ranking.

Flow (FL) and immersion (IM) emerged as the most critical elements. Developers should focus on creating seamless and deeply engaging environments by optimizing user interfaces and utilizing advanced graphics and interactive elements. Ensuring seamless interactions will increase user satisfaction and engagement, adding to the fun and memorable nature of shopping. Ease of use (EU) ranks third in importance. Both developers and marketers must work together to simplify navigation, design intuitive controls, and provide clear instructions and helpful guides. A user-friendly interface will attract and retain more users, reducing frustration and encouraging repeat visits.

Enjoyment (EN), media richness (MR), and informativeness (INF) are also highly significant. Marketers should incorporate elements that enhance user enjoyment, such as rich media, comprehensive information, and immersive content, to create a more engaging and pleasurable shopping experience. By doing so, they can make the shopping process more entertaining and satisfying. Additionally, enhancing avatar self-congruence (ASC) is vital. Developers should allow users to create realistic avatars that closely resemble themselves, providing advanced customization options and accurate virtual try-on features. This increased realism will elevate users' enjoyment and satisfaction.

Synchronicity (SY) is important for maintaining user engagement. Developers should ensure real-time responses and interactions by implementing robust servers and efficient data handling to reduce lag and latency. Real-time interactions will prevent users from switching to other platforms due to frustration with delays. Addressing technological anxiety (TA) is also essential. Developers need to design platforms and devices that are user-friendly and require minimal technical knowledge. Providing user support and resources will help users feel more comfortable, making the platform more accessible to a broader audience.

Finally, mitigating overall risk (RK) is crucial for building user trust. To safeguard user information and financial transactions, developers and marketers need to put strict security measures in place and communicate these measures to users. A secure platform will reduce perceived risks, encourage more transactions, and foster a sense of safety and reliability. Efforts to increase system integration should also be made to ensure that various components of the Metaverse shopping platform work seamlessly together to provide a smooth and cohesive user experience. Developers and marketers can raise the standard and appeal of Metaverse shopping platforms considerably by concentrating on these aspects, which will increase user satisfaction and loyalty in the long run.

VII. Conclusion

In conclusion, this study employed the fuzzy DEMATEL method within the MCDM framework to systematically identify the key factors driving the success of metaverse shopping platforms. Addressing the first research question (RQ1), the factors were identified through a review of the literature and expert evaluations, ensuring a comprehensive and systematic approach to understanding the effectiveness of metaverse shopping platforms. Flow (FL), immersion (IM), and ease of use (EU) emerged as critical elements that enhance user experience, ensuring a seamless and engaging shopping journey. Additionally, enjoyment (EN), media richness (MR), and avatar self-congruence (ASC) were found to impact user adoption and satisfaction significantly.

Regarding the second research question (RQ2), the study analyzed the cause-and-effect relationships among these factors. Informativeness (INF) was identified as the most influential causal factor, which is crucial in enriching user engagement by providing valuable content. Media richness (MR) also acted as a key driver by enhancing the immersive quality of the digital shopping experience. Conversely, social influence (SI) emerged as the most affected factor, heavily influenced by other system elements. Enjoyment (EN), immersion (IM), and synchronicity (SY) were also classified as effect factors, highlighting their reliance on foundational drivers like informativeness and media richness.

Addressing the third research question (RQ3), the findings emphasize the need to prioritize flow (FL), immersion (IM), and ease of use (EU) to create a compelling metaverse shopping experience. Enhancing informativeness (INF) and media richness (MR) can further improve user engagement while mitigating risk (RK) and technological anxiety (TA) can foster greater user confidence.

Future research should explore other MCDM techniques such as Analytic Hierarchy Process (AHP) and Interpretive Structural Modeling (ISM), as well as additional context-specific variables related to the metaverse to further refine the theoretical framework. A deeper understanding of how these factors change over time and affect long-term user satisfaction and engagement may be obtained through longitudinal studies. Additionally, looking into how new technologies, like virtual reality and artificial intelligence, affect the factors mentioned above may provide important new information about how they might improve the metaverse experience. Finally, cross-cultural studies could reveal how these dynamics vary across different demographic and cultural contexts, providing a more comprehensive understanding of user behavior in the metaverse retail environment.

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Authors` Contributions

All authors have participated in drafting the manuscript. All authors read and approved the final version of the manuscript.

Conflict Of Interest

The authors certify that there is no conflict of interest with any financial organization regarding the material discussed in the manuscript.

Data Availability

The data supporting the findings of this study are available upon request from the authors.

Ethical Statement

In this article, the principles of scientific research and publication ethics were followed. This study did not involve human or animal subjects and did not require additional ethics committee approval.

Declaration of AI Usage

No AI tools were used in the creation of this manuscript.

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