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A Fuzzy Logic-Based System for Assessing Customer Trust in C2C E-Commerce Platforms

Mamta[1*] and Monika Saxena[2]

Department of Computer Science, Banasthali University, Rajasthan, India.

Abstract:- With the rapid advancement of internet technology over recent years, e-commerce has seen remarkable growth. For a c2c e-commerce business to succeed, it is crucial to understand the trust issues that prevent customers from choosing online platform for matchmaking. This paper introduces a model to evaluate how trust factors influence customer intentions to select from Indian online matchmaking platforms. The model utilizes the mamdani fuzzy inference system to calculate a trust index for virtual matchmaking platform, assessing customer confidence in online platform. The study begins by identifying key trust factors and then explores their significance through expert opinions. It examines customer feedback on c2c virtual matchmaking portals concerning these factors, leading to the development of a fuzzy system. Data collected via a questionnaire survey informed the creation of rules for the fuzzy inference system.

Keywords*: Trust, Virtual Trust, Trust Factors, Fuzzy system, Matchmaking Portals, Mamdani Fuzzy Inference System*

1. Introduction

India's internet user base has grown significantly, now exceeding 800 million, making it the second-largest online population globally after China. With this substantial increase, India is witnessing rapid growth in e-commerce. The Indian e-commerce market has evolved dramatically, showing a consistent year-on-year growth rate driven by higher disposable incomes and a younger, tech-savvy population. Despite this expansion, online merchants still grapple with trust issues, as many customers remain cautious about online platforms due to concerns about security, privacy, and the lack of face-to-face interaction. Understanding and addressing these trust-related issues are crucial for the continued success of e-commerce c2c matchmaking businesses in India.

The widespread adoption of the internet is one of the most significant technological advancements in recent years, dramatically changing how people live. It enables individuals to connect, meet, shop, search for information, and perform various other tasks online. The internet has also revolutionized traditional matchmaking methods, offering people the convenience of searching for a partner anytime, anywhere. However, this digital shift introduces challenges such as unpredictability, lack of control, and increased anonymity, leading to concerns about trust in online environments.

Clients often worry about the quality of information, service reliability, and the authenticity of online platforms due to the impersonal and intangible nature of these virtual spaces. This uncertainty makes trust a critical factor for initiating any online interaction. In a virtual setting, trust is crucial for boosting revenue and maintaining a good reputation. Without trust, organizations risk losing business and failing to generate profit. A lack of trust can disrupt the operations of online matchmaking services. Therefore, it is vital for online platforms to address the concerns of their current and potential users to ensure customer satisfaction and loyalty[1]. Current research focuses on identifying the key trust factors present in the Indian e-commerce sector.it aims to distinguish the specific factors that significantly influence customer trust within this market and making fuzzy logic-based system to evaluate trust index of virtual matchmaking online platforms.

2. Literature Review

In a virtual environment, the web serves as a prevalent means for gathering information. Quality in this context is assessed based on three key aspects: service quality, information quality, and system quality. System quality

pertains to factors such as usability, accessibility, navigability, and privacy policies, which are crucial for evaluating the performance of a virtual platform [2].

Information quality involves the relevance, clarity, and timeliness of the data provided, which are essential criteria for measuring the effectiveness of information delivery. Service quality is concerned with the level of support and assistance provided to customers, with key indicators including reliability, responsiveness, empathy, and assurance [3][4].

Ahuvia et al.[5] proposed a structure called Social Media Interaction (SMI). Their research emphasizes the value and importance of three main components of online matchmaking services: search, match, and interaction. These elements are pivotal in connecting families and assisting individuals in finding their ideal partner.

Seth [6] study highlights that search, match, and interaction are essential features that drive users to seek partners online. Users can specify their preferences based on criteria like religion, lifestyle, body type, skin tone, and professional background. Online matrimonial platforms offer various interaction tools such as chat, email, and phone, which enable users to communicate and build connections before committing to marriage.

The study further explores how modern online matrimonial services streamline the process of finding a life partner, especially within the Indian context, where such platforms facilitate connections based on factors like caste, religion, and social background. The integration of advanced search capabilities and interaction tools helps users in making informed decisions regarding marriage by allowing them to connect and communicate with potential partners or their families.

Finally, the success of these online matrimonial services largely depends on their ability to meet users' needs effectively, which in turn is reflected in the successful formation of marriages. Trust in an organization is closely linked to its success rate, which can be demonstrated through the number of successful marriages facilitated by the organization. These stories of successful marriages help to establish the credibility and effectiveness of the service. Platforms like Bharatmatrimony.com and Shadi.com frequently showcase such success stories, emphasizing the positive outcomes achieved through their services [7].

A strong brand reputation significantly enhances a company's ability to attract customers. With a high brand value, a company can more easily connect with consumers. The brand itself can be represented through various elements such as a logo, name, or even a celebrity endorsement [8]. According to economic theory, there is a strong correlation between reputation and pricing. Brands with a higher reputation are more likely to command higher prices from customers.Given the importance of human perception and brand recognition, this connection between reputation and customer value plays a crucial role in the success of an organization[9,10].

Together, these studies highlight the complex nature of trust in C2C e-commerce and the necessity of employing advanced systems like fuzzy logic to address these challenges. As C2C platforms continue to grow, the development of sophisticated trust evaluation mechanisms will be essential for their success.

3. Research Gap

In this section, the researcher presents a table summarizing the research gap and problems associated with online matchmaking portals.

Table 1. Tabular data related to research gap.

Authors	Objective behind the study	Technique
Rajpal et al. [11]	Analytical comparison of fame and reputation of virtual matrimony platform pre-COVID and post-COVID time.	Inferential tests

Krishna et al. [12]	Comparative study of factors related to virtual matchmaking portals above old methods of traditional marriage process.	Structure equation modeling
Iyer et al. [13]	Emphasizes to recognize those elements which guide the user to select virtual matrimony portals over other old traditional methods of marriage.	Ordered logistic regression
Rajakumari et al. [14]	Study about the preferences of young generations when choosing an online matrimony portal.	Conclusive research design
Pingle et al. [15]	Study about the power of digitalization on virtual matrimony portals.	Ethnographical method

The influence of technology, power of digitalization, and attractiveness level of online portals have been frequently discussed in prior studies. However, there has been little attention given to the belief and trust factors. Trust is fundamental in the selection of any online platform. It assists organizations in fostering long-term relationships with consumers and helps users make informed decisions when choosing an online matchmaking portal. This study proposed fuzzy logic based expert system to evaluate trust value of customer in virtual matchmaking platform to address these gaps.

4. Fuzzy logic based expert system to evaluate trust value of customer of virtual matchmaking platforms

The rise of customer-to-customer (C2C) e-commerce has redefined the digital marketplace, creating new dynamics and challenges, particularly in building and maintaining customer trust. Unlike traditional business-to-consumer (B2C) models, C2C platforms require users to trust peers, who may lack the formal structures and guarantees that traditional businesses provide.

The model proposed a six-step methodology. The research begins with the identification of trust factors, leading to the calculation of a trust index for a c2c matchmaking virtual portals. The key steps undertaken for the study are:

1. Collection of Trust Factors

Various trust factors relevant to Indian online markets are identified using secondary data sources. Extensive literature review helped identify key trust factors in the online marketplace. The conceptual model of identified factors are below.

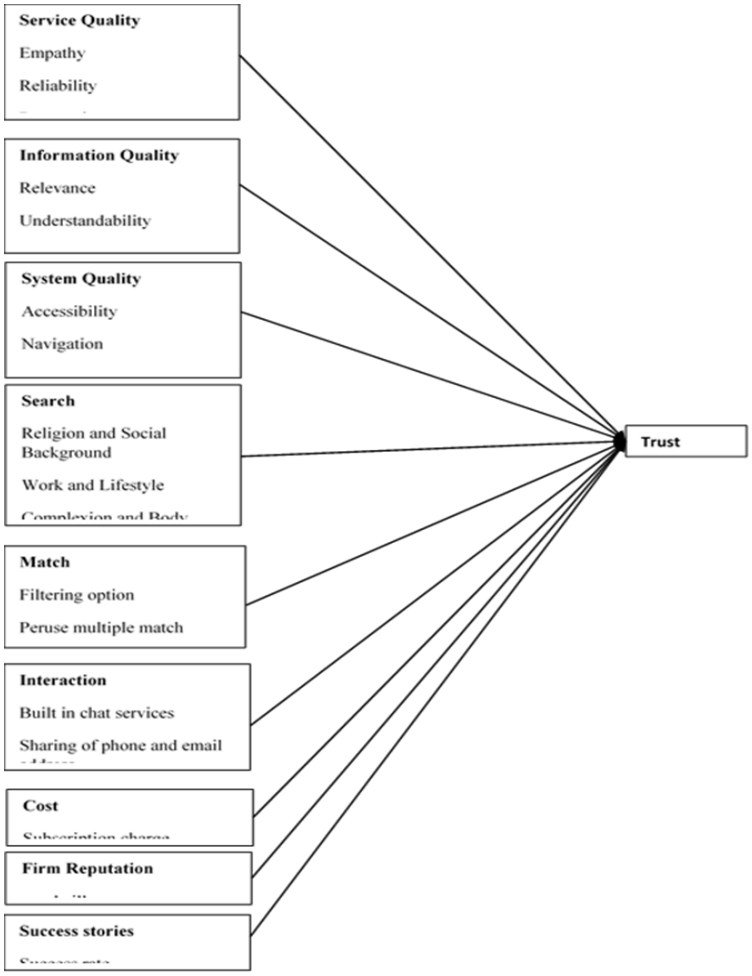

Fig 1. Trust Factor Hierarchy [16].

2. Investigating Experts to Establish Ranking of Trust Factors.

Questionnaire shared with 41 participants to collect information on different trust factors gathered from literature review. This Primary data was collected directly from Indian customers, including those who use e-commerce platforms and those who avoid them due to distrust. After collection a pair wise comparisons matrix created on data collected through expert. AHP called analytical hierarchy process was used to calculate ranking between factors and subfactors.

3. Ranking of factors & subfactors using fuzzy ahp method and OnlineOutput MCDM Software.

Table 2. shows ranking of factors of Trust

Rank	Criterion name	Criterion weight
3	System Quality	0.115
1	Information Quality	0.117
2	Service Quality	0.116
4	Search	0.11
5	Match	0.109
5	Interaction	0.109
6	Cost	0.108
7	Success stories	0.107
4	Firm reputation	0.11

As shown in the table above, according to ranking of factors of Trust , Information Quality is the first priority. Next priorities are assigned to Service Quality, System Quality, Search, Match, Cost and Success stories according to the obtained weights.

Table 3. shows ranking of factors of system quality

Rank	Criterion name	Criterion weight
2	Accessibility	0.25
3	Navigation	0.248
4	Usability	0.241
1	Privacy	0.262

As shown in the table above, according to ranking of factors of system quality, Privacy is the first priority. Next priorities are assigned to Accessibility, Navigation and Usability according to the obtained weights.

Table 4. Ranking of factors of Information Quality

Rank	Criterion name	Criterion weight
3	Relevance	0.249
1	Understandability	0.252
3	Richness	0.249
2	Currency	0.251

As shown in the table above, According ranking of factors of Information Quality, Understandability is the first priority. Next priorities are assigned to Currency and Relevance according to the obtained weights.

Table 5. Ranking of factors of Service Quality

Rank	Criterion name	Criterion weight
2	Empathy	0.252
1	Reliability	0.254
3	Responsiveness	0.249
4	Assurance	0.245

As shown in the table above, According ranking of factors of Service Quality, Reliability is the first priority. Next priorities are assigned to Empathy, Responsiveness and Assurance according to the obtained weights.

Table 6. Ranking of factors of Search

Rank	Criterion name	Criterion weight
2	Religion and Social Background	0.335
1	Work and Lifestyle	0.338
3	Complexion and Body Type	0.326

As shown in the table above, according ranking of factors of Search, Work and Lifestyle is the first priority. Next priorities are assigned to Religion and Social Background and Complexion and Body Type according to the obtained weights.

Table 7. Ranking of factors of Match

Rank	Criterion name	Criterion weight
1	Filtering option	0.341
3	pursue multiple matches simultaneously	0.327

2	Suggestions	0.332

As shown in the table above, according ranking of factors of Match, Filtering option is the first priority. Next priorities are assigned to Suggestions and pursue multiple matches simultaneously according to the obtained weights.

Table 8. Ranking of factors of Interaction

Rank	Criterion name	Criterion weight
1	Built in chat services	0.537
2	phone and email	0.463

As shown in the table above, according ranking of factors of Interaction, Built in chat services is the first priority. Next priorities are assigned to phone and email according to the obtained weights.

Table 9. to ranking of all factors and subfactors of Trust

Rank	Criterion name	Criterion weight
19	Accessibility	0.02875
20	Navigation	0.02852
22	Usability	0.027715
12	Privacy	0.03013
17	Relevance	0.029133
13	Understandability	0.029484
17	Richness	0.029133
15	Currency	0.029367
16	Empathy	0.029232
14	Reliability	0.029464
18	Responsiveness	0.028884
21	Assurance	0.02842
8	Religion and Social Background	0.03685
6	Work and Lifestyle	0.03718
10	Complexion and Body Type	0.03586
7	Filtering option	0.037169
11	pursue multiple matches simultaneously	0.035643
9	Suggestions	0.036188
4	Built in chat services	0.058533
5	phone and email	0.050467
2	Subscription charge	0.108
3	Success rate	0.107
1	goodwill	0.11

As shown in the table above, according to ranking of all factors and subfactors of Trust, goodwill is the first priority. Next priorities are assigned to Subscription charge, Success rate, Built in chat services, phone and email , Work and Lifestyle, Filtering option, Religion and Social Background, Suggestions, Complexion and Body Type, pursue multiple matches simultaneously, Privacy, Understandability, Reliability, Currency, Empathy, Relevance, Responsiveness, Accessibility, Navigation, Assurance and Usability according to the obtained weights.

4. Collection of Data regarding user preferences for various sites After gathering the trust factors in previous step, data was collected to study customer responses regarding the c2c e-commerce portals using the questionnaire. Top 15 factors from overall comparison table 9 was selected for data analysis. 430 valid responses were collected

from the questionnaire which consisted of 16 questions. The Cronbach alpha values for three portals are as given below.

Table 10. shows Cronbach alpha values

Bharat Matrimony	Jivan Sathi matrimony	Local Portal
0.919	0.928	0.954

5. Clustering of Data

Fuzzy c means method apply on data obtained from last step to get rules of fuzzy expert system. Because Data obtained from last step contain human thinking and reasoning so we need to apply fuzzy c means to clusters.

6. Developing Mamdani Fuzzy Inference System and Simulink model

After using fcm on data, mamdani fuzzy inference system is developed to get trust value. Fig 2 shows the module pseudo code and rules generated for the model. To Compute the trust index fuzzy system generated is implemented in Simulink with standard blocks. fig 8 shows the Simulink model and it is combination of 9 constant block, one multiplexer, a display window and fuzzy controller block.

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[System]
Name='mamdani91'
Type='mamdani'
Version=2.0
NumInputs=9
NumOutputs=1
NumRules=46
AndMethod='min'
OrMethod='max'
ImpMethod='min'
AggMethod='max'
DefuzzMethod='centroid'

[Input1]
Name='Firm-Reputation'
Range=[0 4]
NumMFs=3
MF1='low':'gaussmf',[0.7078 -5.551e-17]
MF2='moderate':'gaussmf',[0.7078 2]
MF3='high':'gaussmf',[0.7078 4]

[Input2]
Name='Cost'
```

Range=[0 4]

NumMFs=3

MF1='low':'gaussmf',[0.7078 -5.551e-17]

MF2='moderate':'gaussmf',[0.7078 2]

MF3='high':'gaussmf',[0.7078 4]

[Input3]

Name='Successstories'

Range=[0 4]

NumMFs=3

MF1='low':'gaussmf',[0.7078 -5.551e-17]

MF2='moderate':'gaussmf',[0.7078 2]

MF3='high':'gaussmf',[0.7078 4]

[Input4]

Name='Interaction'

Range=[0 8]

NumMFs=3

MF1='low':'gaussmf',[1.416 -1.11e-16]

MF2='moderate':'gaussmf',[1.416 4]

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[Input5]

Name='Search'

Range=[0 12]

NumMFs=3

MF1='low':'gaussmf',[2.123 -5.551e-17]

MF2='moderate':'gaussmf',[2.123 6]

MF3='high':'gaussmf',[2.123 12]

[Input6]

Name='Match'

Range=[0 12]

NumMFs=3

MF1='low':'gaussmf',[2.123 -5.551e-17]

MF2='moderate':'gaussmf',[2.123 6]

MF3='high':'gaussmf',[2.123 12]

[Input7]

Name='System-Quality'

Range=[0 4]

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MF1='low':'gaussmf',[0.7078 -5.551e-17]

MF2='moderate':'gaussmf',[0.7078 2]

MF3='high':'gaussmf',[0.7078 4]

[Input8]

Name='Information-Quality'

Range=[0 8]

NumMFs=3

MF1='low':'gaussmf',[1.416 -1.11e-16]

MF2='moderate':'gaussmf',[1.416 4]

MF3='high':'gaussmf',[1.416 8]

[Input9]

Name='Service-Quality'

Range=[0 4]

NumMFs=3

MF1='low':'gaussmf',[0.7078 -5.551e-17]

MF2='moderate':'gaussmf',[0.7078 2]

MF3='high':'gaussmf',[0.7078 4]

[Output1]

Name='Trust-Index'

Range=[0 1]

NumMFs=5

MF1='very_low':'trimf',[-0.208333333333333 0 0.208333333333333]

MF2='low':'trimf',[0.0416666666666667 0.25 0.458333333333333]

MF3='moderate':'trimf',[0.291666666666667 0.5 0.708333333333333]

MF4='high':'trimf',[0.541666666666667 0.75 0.958333333333333]

MF5='very_high':'trimf',[0.791666666666667 1 1.20833333333333]

[Rules]

1 1 1 1 1 1 1 1 1, 1 (1) : 1

2 2 2 2 2 2 2 2 2, 3 (1) : 1

3 3 3 3 3 3 3 3 3, 5 (1) : 1

2 1 2 2 2 2 2 2 2, 4 (1) : 1

1 3 3 3 3 3 1 1 1, 1 (1) : 1

3 1 3 1 2 1 3 3 0, 4 (1) : 1

2 2 1 3 1 3 3 2 3, 3 (1) : 1

1 1 2 2 3 3 3 3 2, 1 (1) : 1

3 3 2 3 2 2 2 1 3, 4 (1) : 1

2 1 3 3 3 1 2 3 2, 3 (1) : 1

1 2 2 3 2 2 1 1 3, 1 (1) : 1

3 1 3 1 2 3 3 1 2, 4 (1) : 1

1 1 2 3 1 1 3 3 3, 3 (1) : 1

1 1 2 3 3 3 3 1 3, 1 (1) : 1

3 2 1 3 2 3 1 3 2, 4 (1) : 1

2 1 3 2 3 3 3 2 3, 3 (1) : 1

1 3 3 1 2 1 2 2 2, 2 (1) : 1

3 1 3 2 1 2 2 3 3, 5 (1) : 1

2 3 1 3 2 3 2 1 3, 3 (1) : 1

1 2 3 2 3 1 1 2 1, 2 (1) : 1

3 3 3 2 1 3 2 2 2, 5 (1) : 1

1 1 1 2 2 3 2 1 2, 1 (1) : 1

2 2 2 3 3 2 3 2 3, 3 (1) : 1

3 3 3 2 2 1 2 3 1, 5 (1) : 1

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2 2 3 1 3 2 3 3 3, 3 (1) : 1

3 1 3 2 2 1 1 3 2, 4 (1) : 1

2 1 3 3 2 2 3 2 3, 3 (1) : 1

3 3 3 1 1 3 1 2 3, 5 (1) : 1

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3 2 3 2 3 3 2 2 2, 4 (1) : 1

2 1 2 2 2 2 1 2 3, 3 (1) : 1

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3 1 2 3 3 1 1 2 2, 1 (1) : 1

3 3 2 2 1 1 2 2 2, 4 (1) : 1

2 1 2 3 3 2 2 1 1, 3 (1) : 1

3 3 3 1 3 3 3 3 2, 5 (1) : 1

3 1 3 3 1 2 1 1 3, 4 (1) : 1

1 3 2 2 2 1 2 3 3, 2 (1) : 1

1 2 1 3 2 3 1 1 1, 1 (1) : 1

2 1 2 3 1 1 3 3 2, 2 (1) : 1

3 1 3 2 3 3 3 2 3, 4 (1) : 1

Fig 2. Module Pseudo Code and Rules Generated

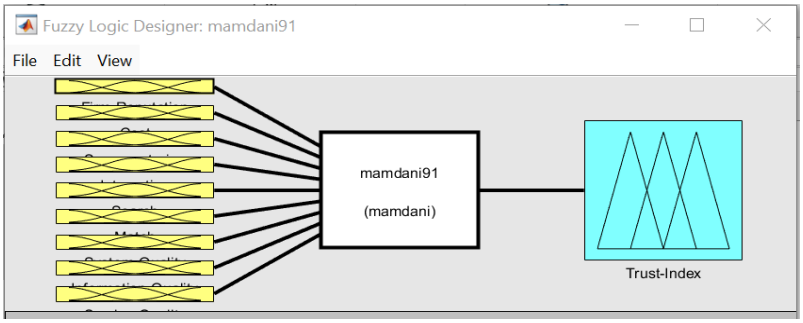

Fig 3. Fuzzy System to Obtain Trust

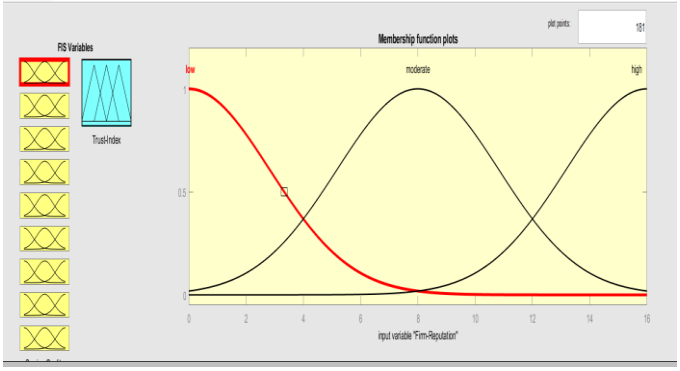

Fig 4. Membership Functions for the Fuzzy System

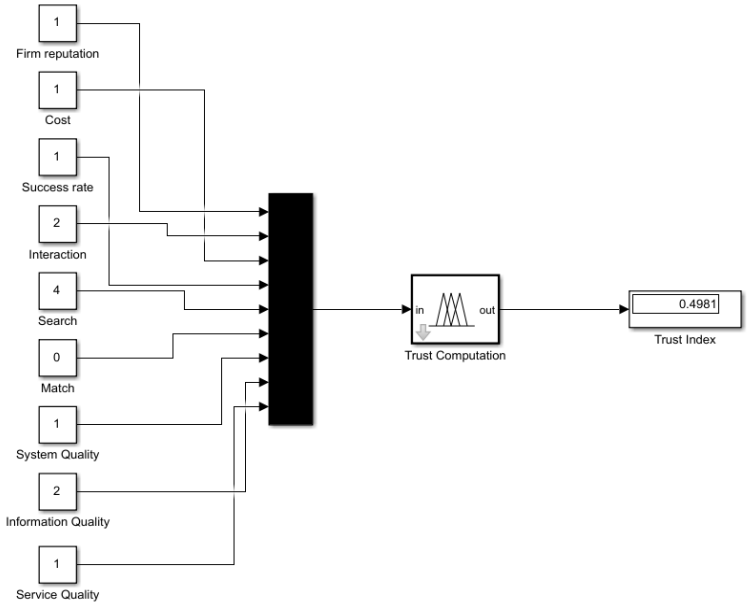

Fig 5. Generation of Trust Index

The model suggests the range of trust as shown below.

Table 11. shows trust value

Trust-Index	Linguistic Value
0-0.3	Low Trust
0.31-0.6	Moderate Trust
0.61-0.97	High Trust

As we can see from overall ranking comparison table 9 top three factors are subscription charges, success stories and goodwill. They have significant impact on development of trust-index.

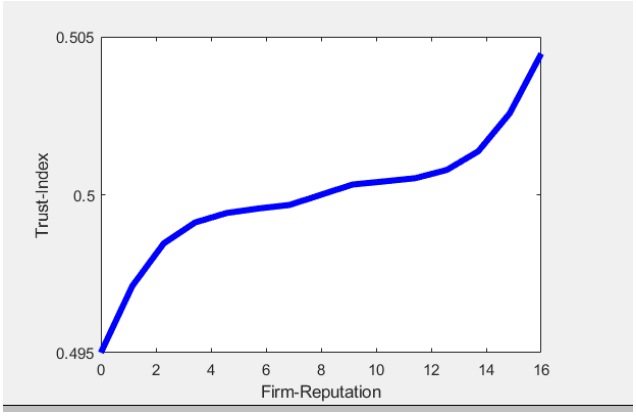

Fig 6. Trust vs Firm reputation

The relationship between firm reputation and trust as depicted by graph clear positive correlation. The findings suggest that an increase in a firm's reputation is directly associated with a higher trust index. This implies that reputation management is a critical factor for organizations aiming to build and maintain trust. As the firm's reputation solidifies, it may be necessary to explore innovative approaches to continue building trust, such as fostering customer loyalty or leveraging brand ambassadors.

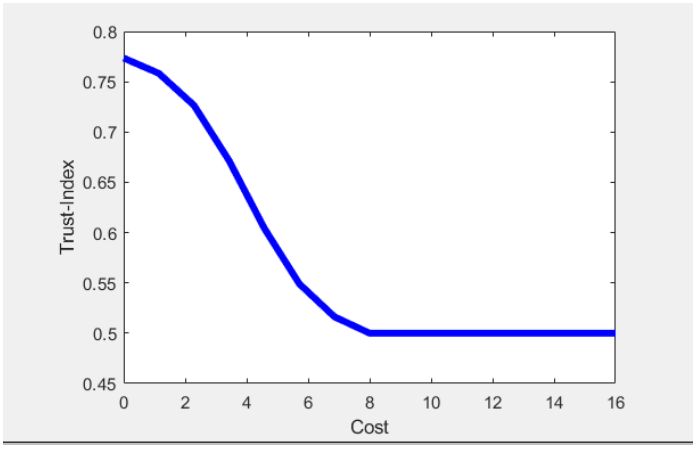

Fig 7. Trust vs Cost

The steep decline in the trust index with increasing costs indicates that customers are highly sensitive to cost increases. Firms must therefore be cautious when raising prices or passing on costs to customers, as this could severely undermine trust.

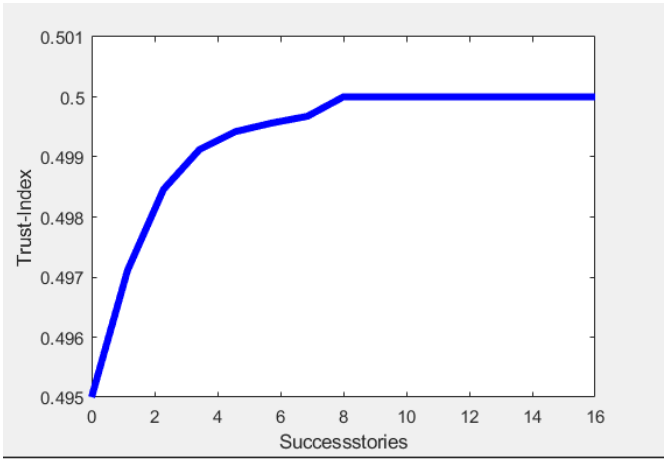

Fig 8. Trust vs Success stories

The relationship between success stories and trust index, as depicted in the graph, shows that an increase in the number of success stories initially leads to a noticeable rise in trust. This suggests that sharing success stories is an effective way to build trust among customers. Success stories are powerful tools in building trust, especially when a firm is in the early stages of its reputation-building efforts. Each success story adds credibility and reinforces the firm ‘s reliability in the eyes of customers.

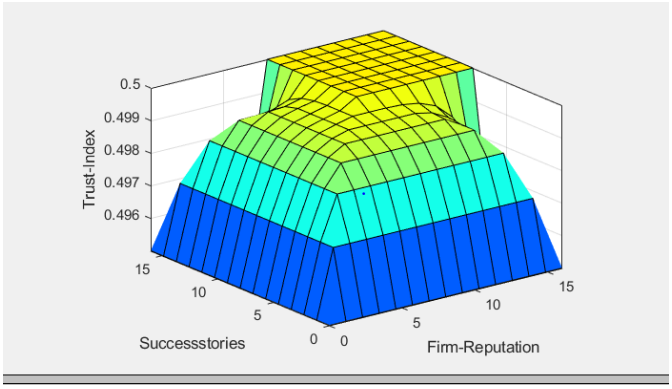

Fig 9. Trust vs Success stories and Firm reputation

It appears that both “success stories “and “firm reputation “are positively correlated with the “Trust-Index”. As the variables increase, the “Trust Index” also increases. For a firm looking to maximizing its “Trust-Index”, focusing on improving both “success stories” and “firm reputation” simultaneously might be an effective strategy.

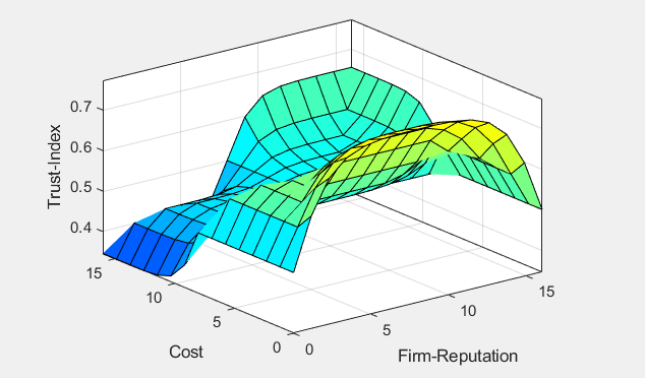

Fig 10. Trust vs Cost and Firm reputation

Initially, increasing cost might improve the “Trust Index,” but after a certain point, further increase in cost could reduce trust, especially if “firm reputation” is not high enough to compensate. Firms should carefully manage their costs to stay within the range where they can maximize the “Trust-Index” particularly if they are working on building or maintaining a strong reputation.

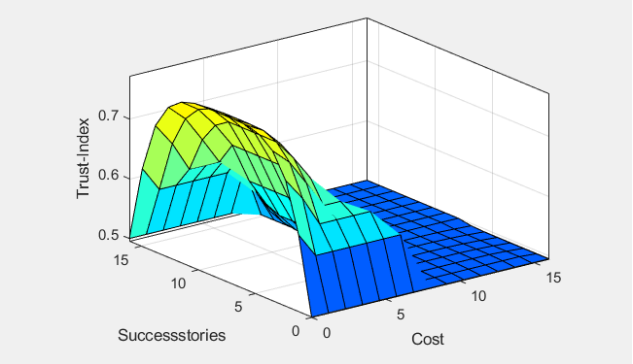

Fig 11. Trust vs Success stories and Cost

The surface demonstrates that the trust-index increases with an initial increase in both success stories and cost. However, beyond a certain point, further increase in cost seem to have a diminishing or even negative impact on the trust-index. The graph indicates that success stories significantly influence the Trust-Index, especially when coupled with moderate costs. Organizations can boost trust without exorbitant spending by effectively leveraging their success stories. Develop communication strategies that highlight key success stories, ensuring that these narratives reach the target audience. Use these stories to build and maintain trust cost-effectively, balancing storytelling with strategic spending. Subscription charge directly impact the trust-index ,organization should closely monitor competitor pricing strategies to ensure their own pricing remains competitive and trust-enhancing.

5. Conclusion

The evolution of customer-to-customer (C2C) e-commerce platforms has brought significant opportunities for peer-to-peer transactions but also introduced new challenges in ensuring trust between users. Traditional methods of trust evaluation, often designed for business-to-consumer (B2C) contexts, are inadequate for the dynamic and subjective nature of C2C interactions. To address these challenges, a fuzzy logic-based system offers a promising solution. Fuzzy logic allows for a more flexible approach to trust evaluation by accommodating the inherent uncertainties in human behaviour and decision-making. By incorporating various factors such as firm reputation, success stories, and cost etc, this system can provide a more comprehensive and reliable assessment of

trustworthiness on C2C matchmaking virtual platforms. As a result, it can enhance the user experience, reduce the risk of fraudulent activities, and ultimately contribute to the sustainable growth of C2C virtual matchmaking portals. The adoption of such advanced trust evaluation systems is essential for the future of C2C online matrimony portals , where trust remains a critical determinant of success. By leveraging fuzzy logic, C2C platforms can better meet the expectations of their users, fostering a safer and more trustworthy online marketplace.

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