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| RESEARCH ARTICLE

Evaluation of Online Markets Considering Trust and Resilience: A Framework for Predicting Customer Behavior in E-Commerce

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| ABSTRACT
The evolution of electronic commerce has led to expanding online markets due to convenience, online incentives, greater access to information, broader selections, competition, pricing, product quality, and lead time, i.e., the time that it takes to deliver the products after an order is placed. However, online markets have captured less attention in environments where consumers are concerned about the security and privacy of their personal data. Such concerns can be due to several reasons, from the reluctance in using electronic commerce to the lack of trust and reliability of web vendors. In this paper, we study trust and resilience engineering in such online markets and identify the most and least significant factors impacting online shopping systems. To tackle the inherent uncertainties of data used in our analysis, we propose a Fuzzy Data Envelopment Analysis (FDEA) model and validate our findings. Numerical examples show the efficiency of the proposed method in evaluating online and offline shopping systems with respect to trust and resilience.

| KEYWORDS
Online shopping, traditional shopping, trust in markets, resilience engineering, fuzzy set theory

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1. Introduction

1.1 Introduction and Literature Review

In today's world, many businesses have pursued the Internet as a means through which they can navigate their marketing activities for competing with their business rivals (S. J. Tan, 1999). It is because the Internet provided added value in markets by increasing processes efficiency, shortening lead times, and automating processes that previously required personnel (Mahmood *et al.,* 2008). As a result, customers are inundated with countless analogous offerings. Nowadays, more than ever, customers insist on their needs to be instantly met, utterly and without paying any extra money (Ahn *et al.,* 2005). Thus, practitioners believe that the most important challenging point in electronic commerce is to meet customers' requirements, make them satisfied, and be competent at serving their customers (Ahn *et al.,* 2005; Miremadi and Ghanadiof 2021a).

The growth of electronic commerce has rapid acceleration because of its advantages such as various choices, convenience, saving time, rapid price comparison, different product quality, and greater access to information (Keeney 1999; Riegelsberger *et al.,* 2005). In fact, sales through online channels are increasing due to the increasing penetration of the Internet worldwide, consumer acceptance of the convenience of online shopping, and increasing emphasis on online shopping (Schubert *et al.,* 2011). While the acceptance of electronic commerce continues to grow, customers' concerns about privacy and security necessitate considering trust and reliability in online market activities (Urban *et al.,* 2009). Such concerns come from customers due to insecurity and dissemination of the available information and the lack of trust and reliability of web vendors. Therefore, trust and reliability play crucial roles in such online interactions (Teo *et al.,* 2007) to mitigate uncertainties in online shopping. The importance of trust is because of its effects on a number of essential factors to online transactions, such as security and privacy. Despite the fact that electronic commerce has advantages to not only customers but also vendors, it also has restrictions like the temporal separation between transaction parties. In order to decrease the blockades, a businessperson must create a trustworthy relationship to develop customer loyalty (Teo *et al.,* 2007; Ghanadiof 2021). The antecedent and background of trust empower us to realize the relative importance of factors that affect trust. In e-commerce, although the importance of trust is completely recognized and acknowledged, there are still many contradictions in online markets. The basis of these contradictions is because of having great difficulties in defining trust, understanding the definition of trust and its antecedents and consequences, failing to consider both trustee and trustor, and confusing levels of analysis due to lack of specificity of trust referents (Mayer *et al.,* 1995; Miremadi and Ghanadiof 2021b).

To incorporate trust in markets, Mayer (Mayer *et al.,* 1995) offered a model combining both trust parties, trustor and trustee, and considered the trustor's perceptions related to the trustee's characteristics. At the beginning of the advent of trust requirements, trust among people and organizations attracted little attention. Actually, there were a few studies that considered consumer trust in Internet shopping. Some researchers like Jarvenpaa (Jarvenpaa *et al.,* 1999) pursued limited models which just focused on the Internet merchant and, in the context of e-commerce, he examined whether some factors like reputation and size of internet stores affect customers trust (Jarvenpaa *et al.,* 1999). Consequences of trust and their effects on customers' behaviors, intentions, and attitudes have been investigated by some practitioners (Jarvenpaa *et al.,* 1999; McKnight *et al.,* 2000; Miremadi and Ghanadiof 2021c; Ghanadiof *et al.*, 2021). The influence of channel integration of a multi-channel firm on customer loyalty has been reviewed by Bendoly (Bendoly *et al.,* 2005). Understanding the fact that design can influence customers' trust (Nielsen, 1999) has led to the development of some researches, such as computer supported cooperative work (CSCW) and human-computer interaction (HCI), and providing systems and environments which are capable of creating, maintaining and increasing trust among consumers and machines, and also among consumers themselves. (Corritore *et al.,* 2003; Sillence *et al.,* 2006).

Regarding the effect of cultural factors on trust, Hofstede (Hofstede, 1984) proposed four dimensions, particularly national culture. Some structures of experimental trust-building processes have been proposed which demonstrate the significance of culture in the expansion and development of trust (Doney *et al.,* 1998; Miremadi and Ghanadiof, 2021b). In a similar vein, Jarvenpaa and Tractinsky (Jarvenpaa et al., 1999) proposed that the antecedents of consumer trust in an online transaction can be affected by cultural factors. Furthermore, cross-cultural e-commerce adoption models were proposed in the literature (Pavlou *et al.,* 2002; Ghanadiof 2021), which showed that customers' attitudes could be directly influenced by trust in different cultures.

Mcknight and Chervany (McKnight *et al.,* 2012) have justified a parsimonious interdisciplinary typology of trust types, defining two levels of trust construct, conceptual-level and operational-level. Walczuch and Lundgren (Walczuch *et al.,* 2004) examined Psychological antecedents of trust in e-vendors. Koufaris and Hampton-Sosa (Koufaris *et al.,* 2004) proposed a model of initial trust and used a questionnaire-based field study to empirically test the model, and results show that initial trust can be affected directly by perceived reputation and inclination to customize products and services. Pennington (Pennington *et al.,* 2003) demonstrated the importance of some interventions that affect trust. Lee MKO (Lee *et al.,* 2001) described a theoretical model and emphasized the importance of merchant integrity in consumer trust Internet shopping.

In another stream of research, a few studies, i.e., (Gefen *et al.,* 2003; Pavlou, 2003; Gefen & Straub, 2004; Ghashami and Kamyar, 2021), have proposed an integrated model of trust with technology acceptance and shown the importance of social presence on these dimensions. Trust has been examined in different English-speaking countries and newly industrialized countries such as the US (Kennedy *et al.,* 2001), Australia (Jarvenpaa et al., 1999), US and Israel (Jarvenpaa et al., 1999), Japan and America (Yamagishi 1994), South Africa Gefen (Gefen *et al.,* 2005; Miremadi *et al.,* 2021b), and Singapore (Teo & Liu, 2007).

Table 1. Literature review summary

	(McKnight Chervany, 2012)	(Tan, 2001; Miremadi and Ghanadiof 2021a)	(Tan, 2003; Miremadi and Ghanadiof 2021b)	(Gefen, 2003 ; Knell & Stix, 2010; Pavlou, 2003; Ghanadiof 2021)	This study
Typology of trust types	√				
Trust model		√	√		
Trust & technology acceptance model				√	√
Impressive factors of trust					√
Trust in traditional shopping					√

Trust in e-commerce		√		√	√
Resilience in traditional shopping					√
Resilience in e-commerce					√

In addition to trust, evaluating the effects of resilience engineering (RE) is another important factor in online and traditional shopping systems. Resilience is the capability of recognizing, adapting to, and coping with unexpected events (Filabadi and Bagheri, 2021). RE provides provocative penetration into system safety as an aggregate of its various components, subsystems, software, organizations, human behaviors, and the way in which they interact (Hollnagel, 2011; Miremadi *et al.,* 2021a, Sadighpour *et al.,* 2022, Movahednia *et al.,* 2021; Movahednia *et al.,* 2022a). Resilience Engineering has arisen as a natural growth from the principles of organizational reliability (Reason *et al.,* 1997; Weick *et al.,* 2008) and a new comprehension of the factors behind human performance and also human error (Woods *et al.,* 1994; Ghashami *et al., 2021*). Consequently, the new field is fostering ways to combine human and organizational risk in engineering tools of life cycle systems and to develop knowledge management tools that take the effects of human and organizational factors on risk (Filabadi and Bagheri, 2021; Movahednia et a., 2022b).

In the literature of online markets, as shown in Table 1, previous studies mainly focused on the impacts of trust in their analysis and considered only two main factors of trust, i.e., integrity and structural assurance, that have been mostly considered. However, researchers have shown there are two additional important factors of trust, such as benevolence and competence, and figuring out the effect of each individual factor can help users create appropriate measures to incorporate trust (Teo *et al.,* 2007). In this paper, we consider four factors of trust and analyze the consequences of all factors of trust to predict customer behavior. Furthermore, we also consider resilience engineering, in addition to trust, in evaluating online markets and providing more accurate and comprehensive analysis. Particularly, in this paper, we investigate the effects of trust, management commitment, awareness, flexibility from the resilience engineering principles and use the concept of data envelopment analysis (DEA) method to evaluate the factors affecting trust and resilience and rank them based on their impacts. In addition, in order to address the potential uncertainties in input data, we propose a fuzzy model combined with the DEA method and evaluate our results. The contributions of this paper are highlighted as follows:

- We evaluate online markets considering four factors of trust such as benevolence, integrity, competence, and structural assurance, and also incorporate resilience engineering in our analysis, which is the first study that considers both trust and resilience in the evaluation model.
- We propose a fuzzy data envelopment analysis (FDEA) model to analyze the factors affecting trust and resilience and rank them based on their impacts considering the uncertainties in data.
- We provide a framework for predicting customer behavior which is beneficial in various businesses to find an optimal decision based on such prediction.

2. Methodology

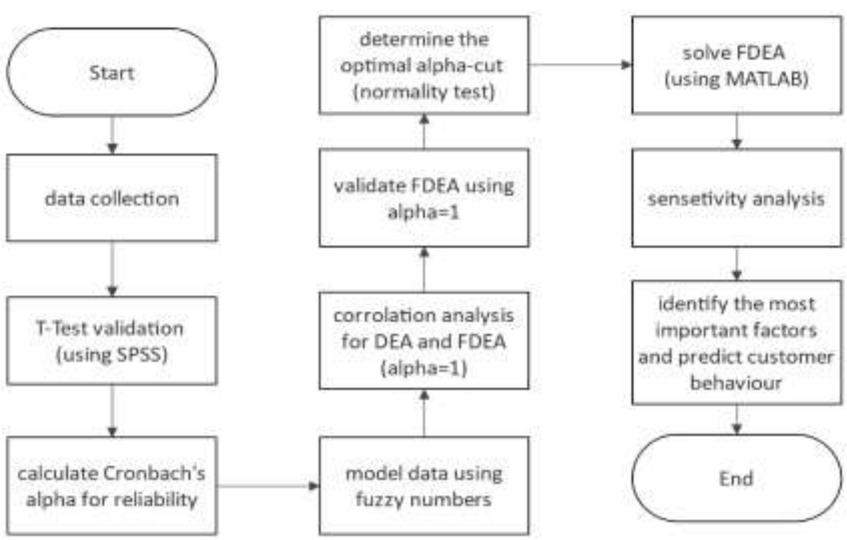

Figure 1. A schematic diagram on the steps of our methodology

In this paper, the methodology consists of data collection, statistical tests and modeling, sensetivity analysis, and performance evaluation. To do so, we use data envelopment analysis and fuzzy theory for identifying the most important factors in markets under uncertainty in data. Also, we use statistical tools to validate our results. Figure 1 shows a schematic diagram of the steps used in the methodology. Required details on each step are provided throughout this section.

2.1 Data envelopment analysis

Data envelopment analysis (DEA) is a non-parametric technique which is initially proposed by Charnes (Charnes, Cooper *et al.,* 1978). This technique is used to evaluate the relative efficiencies of a set of homogenous decision-making units (DMUs). For ranking the efficiencies, a ratio of the weighted sum of outputs to the weighted sum of inputs is used as follows (Talluri 2000):

$$\mathrm{E} = (\text{weighted sum of outputs})/(\text{weighted sum of inputs}) \quad (1)$$

Consider the following notation.

s : the number of DMUs
y_{ki} : is the amount of output p produced by the i^{th} DMU
x_{ij} : represents the amount of input j consumed by the i^{th} DMU
v_j : represents the given weight to input j
u_k : represents the given weight to output k

Charnes (Charnes *et al.,* 1978) proposed a model to acquire the relative efficiency score of a test DMU (for example, the p^{th} DMU) where Each DMU has the same m inputs and same s outputs. The proposed model is as follows:

$$Max \quad \frac{\sum_{k=1}^{s} u_k y_{kp}}{\sum_{j=1}^{m} v_j x_{jp}} \quad (2)$$

$$s.t. \quad \frac{\sum_{k=1}^{s} u_k y_{ki}}{\sum_{j=1}^{m} v_j x_{ji}} \le 1 \qquad \forall\, i = 1, \dots n \quad (3)$$

$$v_j, u_k \ge 0 \quad (4)$$

Where (2) is the objective function to maximize the relative efficiency score. Constraint (3) ensures the relative efficiency scores are all at most 1, and constraint (4) is the non-negativity constraint to assign practical weights to inputs and outputs.
The proposed program is nonlinear due to objective function (2) and constraint (3). Therefore, we transform this program into a linear program as shown below:

$$Max \quad \sum_{k=1}^{s} u_k y_{kp} \quad (5)$$

$$\sum_{j=1}^{m} v_j x_{jp} = 1 \quad (6)$$

$$\sum_{k=1}^{s} u_k y_{ki} - \sum_{j=1}^{m} v_j x_{ji} \le 0 \qquad \forall\, i = 1, \dots n \quad (7)$$

$$v_j, u_k \ge 0 \quad (8)$$

For measuring the efficiency of n DMUs, this program should be run for all DMUs (n times). A DMU with a higher score (which is equal to 1 due to the design of the model) is considered to be efficient, and a DMU with a score of less than 1 is inefficient.

2.2 Fuzzy Data Envelopment Analysis (FDEA)

Data Envelopment Analysis is highly sensitive to the input data, and thus an inaccurate measurement of input and output data can lead to wrong analysis, such as choosing an inefficient DMU as the most efficient DMU. Data uncertainty is inevitable and has appeared in many applications such as business, network management (Filabadi and Bagheri*,* 2021), energy production (Dehghani Filabadi*,* 2019; Movahednia et al., 2020), power grids (Movahednia et al., 2021), etc.

Uncertainty management has been the topic of research in the last decades. Several approaches such as the budget of uncertainty (Bertsimas and Sim, 2004), scenario-based stochastic programming (Asadi *et al.,* 2022), and robust adjustable optimization

(Ardestani-Jaafari and Delage, 2016) have been proposed and implemented in various applications to deal with uncertainty. Recently, a new approach as the effective budget of uncertainty (Filabadi and Azad, 2020; Filabadi and Mahmoudzadeh, 2022; Filabadi, 2022) was proposed that addresses the limitations of previous uncertainty modeling approaches and is being implemented in various areas. The mentioned approaches have been demonstrated to be effective for quantitative data. Alternatively, Fuzzy set theory is a proper way of addressing data uncertainty, particularly when data are represented in the form of qualitative and linguistic data (Zimmermann 1992). In this research, we collect data in the form of a qualitative questionnaire to target wider ranges of customers, such as old people with minimal education. Thus, considering the type of data collected through a questionnaire in this paper, the FDEA is the most appropriate method for analyzing the factors.

Fuzzy DEA models, therefore, are capable of representing real-world problems in a more accurate way than the conventional DEA models. In this section, we implement the concepts of the fuzzy theory below (Azadeh *et al.,* 2008) in the presented DEA model and represent an FDEA model as follows, where '~' in notations represents the fuzziness (the reader is referred to (Azadeh *et al.,* 2008) for further details).

$$Max \sum_{k=1}^{s} u_k \tilde{y}_{kp} \tag{9}$$

$$s.t. \sum_{j=1}^{m} v_j \tilde{x}_{jp} = 1 \tag{10}$$

$$\sum_{k=1}^{s} u_k \tilde{y}_{ki} - \sum_{j=1}^{m} v_j \tilde{x}_{ji} \leq 0, \quad \forall\, i = 1, \dots n \tag{11}$$

$$v_j, u_k \geq 0 \tag{12}$$

Among several types of fuzzy numbers, fuzzy triangular numbers are more applicable (Azadeh *et al.,* 2008). In this paper, the DMUs inputs and outputs are considered as fuzzy triangular numbers where a fuzzy number $\tilde{a}$ that is submect to uncertainty is modeled using three numbers representing the mean (m), lower (l), and upper (u) value of that number. In particular, for each fuzzy number $\tilde{a}$, we model it by $\tilde{a} = (a^m, a^l, a^u)$. Therefore, considering fuzzy numbers $\tilde{x}_{ij}$ and $\tilde{y}_{ij}$, we have

$$x'_{ij} = (x_{ij}^m, x_{ij}^l, x_{ij}^u), \tilde{y}_{ij} = (y_{ij}^m, y_{ij}^l, y_{ij}^u) \tag{13}$$

And thus program of (5)-(8) can be written as follows:

$$Max \sum_{k=1}^{s} u_k (y_{kp}^m, y_{kp}^l, y_{kp}^u) \tag{14}$$

$$s.t. \sum_{k=1}^{s} v_j (x_{kp}^m, x_{kp}^l, x_{kp}^u) = 1 \tag{15}$$

$$\sum_{k=1}^{s} u_k (y_{ij}^m, y_{ij}^l, y_{ij}^u) - \sum_{k=1}^{s} v_j (x_{ij}^m, x_{ij}^l, x_{ij}^u) \leq 0, \quad \forall\, i = 1, \dots n \tag{16}$$

$$v_j, u_k \geq 0 \tag{17}$$

Program (14)-(17) is a linear mathematical program that can be solved easily using commercial solvers such as CPLEX in MATLAB or GAMS. We solve this program n times (each time for one DMU) and then determine the most efficient DMU based on the values obtained. This program properly addresses data uncertainty using 3 values for a fuzzy number.

3. Case Study and Numerical Results

Data are collected through Questionnaires that have been handed to customers and workers of a shopping center that has both online and traditional types of business, which its central office is located in Tehran. The questionnaire consists of 28 trust-related questions and 10 resilience-related questions. The score (weight) to each question was assigned between 1 and 10, and also it includes fractional scores. For determining the validity of a questionnaire, two random samples, with a random number of elements from each factor, have been chosen, and a T-test has been applied. The reliability of the questionnaire has been determined using Cronbach's Alpha. The reliability analysis of a questionnaire determines its ability to get similar results on different occasions and also concerns the consistency among the questions. Validity refers to whether the researchers actually measured what they were supposed to measure (Cooper *et al.,* 2003).

The hypothesis is:

$$H_0: \ \mu_1 = \mu_2 = \dots = \mu_{11}$$

$$H_1: \ \mu_i \neq \mu_j, \quad \forall i, j = 1, \dots, 11, \quad i \neq j$$

According to the done normality test, in traditional shopping, lower bound efficiency is a good index for selecting the efficient factors, while in online shopping case, upper bound efficiency is better. The efficiency of DMUs has been calculated with different α-cut (0.01, 0.05, 0.1, 0.2, 0.3, 0.4, 0.5, 0.6, 0.7, 0.8, 0.9, 0.95, 0.99, 1) to find the optimal α-cut.

Table 2. Tests of Normality for traditional shopping

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	df	Sig.	Statistic	Df	Sig.
a=0.01	.086	89	.104	.953	89	.003
a=0.05	.086	89	.111	.954	89	.003
a=0.1	.087	89	.091	.954	89	.003
a=0.2	.097	89	.036	.954	89	.003
a=0.3	.103	89	.021	.953	89	.003
a=0.4	.111	89	.009	.949	89	.002
a=0.5	.112	89	.008	.948	89	.001
a=0.6	.109	89	.011	.949	89	.002
a=0.7	.102	89	.200	.952	89	.002
a=0.8	.089	89	.079	.953	89	.003
a=0.9	.084	89	.168	.956	89	.004
a=0.95	.080	89	.199*	.957	89	.005
a=0.99	.078	89	.199*	.958	89	.006
a=1	.087	89	.096	.958	89	.006

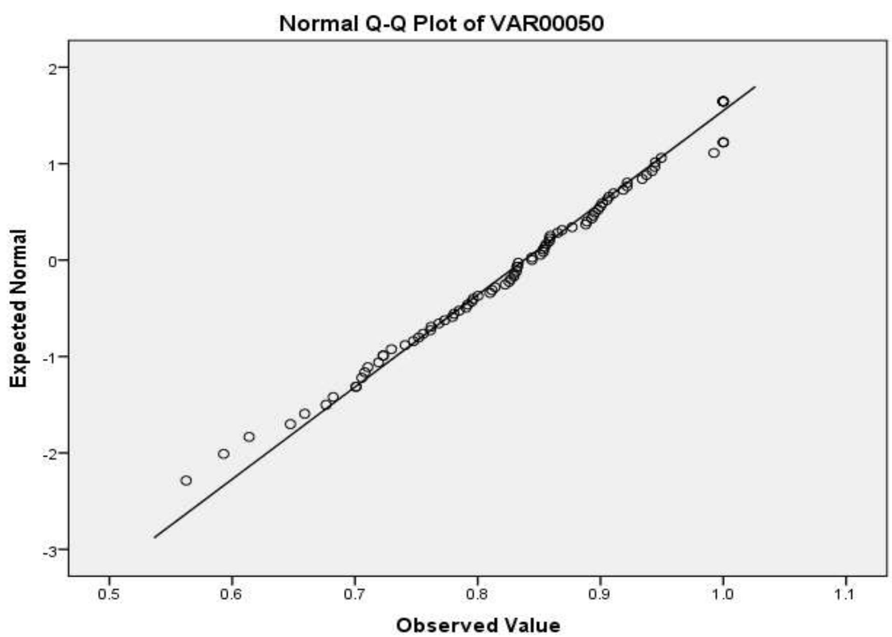

Figure 2. Normal plot for α-cut=0.7

According to the results (Figure 2 and Table 2), the optimal α-cut for the traditional shopping system is α-cut = 0.7 that is chosen for this model. Similarly, we carried out the same analysis using the data of online shopping. In what follows, we present the results for the online shopping in Figure 3 and Table 3, based on which we can conclude that the optimal α-cut for the Online shopping system is α-cut = 0.4.

Table 3. Tests of Normality for online shopping

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	Df	Sig.	Statistic	Df	Sig.
a=0.01	.120	89	.003	.919	89	.000
a=0.05	.116	89	.005	.924	89	.000
a=0.1	.114	89	.006	.927	89	.000
a=0.2	.103	89	.021	.938	89	.000
a=0.3	.092	89	.063	.949	89	.002
a=0.4	.073	89	.200*	.958	89	.006
a=0.5	.073	89	.199*	.964	89	.014
a=0.6	.068	89	.199*	.965	89	.016
a=0.7	.065	89	.199*	.971	89	.046
a=0.8	.078	89	.199*	.968	89	.028
a=0.9	.069	89	.199*	.968	89	.027
a=0.95	.079	89	.199*	.967	89	.024
a=0.99	.079	89	.199*	.967	89	.024
a=1	.079	89	.199*	.967	89	.023

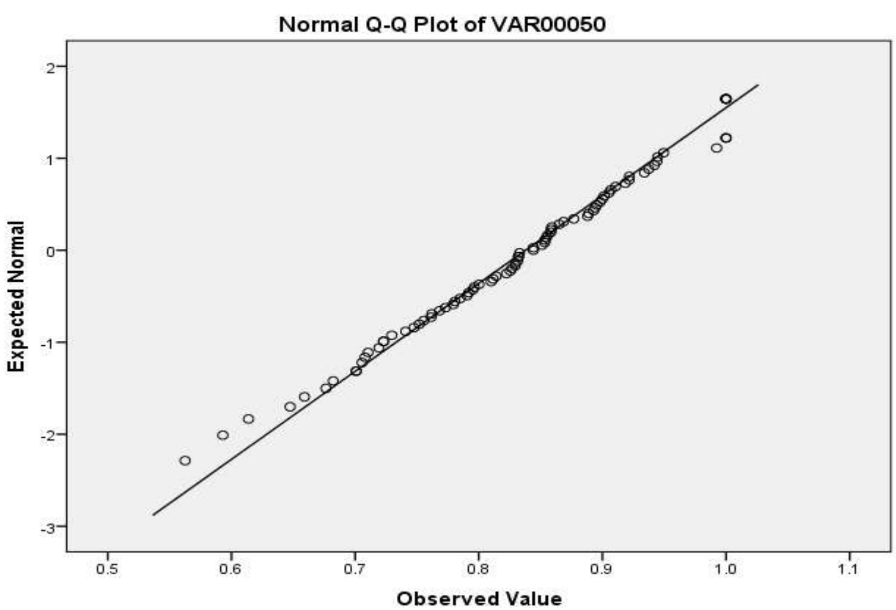

Figure 3. Normal plot for α-cut=0.4

The efficiency of DMUs is examined by DEA with optimal α-cu for both systems and by FDEA with α-cut = 1. The correlation results are summarized in Table 4, based on which we conclude that we can use the FDEA method instead of DEA. It is because we have a high correlation (1), which means the analysis allows us to use FDEA, and our results will remain valid.

Table 4. Validation of FDEA by DEA

Traditional shopping lower bound	DEA(α-cut=0.7) FDEA(α-cut =1)	Correlation 1
Online shopping Upper bound	DEA(α-cut=0.4) FDEA(α-cut =1)	Correlation 1

3.1 Sensetivity Analysis

To predict customer behavior, we would like to see the effect of various factors on the mean efficiency and FDEA value for the most efficient α_cut (i.e., α_cut=0.7). Such analysis would help users figure out the impact of each factor in both traditional and online markets. As a result, one can define various strategies for their online markets based on the most important factors identified. We have used the collected data and analyzed the effects of omitting all factors independently on the mean efficiency. The results are shown in Tables 5 and 6.

From Tables 5 and 6, one can conclude that integrity as a trust-related factor is the most important factor in traditional shopping systems (due to lower values of FDEA), which can influence people's trust in traditional shopping systems. Furthermore, awareness is the most important factor among resilience-related factors in traditional shopping systems. In online shopping systems, to capture customers' trust, we still need to pay important attention to integrity since it has the most impact among trust-related factors. However, in such online markets, management commitment plays an important role among resilience-related factors. Such analysis helps us understand that an online shop with a better management commitment store is more capable of attracting customers' attention and making them loyal customers. Thus, in today's world, one can conclude to design strategies to improve the level of management commitment and make the customers know that so that the business benefits from this factor.

Table 5. Sensitivity analysis Traditional shopping

Correlation	Competence	Integrity	Benevolence	Flexibility	Awareness	Management commitment
FDEA α_cut=0.7	0.9948	**0.9643**	0.9751	0.9865	**0.9017**	0.9948
Mean of efficiency	0.7934	0.7709	0.7839	0.7865	0.7603	0.7934

Table 6. Sensitivity analysis online shopping

Correlation	Structural Assurance	Competence	Integrity	Benevolence	Flexibility	Awareness	Management commitment
FDEA α_cut=0.4	0.9767	0.9176	**0.8389**	0.8755	0.9874	0.9892	**0.8389**
Mean of efficiency	0.8822	0.8679	0.84921	0.9450	0.8837	0.8848	0.8492

We carried out further analysis to compare the efficiency of both online and traditional shopping systems. In particular, Table 7 compares online and traditional shopping systems from a high-level prosoective where we combine the efficiency of trust and resilience factors. It is observed from the table that the online shopping system is more than 20% more efficient than traditional shopping systems, which is significant in competitive markets and provides suppliers with the opportunity to shift to online markets.

Table 7. Comparison of two systems

	Traditional Shopping	Online shopping
Mean of efficiency	0.6675	0.8104

Furthermore, to analyze the impacts of each trust and resilience factor individually, we carried out a further analysis which is summarized in Table 8. From Table 8, we conclude that trust factors are the most efficient factors in both traditional and online shopping systems. Thus, managers may prioritize their investment on trust and resilience factors based on such analysis. It is also observed that trust and resilience factors are significantly more efficient in online markets than traditional markets.

Table 8. Mean of efficiencies

	Traditional shopping		Online shopping	
	Trust factors	Resilience factors	Trust factors	Resilience factors
Mean of efficiency	0.6957	0.6392	0.8221	0.7988

4. Conclusion

Considering the advantages of e-commerce to not only customers but also vendors, these days, many businesses are using the Internet as a means through which they are able to navigate their marketing activities for competing with their business opponents. Trust plays a crucial role in these interactions because of uncertainty and dependency, which exist in many social and economic interactions over the Internet and consumers' concerns regarding the insecurity and dissemination of their personal information and also the lack of trust of web vendors. In this article, traditional and online systems from trust and resilience engineering factor points of view have been analyzed by using a questionnaire. Based on our comprehensive analysis, we conclude that trust and resilience factors are much more efficient and crucial in online shopping than traditional shopping. From a lower-level analysis, we have shown that integrity is the most important factor among trust-related factors in both traditional and online markets. However, it is more crucial in online markets. On the other hand, among resilience-related factors, awareness is the most important factor in traditional shopping, while management commitment is the most important resilience-related factor in online shopping systems. Thus, in today's world, one can conclude to design strategies to improve the level of management commitment and make the customers know that so that the business benefits from this factor. Data in this research has been collected through a questionnaire in the form of qualitative data. A future research direction is to collect quantitative data and form our analysis using recent uncertainty modeling approaches (such as Ardestani-Jaafari and Delage, 2016; Filabadi and Azad, 2020; Filabadi and Mahmoudzadeh, 2022; Filabadi, 2022) as well as fuzzzy approach. A comprehensive comparison using various approaches to address uncertainty would provide users with a framework that highlights the importance, applications, and limitations of each approach in the literature, which can be the direction for future research.

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