An International Journal
JSCDSS
http://www.jscdss.com
Vol.4 No.2 April 2017: 14-20
Article history:
Accepted 29 April 2017
Published online 29 April 2017

Journal of Soft Computing and Decision Support Systems

E-ISSN: 2289-8603

A Fuzzy Logic Analysis of E-Commerce Website Quality Factors for Customers' Purchase Intention

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Abstract

The increasing rate of online purchasing has resulted in the emergence of novel economical activities. It is essential to comprehend consumers' intention to achieve highly competitive advantages offered by e-commerce. Understanding what motivates consumers is crucial because such motivation is of paramount importance to succeed in this hypercompetitive and fast-paced environment. Business-to-Consumer (B2C) e-commerce is one of the various types of e-commerce, which has turned into an influential key to retailing channel. Using fuzzy logic method, this paper was aimed to find out the importance of key factors affecting the consumers' intention to purchase on B2C e-commerce websites. Findings can help researchers and decision makers to determine the factors that can satisfy consumers when using an e-commerce and persuade them to do online purchase. To achieve the objectives of this study, fuzzy logic was employed to effectively assess the factors. The outcome of the proposed system helps shopping websites managers and service providers to know the real level of the factors' importance, which in turn helps them improve their website quality.

Keywords: Fuzzy Logic, B2C Websites, Intention to Purchase, Electronic Commerce.

1. Introduction

In recent years, e-commerce has offered substantial advantages to both consumers and sellers (Schneider, 2007; Schaupp and Bélanger, 2005). According to (Schneider, 2007), e-commerce is the utilization of the web to sell services or products to individual consumers. Many enterprises have therefore embraced the use of e-commerce as an important trading tool to achieve higher efficiency in their daily business processes (Schaupp and Bélanger, 2005).

Trust has been taken into consideration comprehensively in economics (Akter et al., 2012), marketing (Done and Cannon, 1997), and electronic commerce (Pavlou, 2003). Trust has been shown significantly effective on customers' decision to buy in an e-commerce context (Hong and Kim, 2012). Therefore, it is a crucial task to identify significant factors of customer' trust in e-commerce and reveal their actual level of importance. This helps firms to focus on factors and elements with the highest significance to determine the most appropriate policy for improving their websites with high quality and effectiveness for e-commerce. To this end, fuzzy logic has been developed to handle mathematically the vagueness of human linguistics and thinking. In addition, fuzzy logic and fuzzy set are more appropriate in human linguistic reasoning with imprecise concepts in relation to crisp approaches (Nilashi and Ibrahim, 2014). In the evaluation of qualitative information related to human opinions, perceptions, and tastes, linguistic phrases are of higher importance than numerical ones. As a result, to reveal the actual importance level of trust factors, it is more appropriate that the linguistic terms be considered for users to express their knowledge, preferences, knowledge, and personal judgments. This paper is accordingly aimed to develop an assessment tool for customers' trust based on websites' features to improve the intention of purchasing on an e-commerce website. In online environment, three aspects most related to trust are security, privacy, and information quality (Flavián and Guinalíu, 2006; Ponte et al., 2015). Therefore, this research proposes perceived security, perceived privacy, and information quality as three antecedents of trust, and the relationships between them are analyzed and consequently an analysis is done on the effect of trust on customers' intention of purchasing to find out the extent to which these relationships are widespread. Table 1 shows previous studies that have investigated the effect of trust, perceived privacy, perceived security, and information quality on intention to purchase on e-commerce websites, and Table 2 presents the definitions of aforementioned factors.

This paper is organized as follows. The next section discusses research methodology, Section 3 presents the proposed fuzzy logic system together with the obtained results, and finally, Section 4 concludes the paper.

2. Methodology

In this paper, an expert system was developed to assess the Business-to-Consumer (B2C) websites quality factors

that affect customers' trust and accordingly the customers online purchase intention and find their importance level with adopting the fuzzy set theory. Using fuzzy logic approach, the model of assessment was constructed based on features of the B2C websites, which have been used widely in previous studies. The main objectives of this research are:

1. To evaluate the B2C websites quality factors that influence customers online purchase intention using the customers' perspective.
2. To develop an expert system to evaluate the B2C websites' features and find their importance level from the customers' perspective when making decision to choose an appropriate website for their online shopping.

Accordingly, our study addressed the following research questions:

- What are the importance level of Security, Privacy, and Information Quality of B2C websites from the customers' perspective?
- What is the customers' trust level based on their perception of Security, Privacy, and Information Quality?
- How to assess the importance levels of Security, Privacy, and Information Quality of B2C websites from the customers' perspective?
- This study was conducted using fuzzy logic approach for assessing the features of B2C websites. Our research aimed at developing an expert system for assessing the features using fuzzy logic, which was mainly based on human knowledge and experience. The knowledge-based expert systems use human knowledge to solve problems that normally would require human intelligence. A total of 304 students with experience of working with B2C shopping websites were selected and knowledge in the fuzzy logic system was discovered from the collected data. Fig. 1 shows the research framework of this study. Our research involved several chronological steps.

Table 1

Summary of Factors from Previous Studies in Consumers' Purchase Intention on E-commerce Websites

Factor	Reference
Trust	(Chen and Teng, 2013; Hong and Kim, 2012)
Perceived Security	(Kim et al., 2011; Azam et al., 2012)
Perceived Privacy	(Azam et al., 2012; Chiu et al., 2009, Ponte et al., 2015)
Information Quality	(Chen and Teng, 2013; Ponte et al., 2015)

Table 2

Definition of the Important Factors in Intention to Purchase on E-commerce Websites

Factor	Definition	Reference
Trust	"The willingness of a party to be vulnerable to the actions of another party based on the expectation that the other will perform a particular action important to the trustor, irrespective of the ability to monitor or control that other party"	Mayer et al. (1995)
Perceived Security	"Consumers' perceptions about the security of the online transaction (i.e. the safety of the payment methods) along with the protection of financial information from unauthorized access"	Roman (2007)
Perceived Privacy	"Consumers' perceptions about the protection of individually identifiable information on the Internet"	Roman (2007)
Information Quality	"The consumers' general perception about the completeness and accuracy of the website information concerning both the services offered and the procedure for carrying out an online purchase transaction"	Kim et al. (2008)

Fig. 2 presents a general overview of the research methodology and procedure. Each step must be completed before undertaking the next one. Furthermore, the process of research was fixed and the process could not be changed as the research progressed. Table 3 displays all main features and sub-features used for the expert assessment system. As shown in Table 3, the proposed method included three main features and nine sub-features. Using this number of features and sub-features, the systems were developed by means of the fuzzy logic method. In addition, it can be seen that the system only included one output showing the Importance Level of Features using the features and sub-features of B2C websites.

In this study, a questionnaire was organized for developing assessment model based on the fuzzy set theory. The questionnaire was developed to inspect the real importance level of the B2C websites' features. Table 3 showed all features selected from literature for developing the expert system. Three popular B2C websites, i.e., Amazon.com, Lazada.com, and eBay.com were selected for this study survey. Online questionnaire was distributed via Facebook. Students were selected to participate in this study precisely because of it was a convenient and appropriate sample to test acceptance and adoption of new technology. In the questionnaire, a three-point Likert scale ranging as Low=0, Moderate=1, and High=2 for inputs (features) and five-point Likert scale ranging from Very low=0 to Very High=4 for output (degree of the customers' perceptions of features) were considered. Then, based on three- and five-point Likert scales, the respondents were asked to point out their evaluation of the three B2C websites using a number of features.

In this survey, 39.80% (n=121) of total respondents were master students and 60.20% (n=183) were Ph.D students who had experience with the online shopping through B2C websites. The 32.24% respondents had experience with the websites for more than 3 years. In addition, about 54.61% (n=166) of the respondents were male.

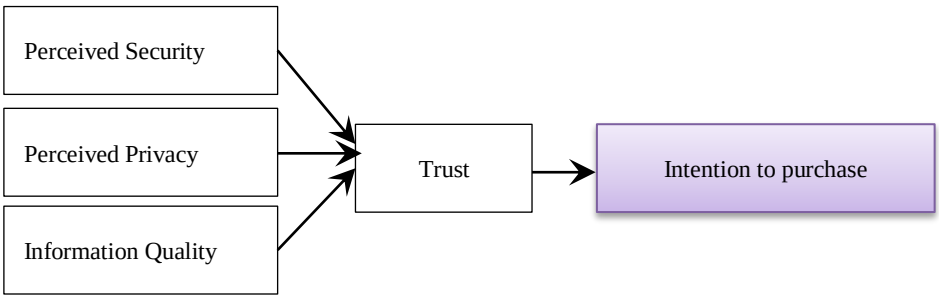

Fig. 1. Proposed Research Framework

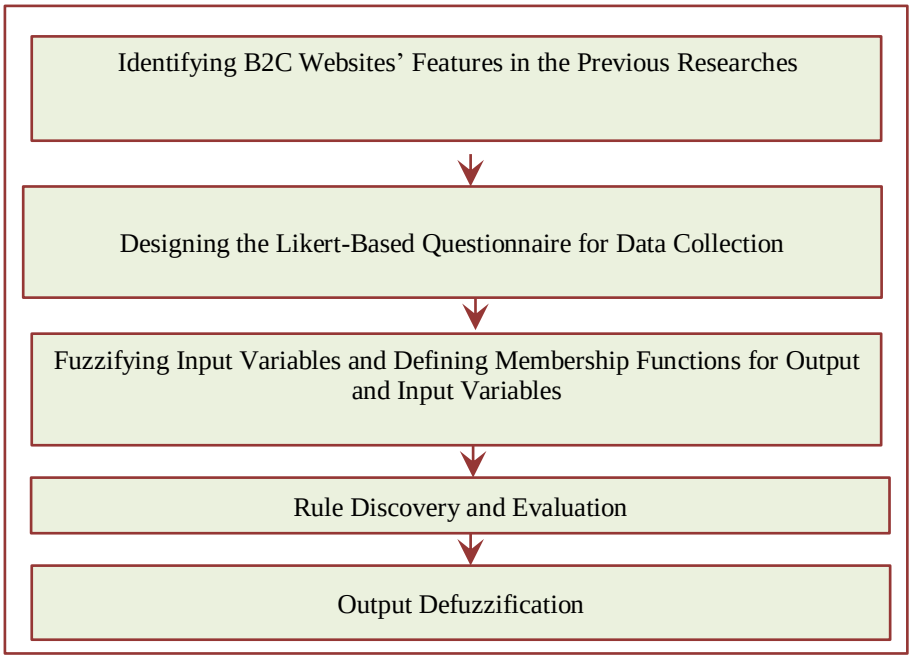

Fig. 2. The process of research

3. Proposed fuzzy logic system

Fuzzy set theory has been developed for modelling complex systems under uncertain or imprecise environments. In the past decades, fuzzy logic has been widely used in different fields (Nilashi et al., 2017; Nilashi et al., 2016; Nilashi et al., 2015a; Nilashi et al., 2015b; Nilashi et al., 2015c; Nilashi et al., 2015d; Nilashi et al., 2015e; Nilashi et al., 2014a; Nilashi et al., 2014b; Nilashi et al., 2014c; Nilashi and Ibrahim, 2014). Converting the knowledge of the human expert to an equation that a computer can process is difficult when the process involves a number of variables and conditions. By encoding the human experience in a series of decision-making rules, fuzzy logic is able to produce a smooth output surface for all input combinations without an explicit model of the process involved.

Linguistic variables play a significant role especially in fuzzy logic. A linguistic variable is defined as a variable whose values are expressed through expressions in natural language. A linguistic variable is characterized by four items: name, base variable, linguistic value, and Membership Functions (MFs). In this research, two types of MF will be inspected. They are Triangular MF (see Eq. (1)), and Gaussian MF (see Eq. (2)).

Table 3: Man features and sub-features used in the expert assessment system

	Main Features	Sub-Features	Reference
Inputs	**Security**	1. This website is safe for personal information. 2.. This web site shows great concern for the security of any transactions 3. This website has Sufficient technical capacity to ensure that the data was send by customer cannot be modified by a third party.	(Ranganathan and Ganapathy, 2002)
	Privacy	1. Protection of information on customers' Web behavior. 2. Non-sharing of customer information with other sites. 3. Protection of customers' credit card information.	(Kang et al., 2016)
	Information Quality	1. This website provides accurate information on the item. 2. This website provides reliable information. 3. This website provides sufficient information during transaction.	(Kim and Park, 2013)
Output	**Importance Level of Features**		

$$f(x,a,b,c)=\begin{cases}0 & x\le a\\ \dfrac{x-a}{b-a} & a\le x\le b\\ \dfrac{c-x}{c-b} & b\le x\le c\\ 0 & c\le x\end{cases} \quad (1)$$

$$f(x,c,\sigma)=e^{-\frac{(x-c)}{2\sigma^2}} \quad (2)$$

In the above equations, x is the input variable, a, b, c, and d stand for scalar parameters, and σ is the constant variable that signifies the MF. Gaussian and Triangular fuzzy MFs are very common in fuzzy logic systems.

In this study, the fuzzy rule-based system was developed through several subsequent steps. In the fuzzification step, we took the inputs and determined the degree to which they belonged to each of the appropriate fuzzy sets via membership functions (Gaussian and Triangular). After developing membership functions, fuzzy rules were extracted from the respondents' responses to be used in the fuzzy rule based system. Then, in the defuzzification step, the fuzzy outputs were converted into a scalar output quantity, as the output of each rule was fuzzy. It should be noted that as we applied the fuzzy rule-based system in the fuzzy logic toolbox of MATLAB software, centroid of area (COA) method [34] was used for deffuzification purpose. COA is the most popular defuzzification method, which returns the center of area under the curve. The results of defuzzification step were then used for revealing the importance level of B2C websites' features. For each rule, the individual fuzzy conclusion was derived by taking a minimum value (using MIN operator) of the membership degrees. The individual conclusions were aggregated using maximum (MAX) operator to generate the overall fuzzy conclusion. Table 4 presents the information of membership functions for inputs and output in the fuzzy model.

This study was based on the rationale that the customer trust in B2C website was based on three features, i.e., Security, Privacy, and Information Quality. Therefore, an assessment model was proposed using fuzzy logic approach to find the importance level of websites' features, thereby showing the customers' trust. Based on the three features of websites, we then defined the following relationship:

$$L(\text{Trust}) = f(\text{Security, Privacy, Information Quality}) \quad (3)$$

Table 4

Information of membership functions for inputs and output in fuzzy model

	Variables	Type of Membership Function
Inputs	Security	Gaussian
	Privacy	Gaussian
	Information Quality	Gaussian
Output	Importance Level of Features	Triangular

From the relationship, we can define that the level of B2C website trust is based on Security, Privacy, and Information Quality. As totally 9 sub-features and 3 features were considered for constructing the fuzzy logic-based assessment model, the Likert-based questionnaire was designed based on these features and sub-features to collect the data from 304 respondents. The collected data from this group was used for forming the fuzzy rules (discovering knowledge) to be used in the Fuzzy Inference System (FIS) of fuzzy logic-based assessment model. The fuzzy model based on the Mamdani algorithm was implemented on fuzzy logic toolbox of MATLAB software package. To develop the fuzzy logic-based assessment model, the appropriate MFs should be defined for the inputs and outputs (fuzzifying the variables) of model in Fuzzy Inferences System (FIS). In this research, all input variables in the FIS model used linguistic terms of Low, Moderate, and High with their MFs modelled as Gaussian MFs presented in Eq. (2). In addition, for the outputs of the model, the Triangular MFs were considered as presented in Eq. (1). They were defined with the linguistic variables as VLow, Low, Moderate, High, and VHigh.

Based on MFs for inputs and outputs, the linguistic variables for inputs and outputs were considered in three and five levels, respectively. Using the defined MFs, the fuzzy model was able to reveal the level of trust in B2C websites. It should be noted that selecting the MF types and its ranges for the inputs and outputs played an important role in features assessment versus the customers trust in B2C websites. Thus, based on our experience and data collected from the customers, different ranges and types were selected for MFs. Furthermore, the Gaussian type of MFs was selected for inputs because of being the most natural, smooth, and nonzero at all points.

In this study, the fuzzy rule based system was developed in several consequent steps. In the fuzzification step, we take the inputs and determine the degree to which they belong to each of the appropriate fuzzy sets via MFs (Gaussian and Triangular). After developing membership functions, we extracted fuzzy rules from the respondents' responses to be used in the fuzzy rule based system. Then, in the defuzzification step, the fuzzy outputs are converted into a scalar output quantity, as the output of each rule is fuzzy.

In Table 5, a formation of the fuzzy rules generated from the respondents' response to the survey are presented. In this table fuzzy rules for inference engine describe the relationship between different levels of B2C websites' features (antecedents) with the importance level of features for the customers' trust (consequent). For example, the fuzzy rule #1 reveals that when customers feel all features

of a B2C website are in low level, a very low level of trust is put in that website. And in the fuzzy rule #27, a Very High level of trust is obtained when security, privacy, and information quality are in a High level.

Through combining both the input MFs and the output MFs with the rules presented in Table 5, 2-D curves can be obtained to give a snapshot relationship between the inputs and outputs. Illustrating the interdependency between inputs and output is helpful in revealing the importance level of B2C websites' features. Fig. 3 illustrates the interdependency of trust and three main features through the curves obtained from the fuzzy rules generated from the data. The level of trust can be depicted as a continuous function of its input parameters as Security, Privacy, and Information Quality. The curves depict the variation of trust based on discovered rules.

These curves show exactly the importance level of each feature of websites versus the trust. Considering the curves and discovered fuzzy rules, it can be said that the trust is more influenced by Security feature compared to the Privacy and Information Quality factors. It shows that security in high level can adversely be effective on customers' trust. Higher level of security affects users' trust (Flavián and Guinalíu, 2006), hence increasing the customers' intention to use e-commerce websites. The levels of importance for Security, Privacy, and Information Quality were obtained in its maximum levels about 0.656, 0.512, and 0.357, respectively. Moreover, our analyses show that trust in the internet is particularly influenced by the security perceived by consumers regarding the handling of their private data by the web site. This result is consistent with past studies (Flavián and Guinalíu, 2006; Kim, 2011) in which a significant and positive effect of Perceived Security on Trust has been reported. Here, it can be said that assessing the B2C websites' features can be effectively modeled by FIS based on the customers' knowledge about the B2C websites' features, which is formed as fuzzy rules. In Table 6, the maximum weights of all B2C websites' features are presented. Note that in each curve, the weights were calculated for high level by keeping other features in high.

Table 5
Fuzzy rules formation for B2C websites' features assessment

Rule #	**IF**	Security	**AND**	Privacy	**AND**	Information Quality	**THEN**	Trust
1		Low		Low		Low		VLow
8		Low		Low		Moderate		VLow
15		Low		High		High		Low
18		Moderate		High		High		Moderate
21		Low		Low		High		VLow
25		High		Moderate		High		VHigh
27		High		High		High		VHigh

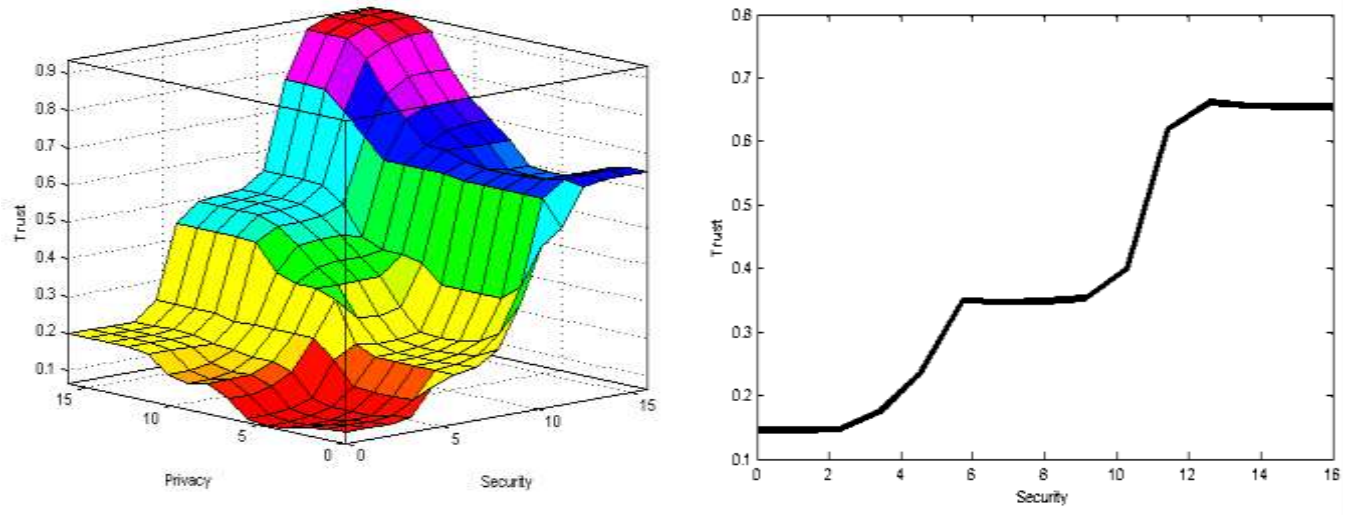

Fig. 3. Importance level of B2C websites' features

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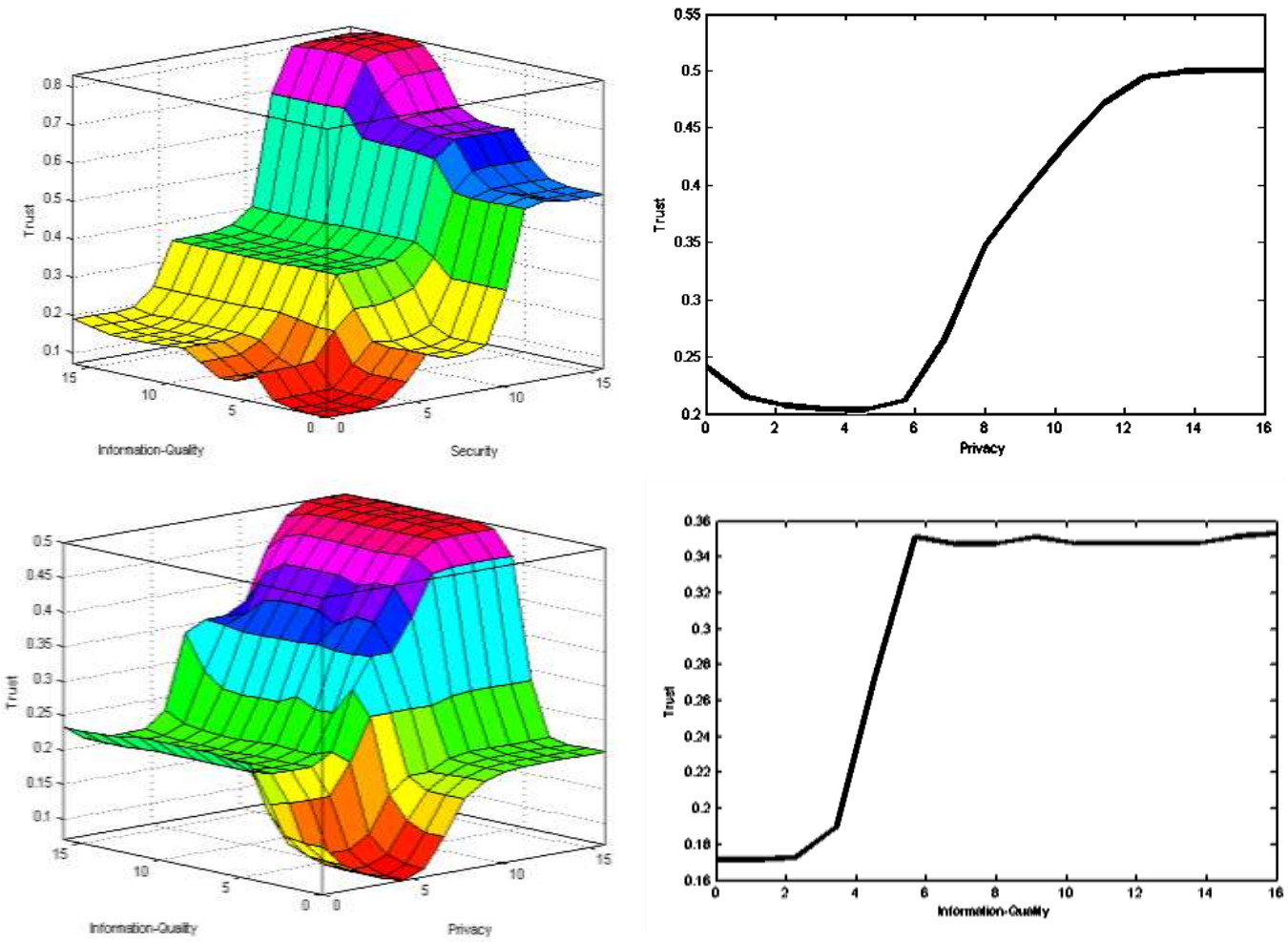

Fig. 3. Importance level of B2C websites' features (Cont.)

Table 6. Final assessment weights for B2C websites' features

Features	Maximum Weight
Security	0.656
Privacy	0.512
Information Quality	0.357

4. Conclusions

In this study, an effort was made to develop an expert system using fuzzy logic approach to assess the B2C websites' features from the customers' perspective and to show which features affect further the customers' purchase intention. The B2C websites' features, namely Security, Privacy, and Information Quality were selected from literature. The data for this research was collected through an online survey from the students with experience in online shopping through B2C websites. Based on three B2C websites' features, an assessment system based on fuzzy logic was developed together with its FIS to evaluate the features. All input variables in the FIS model used linguistic terms modelled as Gaussian MFs, and the Triangular MFs were considered for the outputs of the model. With defining these MFs for all inputs and output of fuzzy system, fuzzy rules were discovered to be used in the FIS. The results of the proposed expert system showed the fuzzy logic capability of evaluating the B2C websites' features. The results also showed that the customers' trust was more influenced by Security compared with other features of B2C websites with maximum levels about 0.656 in relation to the other features.

In this study, some implications and limitations existed, which needed to be focused and scrutinized in future research. First, there was a small number of respondents in fulfilling the survey for this study. As a sophisticated analysis was derived by the large sample size of the respondents, there is a call for future studies conducting a rigorous study to evaluate B2C websites' features using a large number of respondents, which causes to further

E-ISSN: 2289-8603

generalize findings of the prospective studies. Therefore, collecting data from multiple sources and with considering other websites can improve the scope of generalizability of the proposed fuzzy model. Second, in this research, the output of the FIS was restricted by the design and number of MFs and rules of the knowledge-based system in the Inference Engine.

This study therefore offers an insight into developing online shopping websites to consider the important features in designing the websites and helps customers to make a selection decision more solid based on actual appearances of various websites' features.

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E-ISSN: 2289-8603