Modelling and Analyzing Trust Conformity in E-Commerce Based on Fuzzy Logic

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Abstract: - Along with the breakthrough of networking, communications, and information technology, E-Commerce gains rapid development in recent years. Trust is the premise and foundation of transaction activities in E-Commerce. While conformity is an important factor which influences customers' trust to vendors, as well as customers' choices in online purchasing. Conformity behaviour in E-Commerce is two-edged. It should be correctly treated and actively guided. In order to understand in depth conformity behaviour and its influence, this paper proposes a fuzzy logic approach to model conformity behaviour in E-Commerce. The proposed fuzzy logic system is simulated with MATLAB. Simulation results are congruent with observed conformity phenomena in E-Commerce. This paper then further discusses conformity behaviour in E-Commerce. This paper not only guides customers to properly trust vendors and prevent being cheated in electronic transactions, but helps designers develop more appropriate evaluation methods for trust in E-Commerce.

Key-Words: - Fuzzy modelling; Fuzzy logic; E-Commerce; Trust; Conformity behaviour; Credit speculation

1 Introduction

Electronic commerce, also known as E-Commerce, is a type of industry where buying and selling of commodity or service is conducted over electronic systems such as the Internet and other computer networks. Trust is the premise and foundation of transaction activities in E-Commerce, since both sides in transactions are invisible to each other.

In the broadest sense, conformity in E-Commerce refers to the behaviour and phenomenon that customers construct their trust to vendors from different sources besides their experience. It influences customers' choices in online purchasing. Conformity behaviour is two-edged. On the one hand, some vendors correctly treat and actively guide customers' conformity behaviour, thus enriching contents and forms of E-Commerce. For example, in recent years, recommender systems build a bridge between vendors and customers, thus helping customers make decision when facing a wide variety of commodities; online group-buying becomes a popular form of E-Commerce, under which customers enjoy a discounted group price if they are willing and able to achieve a required group size and coordinate their transaction time [1]. These novel contents and forms urge rapid and sustainable development of E-Commerce. On the other hand, some disingenuous vendors misguide customers through credit speculation and credit fraud. These negative aspects shadow the development of E-Commerce. Therefore, it is important to understand in depth conformity behaviour and its influence in E-Commerce.

In E-Commerce, people have accumulated much linguistic knowledge for characterizing and describing customers' conformity behaviour in transaction activities. Among the existing modelling approaches, fuzzy modelling is the most effective one for converting linguistic data into mathematical models, and vice versa. The foremost advantage of fuzzy modelling is that it maintains the close relationship between the linguistic description and the resulting mathematical model which can be used to verify the validity of the verbal explanations suggested by the observer [2].

Accordingly, this paper adopts a fuzzy logic approach to model conformity behaviour in E-Commerce. The proposed fuzzy logic system is simulated under MATLAB environment. Simulation results are congruent with observed conformity phenomena in E-Commerce. This paper then further discusses conformity behaviour in E-Commerce.

The main contributions of this paper are: a) It provides a significant attempt to understand e-transaction activities from conformity point of view; b) It presents a fuzzy logic approach to model conformity behaviour in E-Commerce; c) It further discusses the benefits from deep understanding trust conformity in E-Commerce. This paper is expected to not only guide customers to properly trust vendors and prevent being cheated in electronic transactions, but also help designers develop more appropriate evaluation methods for trust in E-Commerce.

The remainder of this paper is organized as follows. Section 2 summarizes research work related to conformity, trust and fuzzy modelling. Section 3 presents formal definitions and preliminaries. Section 4 describes a conformity phenomenon observed in Taobao[1] website, and then proposes a model based on a fuzzy logic approach to model trust conformity in E-Commerce. Section 5 simulates the constructed fuzzy logic system in MATLAB, and analyzes the simulation results. Then it gives further discussions. Section 6 gives conclusions and looks into future work.

2 Related work

This section summarizes research work related to conformity, trust, and fuzzy logic modelling.

2.1 Conformity

The research work on conformity can be dated back to Sherif's pioneering experiment [3] and Asch's series experiments on conformity (e.g., [4]). The researches in social psychology indicate that individual's behaviour is influenced by environment, other people, and group. Social psychologists summarize three types of social influence: *conformity*, *compliance*, and *obedience to authority* [5]. *Conformity* refers to the tendency to change one's belief or behaviour to match the behaviour of others [5]. Conformity behaviour is also referred to as *herd behaviour* [6, 7, 8], or *collective behaviour* [8], etc.

The researches in social psychology indicate that the factors affecting conformity include the size of the group, the unanimity of the group opinions, and individual's commitment to the group. In addition, there are individual differences in the desire for individuation or uniqueness that also influence whether an individual conforms or dissents [5].

Conformity and the effects of social influence have been studied for a long time in face-to-face situations, but they have received less attention in contexts of Internet. Therefore, Rosander and Eriksson [9] survey conformity phenomenon behaviour in use of the Internet. Their research work shows that about half the participants suffer from conformity manipulations. The result indicates that the participants clearly conform to erroneous majority alternatives. They further discuss the underlying reasons for conformity on the Internet, such as turning to the group for guidance, avoiding social isolation, and protecting one's self-esteem.

Onnelaa and Tsochase [8] conduct a study tracking the popularity of a set of applications downloaded and installed by Facebook users. Their study indicates that online human behaviour exhibits conformity: once applications cross a particular threshold of popularity, social influence processes induce highly correlated adoption behaviour among the users, which propels some of the applications to extraordinary levels of popularity; while below this threshold, the collective effect of social influence appears to vanish almost entirely.

In E-Commerce, people usually adopt commodity evaluations from different sources to value commodity quality. Chen [6] presents four studies examining herd behaviour of online book purchasing. The former two studies address two cues, *star ratings* and *sales volume*, which influence customer choices for online commodities. The latter two studies investigate relative effectiveness of two different recommendation sources: recommendations of other customers, and recommendations from some recommender systems.

The convenience of online shopping and the lack of normative standards on the Internet can cause online compulsive buying, which may bring serious negative consequences. Lee and Park [10] explore the relationship between conformity in virtual communities and online compulsive buying tendencies. They also examine the influence of member expertise and the sense of belongingness on conformity.

Most of existing studies on conformity conduct research through experiments (e.g., [3-4]) or questionnaires (e.g., [6]). This paper constructs a fuzzy logic model to characterize conformity behaviour in E-Commerce.

2.2 Trust & fuzzy logic modelling

[1] Taobao is an E-Commerce website, which belongs to Alibaba Inc., one of the largest E-Commerce companies in the world.

Human activities involve two aspects, learning the world and changing the world. Based on observing and understanding the objective world, people make appropriate decisions and actions. This process can be abstracted as a mapping from an input space to an output space. Various methods can be adopted to implement this mapping, such as linear system, expert system, differential equation, neural network, matrix transition net [11], fuzzy logic [12-20]. In addition, modelling and simulation (e.g., [21, 22]) are important and widely adopted methods for formalizing causal relationships of the observed systems.

Among aforementioned methods, fuzzy logic is one of the most effective one. The underlying reason is that fuzzy logic adopts natural languages to describe and characterize an observed system. Natural languages have undergone thousands of years of historical development. Therefore, these languages are undoubtedly the most convenient, appropriate, and effective expression means for human.

Fuzzy sets were introduced by Lotfi A. Zadeh [12] in 1965 as an extension of the classical notion of set. In 1973, Zadeh proposed the theory of fuzzy logic [13]. After decades of development, fuzzy logic has now been widely and successfully applied to intelligent control [14, 15, 16], fault diagnosis [17, 18, 19], data mining [20], etc.

Trust is often expressed by linguistic knowledge rather then numerical values. Therefore, fuzzy logic is suitable for trust evaluation as it takes into account the uncertainties within E-Commerce data. Some literatures address trust evaluation based on fuzzy logic.

Since a strict trust verification and authentication process may pose unnecessarily heavy cost to the vendor, Zhuang et al. [23] present a trust evaluation framework based on fuzzy logic to reduce costs for vendors. This framework consists of three functional blocks, Fuzzy Trust Module, Cost Evaluation Module, and Parameter Tuning Module. The Fuzzy Trust Module makes trust decisions based on inputs such as the customer's credit history and the price of the commodity.

In a mobile ad hoc network (MANET), trust is considered as the reliance of a network node on the ability to forward packets or offer services timely, integrally and reliably. Xia et al. [24] introduce trust into MANET, and construct a new subjective trust management model (AFStrust) with multiple decision factors based on the analytic hierarchy process (AHP) theory and the fuzzy logic rules prediction method. In order to reflect complexity and uncertainty of trust relationship, AFStrust takes into account multiple decision factors, including direct trust, recommendation trust, incentive function and active degree.

Risk is rarely considered in existing trust models for open network. With fuzzy logic technology, Zhang et al. [25] propose a trust decision mechanism based on trust and risk. This mechanism evaluates trust propagation and risk propagation in open network.

Zhang et al. [26] propose a trust evaluation model based on semantic rating and fuzzy logic. Yu et al. [27] propose a customizable and preferred trust negotiation strategy.

Compared to aforementioned research work [7, 23-27], this paper presents a fuzzy approach to model conformity behaviour in E-Commerce, and the influence of conformity on customers' trust to vendors.

3 Definitions and preliminaries

This section introduces some formal definitions and related preliminaries.

3.1 Trust & conformity

From social psychology point of view, trust relation is one of the most complex social relations. Jones [28] exhibits considerable diversity in definitions of the concept of *trust*. Despite the diversity in these attempts to define trust, there is perhaps a core common to most of them, which can be located in the notion of *expectation*.

Definition 1 (Trust): In network transactions (such as E-Commerce), trust is the belief and expectation of one party in that the other party is reliable and able to fulfill their commitments.

Only in mutual trust case, transactions can be carried out smoothly. Therefore, trust is the premise and foundation of transaction activities in E-Commerce.

In the complex network environment, trust between entities can be divided into *direct trust* and *recommendation trust*.

Definition 2 (Direct trust): Direct trust is a direct trust relationship that built up between two entities based on direct feelings in the current transaction, as well as past experience in transactions.

Definition 3 (Recommendatory trust): Recommendatory trust, also referred to as indirect trust, is an indirect trust relationship established by means of other entities' recommendation. There are several sources of recommendations, such as other customers who have purchased the commodity, recommender systems, experts, website owners.

Combining the definitions of conformity in literatures [5, 29], this paper gives the formal definition. In particular, this paper focuses on conformity in E-Commerce.

Definition 4 (Conformity): Conformity is the act of matching attitudes, beliefs, and behaviours to group norms. During transaction activities in E-Commerce, conformity refers to the behaviour and phenomenon that customers construct their trust to vendors from different sources besides their experience.

3.2 Fuzzy logic modelling

In classical set theory, an element either belongs or does not belong to a set. In other words, the membership of elements in a classical set is assessed in binary terms, i.e., 0 or 1. By contrast, fuzzy set theory permits the gradual assessment of the membership of elements in a set, which is described with the aid of a membership function valued in the real unit interval [0, 1].

Definition 5 (Fuzzy set): Fuzzy sets are sets whose elements have degrees of membership.

Definition 6 (Membership or **degree of membership)**: The membership of an element x in a fuzzy set A represents the extent to which x belongs to A.

Definition 7 (Membership function): The membership function of a fuzzy set is a generalization of the indicator function in classical sets. The membership function $\mu_A(x)$ describes the membership of the elements x in the fuzzy set A.

The membership functions adopted in this paper are all built-in ones in MATLAB, which are listed as follows.

The trapezoidal membership function *trapmf*(x, [a b c d]), ($a \le b \le c \le d$) is defined as:

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

The Gaussian membership function *gaussmf*(x, [σ c]) is defined as:

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

The two-sided Gaussian membership function *gauss2mf* = $f(x,\sigma_1,c_1,\sigma_2,c_2)$ is a combination of two Gaussian membership functions: $f_1(x,\sigma_1,c_1)$, and $f_2(x,\sigma_2,c_2)$, which determine the shape of the leftmost curve and the rightmost curve, respectively. If $c_1 < c_2$, the *gauss2mf* function reaches a maximum value of 1 (the value on the interval [c_1, c_2] is 1). Otherwise, the maximum value is less than 1.

The sigmoidally-shaped membership function *sigmf*(x, [a c]) is defined as:

$$f(x,a,c) = \frac{1}{1+e^{-a(x-c)}}. \quad (3)$$

The Z-shaped membership function *zmf*(x, [a b]), ($a \le b$), is defined as:

$$f(x,a,b) = \begin{cases} 1 & x \le a \\ 1-2[(x-a)/(b-a)]^2 & a \le x \le (a+b)/2 \\ 1-2[(b-x)/(b-a)]^2 & (a+b)/2 \le x \le b \\ 0 & x \ge b \end{cases}. \quad (4)$$

Definition 8 (Fuzzy logic): Fuzzy logic is a form of many-valued logic or probabilistic logic. It deals with reasoning that is approximate rather than fixed and exact.

Fuzzy logic forms a bridge between qualitative modelling and quantitative modelling. Although the input-output mapping of such a model is integrated into a system as a quantitative map, internally it can be considered as a set of qualitative linguistic rules.

4 A fuzzy logic approach for modelling trust conformity in E-Commerce

This section first describes an observed conformity phenomenon in E-Commerce by natural language. Then it presents a fuzzy logic approach to model trust conformity.

4.1 Phenomenon description

An interesting phenomenon is observed in Taobao about two vendors: one is with high credit originally; the other is with low credit originally.

"These two vendors mainly sell a same kind of commodity. Moreover, they sell this commodity starting almost the same time. Fig. 1 shows the cumulative sales of these two vendors. In the first 20 days, the cumulative sale of the high-credit vendor is just a little bit more than that of the low-credit vendor. But along with the increase of evaluation from customers who have purchased the commodity, the cumulative sale of high-credit vendor increases sharply (shown in Fig. 1), so does his credit (shown in Fig. 2). However, the cumulative sale and credit of the low-credit vendor increase much slowly, despite he sells the same commodity as the high-credit vendor does."

The above phenomenon can be identified as a conformity phenomenon and behaviour in social psychology. This paper presents a fuzzy logic approach to study how individual customer' choice is influenced by evaluations of other customers who have purchased the commodity.

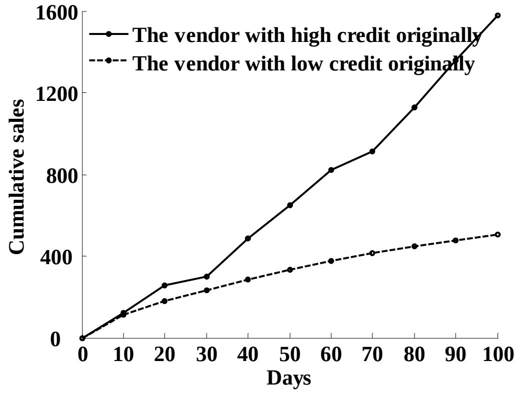


Fig. 1. The Cumulative sales of two vendors.

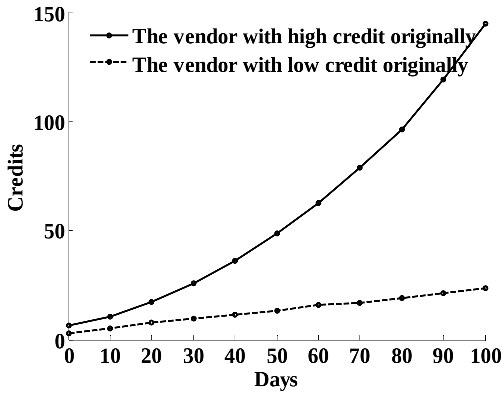


Fig. 2. The Credits of two vendors.

4.2 The constructed fuzzy logic systems

For the above-mentioned conformity phenomenon, this paper constructs a fuzzy logic system from three aspects as follows.

(1) *The possibility of a customer to buy a commodity*

The purpose of this fuzzy logic model is to study how *the possibility of a customer to buy a commodity* is influenced by conformity. The *possibility* is determined by two factors: *direct trust*, and *recommendatory trust*.

A. *Possibility*, *p*: It is the likelihood of a customer to buy a commodity, $p \in [0, 1]$.

B. *Direct trust*, *d*: It is a customer's direct trust in a vendor, which is built up from direct feelings in the current transaction, and past trust in transactions, $d \in [0, 1]$.

C. *Recommendatory trust*, *r*: It is a customer's indirect trust in a vendor, which is established from the evaluations of other customers who have purchased the commodity, $r \in [0, 1]$.

The *possibility*, *p*, has three fuzzy variables: *high*, *medium*, and *low*. The membership of *high*, *medium*, and *low possibility* are defined as functions: f_1, f_2, and f_3, respectively.

Direct trust, *d*, has three fuzzy variables: *high*, *medium*, and *low*. The membership of *high*, *medium*, and *low direct trust* are defined as functions: f_4, f_5, and f_6, respectively.

Recommendatory trust, *r*, has three fuzzy variables: *high*, *medium*, and *low*. The membership of *high*, *medium*, and *low recommendatory trust* are defined as functions: f_7, f_8, and f_9, respectively.

The fuzzy logic rules are:

(*a*) IF *direct trust* is *high*, and *recommendatory trust* is *high*, THEN *possibility* is *high*.

(*b*) IF *direct trust* is *high*, and *recommendatory trust* is *medium*, THEN *possibility* is *high*.

(*c*) IF *direct trust* is *high*, and *recommendatory trust* is *low*, THEN *possibility* is *medium*.

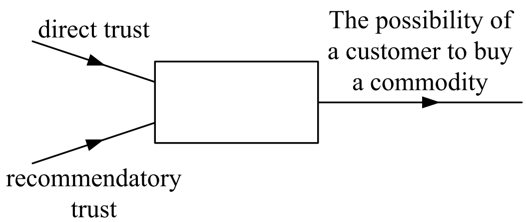
(*d*) IF *direct trust* is *medium*, and *recommendatory trust* is *high*, THEN *possibility* is *high*.

(*e*) IF *direct trust* is *medium*, and *recommendatory trust* is *medium*, THEN *possibility* is *medium*.

(*f*) IF *direct trust* is *medium*, and *recommendatory trust* is *low*, THEN *possibility* is *low*.

(*g*) IF *direct trust* is *low*, THEN *possibility* is *low*.

The above fuzzy logic model and rules of determining *the possibility of a customer to buy a commodity* is illustrated as Fig. 3.



(a) The fuzzy logic model

direct trust	recommendatory trust	possibility
high	high	high
high	medium	high
high	low	medium
medium	high	high
medium	medium	medium
medium	low	low
low	\	low

(b) Fuzzy logic rules

Fig. 3. The fuzzy logic model and rules of determining *the possibility of a customer to buy a commodity*.

(2) *Direct trust*

Direct trust is determined by four factors: *consistency extend of commodity's description*, *service attitude*, *delivery speed*, and *past trust*. (For simplicity, this paper assumes that the customer always trust the vendor in the past.)

E. Consistency extend of commodity's description, *c*: It represents the observed extend to which commodity's description is consistent with the commodity, $c \in [0, 5]$.

F. Service attitude, *a*: It represents the service level that the customer feels when he communicates with the vendor, $a \in [0, 5]$.

G. Delivery speed, *s*: It represents the number of days that the vendor promises to deliver the commodity, $s \in [0, 5]$.

Consistency extend, *c*, has two fuzzy variables: *high*, and *low*. The membership of *high*, and *low consistency extend* are defined as functions: f_{10}, and f_{11}, respectively.

Service attitude, *a*, has two fuzzy variables: *good*, and *bad*. The membership of *good*, and *bad service attitude* are defined as functions: f_{12}, and f_{13}, respectively.

Delivery speed, *s*, has two fuzzy variables: *fast*, and *slow*. The membership of *fast*, and *slow delivery speed* are defined as functions: f_{14}, and f_{15}, respectively.

The fuzzy logic rules are:

(*h*) IF *consistency extend* is *high*, *service attitude* is *good*, and *delivery speed* is *fast*, THEN *direct trust* is *high*.

(*i*) IF *consistency extend* is *high*, *service attitude* is *good*, and *delivery speed* is *slow*, THEN *direct trust* is *high*.

(*j*) IF *consistency extend* is *high*, *service attitude* is *bad*, and *delivery speed* is *fast*, THEN *direct trust* is *medium*.

(*k*) IF *consistency extend* is *high*, *service attitude* is *bad*, and *delivery speed* is *slow*, THEN *direct trust* is *medium*.

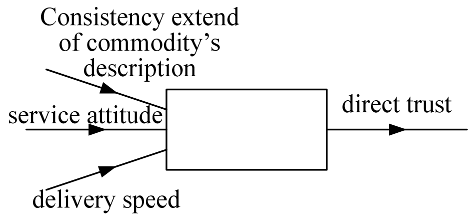
(*l*) IF *consistency extend* is *low*, *service attitude* is *good*, and *delivery speed* is *fast*, THEN *direct trust* is *medium*.

(*m*) IF *consistency extend* is *low*, *service attitude* is *good*, and *delivery speed* is *slow*, THEN *direct trust* is *low*.

(*n*) IF *consistency extend* is *low*, *service attitude* is *bad*, and *delivery speed* is *fast*, THEN *direct trust* is *low*.

(*o*) IF *consistency extend* is *low*, *service attitude* is *bad*, and *delivery speed* is *slow*, THEN *direct trust* is *low*.

The above fuzzy logic model and rules of determining *direct trust* is illustrated as Fig. 4.



(a) The fuzzy logic model

consistency	service attitude	delivery speed	direct trust
high	good	fast	high
high	good	slow	high
high	bad	fast	medium
high	bad	slow	medium
low	good	fast	medium
low	good	slow	low
low	bad	fast	low
low	bad	slow	low

(b) Fuzzy logic rules

Fig. 4. The fuzzy logic model and rules of determining *direct trust*.

(3) *Recommendatory trust*

Recommendatory trust is determined by two factors: *overall evaluation*, and *evaluation time weight*.

F. Overall evaluation, *o*: It represents the overall grade of the commodity, which is reflected in the feedback evaluations from customers who have purchased the commodity, $o \in [0, 1]$.

G. Evaluation time weight, *w*: Recent evaluations are usually more persuasive and valuable than earlier evaluations. Therefore, time of evaluation should also be considered in *recommendatory trust*. *Evaluation time weight* represents the proportion of recent evaluations in all evaluations, $w \in [0, 1]$. A higher value of *w* represents that the majority of evaluations are recent ones.

Overall evaluation, *o*, has three fuzzy variables: *high*, *medium*, and *low*. The membership of *high*, *medium*, and *low overall evaluation* are defined as functions: f_{16}, f_{17}, and f_{18}, respectively.

Evaluation time weight, *w*, has three fuzzy variables: *high*, *medium*, and *low*. The membership of *high*, *medium*, and *low evaluation time weight* are defined as functions: f_{19}, f_{20}, and f_{21}, respectively.

The fuzzy logic rules are:

(*p*) IF *overall evaluation* is *high*, and *evaluation time weight* is *high*, THEN *recommendatory trust* is *high*.

(*q*) IF *overall evaluation* is *high*, and *evaluation time weight* is *medium*, THEN *recommendatory trust* is *high*.

(*r*) IF *overall evaluation* is *high*, and *evaluation time weight* is *low*, THEN *recommendatory trust* is *medium*.

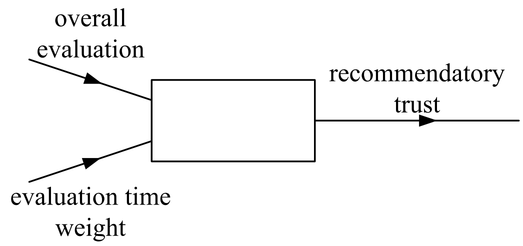
(*s*) IF *overall evaluation* is *medium*, and *evaluation time weight* is *high*, THEN *recommendatory trust* is *medium*.

(*t*) IF *overall evaluation* is *medium*, and *evaluation time weight* is *medium*, THEN *recommendatory trust* is *medium*.

(*u*) IF *overall evaluation* is *medium*, and *evaluation time weight* is *low*, THEN *recommendatory trust* is *low*.

(*v*) IF *overall evaluation* is *low*, THEN *recommendatory trust* is *low*.

The above fuzzy logic model and rules of determining *recommendatory trust* is illustrated as Fig. 5.



(a) The fuzzy logic model

overall evaluation	evaluation time weight	recommendatory trust
high	high	high
high	medium	high
high	low	medium
medium	high	medium
medium	medium	medium
medium	low	low
low	\	low

(b) Fuzzy logic rules

Fig. 5. The fuzzy logic model and rules of determining *recommendatory trust*.

The above three fuzzy logic models and rules ((*a*) ~ (*v*)) constitute the constructed fuzzy system. Given the values of input variables, *the possibility of a customer to buy a commodity* can be concluded.

5 Experiments and analyses

This section simulates the proposed fuzzy logic system in MATLAB and analyzes the simulation results.

5.1 Membership functions and operators

The most difficult task in a fuzzy logic system is to determine the membership functions. This paper adopts fuzzy statistics to estimate aforementioned 21 membership functions.

For example, aiming at estimating the membership function of *medium direct trust*, this paper makes a sampling survey among customers who frequently purchase commodities online (over two times per week). Given the domain, $U = [0, 1]$, 219 customers are asked to write down the most appropriate interval that describe *medium direct trust*. It then randomly selects 100 answers, which listed in Table 1.

Table 1. Randomly selected 100 intervals that describe *medium direct trust*.

[0.40, 0.77]	[0.41, 0.72]	[0.30, 0.82]	[0.37, 0.70]	[0.30, 0.69]
[0.44, 0.73]	[0.44, 0.77]	[0.30, 0.66]	[0.37, 0.82]	[0.30, 0.64]
[0.39, 0.82]	[0.30, 0.66]	[0.31, 0.75]	[0.43, 0.65]	[0.31, 0.69]
[0.32, 0.82]	[0.30, 0.67]	[0.32, 0.67]	[0.45, 0.73]	[0.32, 0.82]
[0.41, 0.81]	[0.33, 0.75]	[0.33, 0.69]	[0.41, 0.68]	[0.33, 0.78]
[0.34, 0.72]	[0.35, 0.73]	[0.47, 0.76]	[0.35, 0.69]	[0.50, 0.82]
[0.35, 0.78]	[0.46, 0.68]	[0.36, 0.78]	[0.36, 0.68]	[0.44, 0.70]
[0.37, 0.79]	[0.30, 0.71]	[0.45, 0.67]	[0.37, 0.80]	[0.37, 0.80]
[0.37, 0.82]	[0.44, 0.78]	[0.37, 0.70]	[0.30, 0.72]	[0.38, 0.77]
[0.45, 0.76]	[0.38, 0.73]	[0.48, 0.80]	[0.39, 0.71]	[0.39, 0.81]
[0.43, 0.72]	[0.39, 0.73]	[0.30, 0.64]	[0.39, 0.70]	[0.44, 0.82]
[0.39, 0.68]	[0.40, 0.67]	[0.30, 0.71]	[0.40, 0.71]	[0.44, 0.70]
[0.40, 0.80]	[0.42, 0.80]	[0.30, 0.68]	[0.33, 0.72]	[0.33, 0.68]
[0.41, 0.70]	[0.48, 0.74]	[0.41, 0.74]	[0.42, 0.79]	[0.42, 0.79]
[0.42, 0.82]	[0.40, 0.74]	[0.39, 0.82]	[0.43, 0.74]	[0.31, 0.78]
[0.43, 0.70]	[0.30, 0.71]	[0.32, 0.68]	[0.44, 0.67]	[0.40, 0.76]
[0.44, 0.74]	[0.39, 0.78]	[0.37, 0.71]	[0.44, 0.68]	[0.36, 0.76]
[0.45, 0.63]	[0.38, 0.74]	[0.37, 0.74]	[0.32, 0.69]	[0.46, 0.77]
[0.46, 0.70]	[0.46, 0.70]	[0.36, 0.63]	[0.47, 0.73]	[0.35, 0.75]
[0.48, 0.74]	[0.41, 0.73]	[0.38, 0.76]	[0.49, 0.75]	[0.35, 0.76]

Since the domain U is a continuous one, U is divided into 100 equivalent subintervals. The frequency, f, of each subinterval, is computed and listed in Table 2.

Table 2. The frequency of each subinterval.

Subinterval	[0.0, 0.01]	[0.01, 0.02]	…	[0.40, 0.41]
f	0.00	0.00	…	0.62
Subinterval	[0.41, 0.42]	[0.42, 0.43]	[0.43, 0.44]	[0.44, 0.45]
F	0.68	0.72	0.76	0.85
Subinterval	[0.45, 0.46]	[0.46, 0.47]	[0.47, 0.48]	[0.48, 0.49]
f	0.89	0.93	0.95	0.98
Subinterval	[0.49, 0.50]	[0.50, 0.51]	…	[0.99, 1.00]
f	0.99	1.00	…	0.00

At last, for the frequency distribution in Table 2, a histogram is plotted and shown in Fig. 6. The membership function of *gauss2mf*(x, 0.1, 0.5, 0.09, 0.62) is also plotted on the same figure. From Fig. 6, it can be found that this membership function is a good estimation of membership degree of *medium direct trust*.

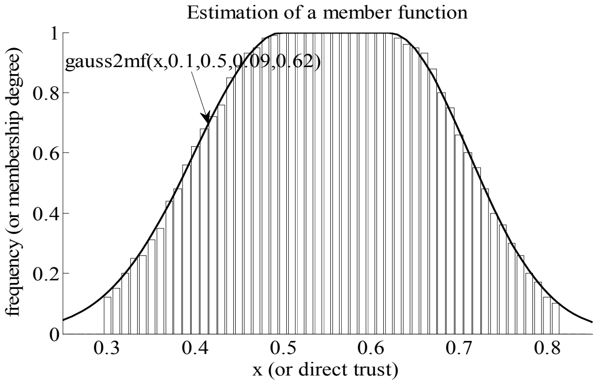


Fig. 6. Fuzzy statistics to estimate the membership function of *medium direct trust*.

According to above fuzzy statistics, this paper determines all the aforementioned 21 membership functions as follow.

The *possibility*, *p*: the membership functions of *high*, *medium*, and *low possibility* are f_1 = *sigmf*(*x*, 36, 0.7), f_2 = *gauss2mf*(*x*, 0.08, 0.49, 0.08, 0.62), and f_3 = *zmf*(*x*, 0.23, 0.58), respectively.

Direct trust, *d*: the membership functions of *high*, *medium*, and *low direct trust* are f_4 = *trapmf*(*x*, 0.6, 0.8, 1, 1), f_5 = *gauss2mf*(*x*, 0.1, 0.5, 0.09, 0.62), and f_6 = *trapmf*(x, 0, 0, 0.25, 0.55), respectively.

Recommendatory trust, *r*: the membership functions of *high*, *medium*, and *low recommendatory trust* are f_7 = *trapmf*(*x*, 0.64, 0.85, 1, 1), f_8 = *gauss2mf*(*x*, 0.09, 0.52, 0.11, 0.65), and f_9 = *trapmf*(x, 0, 0, 0.28, 0.57), respectively.

Consistency extend, *c*: the membership functions of *high*, and *low consistency extend* are f_{10} = *smf*(*x*, 1.75, 3.35), and f_{11} = *zmf*(*x*, 1.82, 3.65), respectively.

Service attitude, *a*: the membership functions of *good*, and *bad service attitude* are f_{12} = *smf*(*x*, 1.95, 3.87), and f_{13} = *zmf*(*x*, 1.95, 3.96), respectively.

Delivery speed, *s*: the membership functions of *fast*, and *slow delivery speed* are f_{14} = *smf*(*x*, 1.65, 3.15), and f_{15} = *zmf*(*x*, 1.75, 3.22), respectively.

Overall evaluation, *o*: the membership functions of *high*, *medium*, and *low overall evaluation* are f_{16} = *trapmf*(*x*, 0.65, 0.86, 1, 1), f_{17} = *gauss2mf*(*x*, 0.09, 0.55, 0.08, 0.68), and f_{18} = *trapmf*(x, 0, 0, 0.32, 0.6), respectively.

Evaluation time weight, *w*: the membership functions of *high*, *medium*, and *low evaluation time weight* are f_{19} = *trapmf*(*x*, 0.6, 0.82, 1, 1), f_{20} = *gauss2mf*(*x*, 0.1, 0.49, 0.1, 0.61), and f_{21} = *trapmf*(x, 0, 0, 0.25, 0.52), respectively.

The above membership functions are all built-in ones in MATLAB, as shown in Section 3.2.

In addition, the fuzzy operators adopted in this fuzzy model are:

a) And method: min
b) Or method: max
c) Implication: min
d) Aggregation: max
e) Defuzzification: centroid.

5.2 Simulation results and analyses

This paper further examines the factors that influence *the possibility of a customer to buy a commodity*.

Firstly, the relation between *the possibility of a customer to buy a commodity* and trust (including *direct trust* and *recommendatory trust*) is described by the surface shown in Fig. 7.

As Fig. 7 shows, the surface slides down along the axes of *direct trust* and *recommendatory trust*. Therefore, these two factors both influence *the possibility of a customer to buy a commodity*.

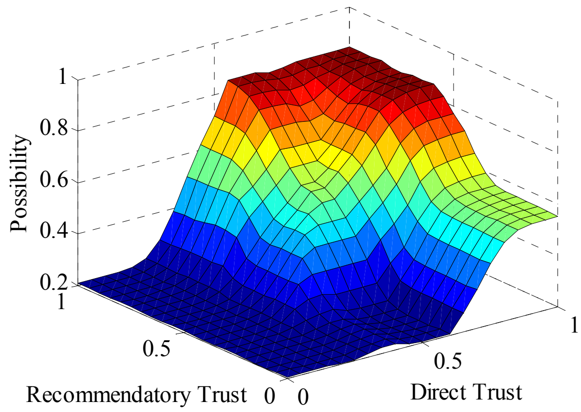


Fig. 7. Relation between *the possibility of a customer to buy a commodity* and trust (including *direct trust* and *recommendatory trust*).

Secondly, the relation between *the possibility of a customer to buy a commodity* and the factors influencing *recommendatory trust* (i.e., *overall evaluation* and *evaluation time weight*) is described by the surface shown in Fig. 8, where *direct trust* is fixed at a medium value, 0.6.

From Fig. 8, it can be found that when determining whether buy a commodity, a customer is verifiably influenced by *overall evaluation* and *evaluation time weight*. Moreover, the impact of *overall evaluation* on a customer's decision is greater than that of *evaluation time weight*, since the surface in Fig. 8 slides down faster along the axis of *overall evaluation*.

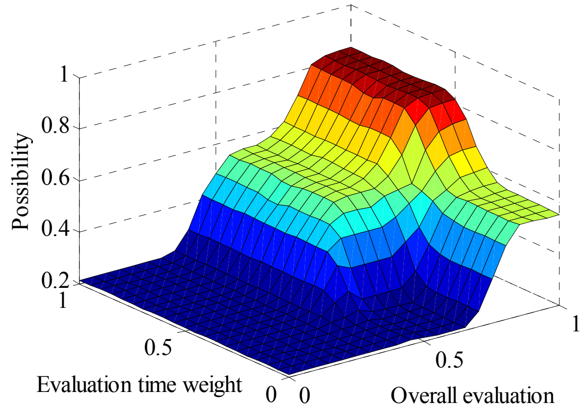


Fig. 8. Relation between *the possibility of a customer to buy a commodity* and the factors influencing *recommendatory trust*.

From the above simulation results, it can be concluded that a customer's trust in a vendor exhibits conformity. In other words, when determining whether buy a commodity, besides a customer's direct trust in a vendor, the customer resorts to evaluations of other customers who have purchased the commodity. When constructing recommendatory trust to a vendor, a customer relies on a commodity's overall feedback evaluation grade, as well as the time of evaluation, of customers who have purchased the commodity.

5.3 Discussion

Deep characterizing and understanding trust conformity in E-Commerce benefits the following two aspects.

(1) *Trust modelling and formalization*. Existing trust modelling and formalization methods do not consider conformity, thus fail to reflect conformity influence between individual and groups. This paper is expected to help researchers improve these modelling and formalization methods.

(2) *Credit speculation prevention*. Currently, Taobao simply calculates a vendor's credit plus one or minus one. If a customer evaluates a purchased commodity "good", the vendor's credit increases by 1; if the evaluation is "medium", the vendor's credit remains unchanged; while if the evaluation is "poor", the vendor's credit decreases by 1. This simple calculation does not consider such factors as commodity price, LBR (Look-to-Buy) rate. Some disingenuous vendors can gain credit points quickly through selling out cheap commodities in bulk, which is called *credit speculation*. In order to prevent credit speculation, more appropriate evaluation methods should be introduced to fully evaluate a vendor's credit.

6 Conclusion and future work

This paper presents a fuzzy approach to model trust conformity in E-Commerce, which provides a significant attempt to understand e-transaction activities from conformity point of view. Simulation results are congruent with the observed phenomena in Taobao website. This paper further discusses the benefits from deep understanding such conformity. The research work in this paper will guide customers to properly trust vendors and prevent being cheated in electronic transactions. Moreover, it helps designers develop more appropriate evaluation methods for trust in E-Commerce.

The future work of this paper will further survey more qualitative and quantitative methods. These methods are used for analyzing customer' conformity behaviour, as well as evaluating trust in E-Commerce. In particular, the future work will focus on the effectiveness of these methods, and new findings discovered by these methods.

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