

Comparison of E-payment of the B2C E-commerce in China from the Security and Trust Perspective

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Abstract

With the development of electronic commerce (e-commerce), the electronic payment (e-payment) has become a popular method of payment. Its security and trust are the great attention of customers. This paper is an attempt to compare the current widely used e-payment systems to invest the issues and priority of e-payment over e-commerce, specifically the B2C e-commerce in a specific market - China. Grey approach is employed to evaluate the security and the current e-payment systems of the B2C e-commerce in China. The managerial implications and suggestions for future research are also discussed.

Keywords: *E-payment, B2C e-commerce, Empirical Study, China*

1. Introduction

As the most populated nation on the earth, China for the first time has passed the U.S. to become the world's biggest personal-computer market in 2011[1]. With the development of the internet and computer, an increasing number of customers have used the e-commerce websites to obtain information about products and services, with possible follow-up purchase [2-5]. The critical factor of success of every commercial entity to implement and operate an e-business mechanism is money flow, material flow and information flow in commerce process. Strong and long-lasting business relationships have always been depended on trust. The transition to digital economy, forces enterprises not only to develop customer intimacy but also to ensure that security requirements are part of the customer relationship strategy.

E-payments have been reported to be the ultimate test of security and trust in e-business environment. In order to provide practical insight and guidelines for improving the trust and security of the e-payment, an investigative empirical study to evaluate these e-payment systems is needed, which is the primary motivation of this research.

This paper is focused on the e-payment systems that either currently available or have been previously put into practice for a period of time, including the credit card, the store-value card, the debit card and COD (cash on delivery).

(1). The credit card

The credit card is the most popular payment method for online shopping today, despite its vulnerability to security breaches when used online. The secure sockets layer (SSL) protocol was invented in 1994 to deter false uses. The credit card is a postpaid method.

(2). The stored-value card

The stored-value card is often viewed as a prepaid method. Indeed, credit cards, stored-value cards, and smart cards all function like magnetic strip cards, but with different payment times. When the stored-value card is used in online commerce, customers must key-in certain identification numbers that match the information stored on the magnetic strip. The amount of the product or service is then deducted by the card reader and the reader rewrites information back to the card. Many stores desiring micropayment mechanisms adopt the stored-value card payment system. The stored-value card can be either anonymous or identifiable. Anonymous cards have the advantage to be transferred from one person to another, whereas identifiable cards are nontransferable [6].

(3). The debit card

The debit card (also known as a bank card or check card) is a plastic payment card that provides the cardholder electronic access to his or her bank account(s) at a financial institution. Some cards have a stored value with which a payment is made, while most relay a message to the cardholder's bank to withdraw funds from a payer's designated bank account.

Online debit cards require electronic authorization of every transaction and the debits are reflected in the user's account immediately. The transaction may be additionally secured with the personal identification number (PIN) authentication system; some online cards require such authentication for every transaction, essentially becoming enhanced automatic teller machine (ATM) cards.

One difficulty with using online debit cards is the necessity of an electronic authorization device at the point of sale (POS) and sometimes also a separate PINpad to enter the PIN, although this is becoming commonplace for all card transactions in many countries.

(4). COD (cash on delivery)

Cash on delivery, also known as COD, is a method of payment for goods received, which will be delivered. Payment is given at the time delivery is accomplished. COD doesn't always mean cash as a payment, but certainly can also mean cashier's check, credit card or personal check. It really depends upon the establishment from which you're purchasing something, as to what forms of payment are acceptable. At present, many e-commerce sites are starting to support this kind of payment. It is one of the most favorite ways to pay. However, the mode of payment and logistics together also has a lot of problems. First of all, payment in cash on delivery cost is higher, it is impossible for most small and medium-sized e-commerce enterprises since they don't have self-built logistics. The arrival of the goods payment business is more suitable for some products in the high price, and COD restricted by area, mostly express company payment in cash on delivery business support only a second-tier cities.

The paper is organized as follows. The next section introduces the related literature about e-payment. Following is a brief introduction about the grey approach used in this research. Section 4 describes an empirical analysis of evaluating the e-payment of the B2C e-commerce in China. The primary data for this research are collected through a comprehensive website evaluation. Finally, major issues and challenges for promoting the security of the e-payment are identified and discussed.

2. Literature Review

E-commerce can be described as “any form of business transaction in which the parties interact electronically rather than by physical exchanges or direct physical contact” [7]. The electronic Payment Systems Observatory (ePSO) defines that “electronic payment” or “e-payment” is the transfer of an electronic means of payment from the payer to the payee through the use of an electronic payment instrument. E-payment is defined here as the transfer of an electronic value of payment from a payer to a payer through an e-payment mechanism. E-payment services exist as web-based user-interfaces that allow customers to remotely access and manage their bank accounts and transactions [8, 9]. The payment process involves a payer, a merchant and a bank. The entities transacting in a payment system are appointed by the specific commercial relationship which by itself may depend on series of conditions.

E-payment is now one of the most central research areas in e-commerce, mainly regarding online and offline payment scenarios. Fayoumi *et al.*, describe e-payment is now one of the most central research areas in e-commerce, mainly regarding online and offline payment scenarios [10]. Sattar argue an important e-payment protocol namely Kim and Lee scheme examine its advantages and delimitations, which encourages the author to develop more efficient scheme that keeping all characteristics intact without concession of the security robustness of the protocol [11]. Chen *et al.* propose a new and efficient conditional e-payment system based on Chen *et al.*'s., restrictive partially blind signature scheme, and they describe a conditional e-payment system with transferability which allows the coin to be further transferred anonymously by a chain of payees [12]. Isfahani *et al.*, study the effect of E-bank service on E-Trust with E-Security approach and the issue based on theoretical frame work of marketing and e-banking [13]. They argue that E-bank service affects E-trust on the whole. It was also revealed that each component of E-Banking affects E-trust. Electronic transaction through e-payment protocol will grow tremendous in the coming years. Wang develops a fair electronic payment scheme for electronic commerce, which can ensure two participants' right simultaneously in electronic transaction process by conversely using blind signature [14].

Özkan *et al.*, study the critical factors (security, advantage, web assurance seals) which are necessary through customer intentions to adopt an e-payment system [15]. The perceptions of good security and trust will ultimately increase the use of electronic commerce. In fact, customers' perceptions of the security of e-payment systems have become a major factor in the evolution of electronic commerce in markets. Kim *et al.* examine issues related to e-payment security from the viewpoint of customers [16]. They study proposes a conceptual model that delineates the determinants of consumers' perceived security and perceived trust, as well as the effects of perceived security and perceived trust on the use of e-payment systems. The use of e-commerce has been associated with a lot of skepticism and apprehension due to some crimes associated with e-commerce and specifically to payment systems. The secure socket layer (SSL) protocol is trusted in this regard to secure transactions for sensitive applications like e-commerce. Unfortunately, the use of SSL protocol causes slow response time on the server which is a major cause of frustration for on-line shoppers. Nayer *et al.* describe a model for implementing personalized security in e-banking over a cloud environment is introduced [17].

3. Methodology

3.1. Grey System Theory

Grey system theory which can help evaluate outcomes under the situation with incomplete and indeterminate information is first proposed in 1982 [18]. Considering the incomplete information in this paper, grey approach which has been recognized as an effective tool to solve this kind of the problems is adopted to select the leading industries.

To introduce some fundamental aspects of grey system theory, some basic definitions and notation are shown as follows:

x is denoted as a closed and bounded set of real numbers. A grey number, $\otimes x$, is defined as an interval with known upper and lower bounds but unknown distribution information for x (Deng, 1989), which is,

$$\otimes x = [\underline{\otimes}x, \overline{\otimes}x] = \{x' \in x \mid \underline{\otimes}x \leq x' \leq \overline{\otimes}x\}$$

where $\underline{\otimes}x$ and $\overline{\otimes}x$ are the lower and upper bounds of $\otimes x$ respectively.

Expression below demonstrate some basic grey number mathematical operations:

$$\otimes x_1 + \otimes x_2 = [\underline{x}_1 + \underline{x}_2, \overline{x}_1 + \overline{x}_2]$$

$$\otimes x_1 - \otimes x_2 = [\underline{x}_1 - \overline{x}_2, \overline{x}_1 - \underline{x}_2]$$

$$\otimes x_1 \times \otimes x_2 = [\min(\underline{x}_1 \underline{x}_2, \underline{x}_1 \overline{x}_2, \overline{x}_1 \underline{x}_2, \overline{x}_1 \overline{x}_2), \max(\underline{x}_1 \underline{x}_2, \underline{x}_1 \overline{x}_2, \overline{x}_1 \underline{x}_2, \overline{x}_1 \overline{x}_2)]$$

$$\otimes x_1 \div \otimes x_2 = [\underline{x}_1, \overline{x}_1] \times \left[\frac{1}{\overline{x}_2}, \frac{1}{\underline{x}_2} \right]$$

3.2. GRA (Grey Relational Analysis)

Below is a briefly review of relevant definitions and the calculation procedure for the GRA approach.

GRA uses several small sub-problems to present the decision problem, and the problem is decomposed into a hierarchy with a goal at the top, criteria and sub-criteria at levels and sub-levels and decision alternatives at the bottom of the hierarchy.

The comparison matrix involves the comparison in pairs of the elements of constructed hierarchy. The aim is to set their relative priorities with respect to each of the elements at the next higher level.

$$D = \begin{matrix} & \begin{matrix} C_1 & C_2 & C_3 & \cdots & C_n \end{matrix} \\ \begin{matrix} C_1 \\ C_2 \\ C_3 \\ \vdots \\ C_m \end{matrix} & \left[\begin{array}{ccccc} x_{11} & x_{12} & x_{13} & \cdots & x_{1n} \\ x_{21} & x_{22} & x_{23} & \cdots & x_{2n} \\ x_{31} & x_{32} & x_{33} & \cdots & x_{3n} \\ \vdots & \vdots & \vdots & \ddots & \vdots \\ x_{m1} & x_{m2} & x_{m3} & \cdots & x_{mn} \end{array} \right] \end{matrix}$$

Where x_{ij} is the degree preference of i^{th} year over j^{th} criterion. Before the calculation of vector of priorities, the comparison matrix has to be normalized into the range of [0, 1] by the equation below:

The larger, the better type [19]:

$$y_{ij} = \frac{[x_{ij} - \min\{x_{ij}\}]}{[\max\{x_{ij}\} - \min\{x_{ij}\}]}$$

The smaller, the better type:

$$y_{ij} = \frac{[\max\{x_{ij}\} - x_{ij}]}{[\max\{x_{ij}\} - \min\{x_{ij}\}]}$$

The normalized decision matrix is denoted by $Y = [y_{ij}]_{m \times n}$.

Assume Y is a factor set of grey correlation. Let $y_0(k)$ and $y_i(k)$ denote the initial criteria values of y_0 and y_i on company k respectively.

As average correlation value $r(y_0, y_i)$ of $\{r(y_0(k), y_i(k)) | k = 1, 2, \dots, m\}$ is a real number, the value can be defined by grey correlation.

Let $r(y_0, y_i) = \frac{1}{m} \sum_{k=1}^m r(y_0(k), y_i(k)) = r_{oi}$,

where $r(y_0(k), y_i(k)) = \frac{\min_i \min_k |y_0(k) - y_i(k)| + \rho \max_i \max_k |y_0(k) - y_i(k)|}{|y_0(k) - y_i(k)| + \rho \max_i \max_k |y_0(k) - y_i(k)|}$, where ρ is

the distinguished coefficient ($\rho \in [0,1]$).

Grey correlation matrix $R = (r_{ij})$ is derived by grey correlation analysis, where $i = 1, 2, \dots, m, j = 1, 2, \dots, n$. The definition of clustering financial ratios based on the entries of the grey correlation matrix is presented as follows.

Definition 3.1 As $r_{ij} \geq r$ and $r_{ji} \geq r$, Y_i and Y_j belong to the same cluster, where r is a threshold value of clustering.

Definition 3.2 When $r_{ij} \geq r, r_{ji} \geq r, r_{ik} \geq r$ and $r_{ki} \geq r$, but $r_{jk} < r$ or $r_{kj} < r$, if $\min\{r_{ij}, r_{ji}\} \geq \min\{r_{ki}, r_{ik}\}$, then Y_i, Y_j and Y_k belong to the same cluster.

As those indices can be partitioned into several clusters, the finding of representative indices of clusters is stated as follows.

Definition 3.3 As Y_i and Y_j belong to the one cluster, the representative index of the cluster is determined according to the maximum value of r_{ij} and r_{ji} . If $r_{ij} \geq r_{ji}$, the representative index of the cluster is financial ratio i .

Definition 3.4 As Y_i, Y_j and Y_k are in the one cluster, the representative index of the cluster is decided according to the maximum value of $r_{ij} + r_{ik}, r_{ji} + r_{jk}$ and $r_{ki} + r_{kj}$. If $r_{ij} + r_{jk}$ is the maximum value, then the representative index of the cluster is financial ratio i .

3.3. The Grey Approach

The grey approach is appropriate for solving the group decision-making problem in an uncertain environment. Let $A = \{A_1, A_2, \dots, A_m\}$ is a discrete set of m leading industry alternatives. $\otimes w = \{\otimes w_1, \otimes w_2, \dots, \otimes w_n\}$ is the vector of criteria weights. Linguistic variables are adopted in this research, as shown in Table 1:

Table 1. Scale of Attribute Weights

Rank	Sub-criteria grade	Membership function
Very Low (VL)	1	[0.00,0.10]
Low (L)	2	[0.10,0.30]
Medium Low (ML)	3	[0.30,0.40]
Medium (M)	4	[0.40,0.50]
Medium High (MH)	5	[0.50,0.60]
High (H)	6	[0.60,0.90]
Very High (VH)	7	[0.90,1.00]

The criteria rating value is shown in Table 2:

Table 2. Scale of Criteria Rating Value

Rank	Sub-criteria grade	Membership function
Very Poor (VP)	1	[0.00,0.10]
Poor (P)	2	[0.10,0.30]
Medium Low (ML)	3	[0.30,0.40]
Medium (M)	4	[0.40,0.50]
Medium High (MH)	5	[0.50,0.60]
High (H)	6	[0.60,0.90]
Very High (VH)	7	[0.90,1.00]

The detailed procedure is summarized as follows:

Step 1: Criteria weight identification

If the decision maker group has K raters, then the criteria weight is calculated using:

$$\otimes w_j = \frac{1}{K} [\otimes w_j^1 + \otimes w_j^2 + \dots + \otimes w_j^K]$$

Where $\otimes w_j^K$ ($j = 1, 2, \dots, n$) is the criteria weight of K^{th} rater and can be described by

Grey number $\otimes w_j^K = [\underline{w}_j^K, \overline{w}_j^K]$.

Step 2: Criteria rating value in linguistic variables

Criteria rating value in linguistic variables are calculated using

$$\otimes Y_{ij} = \frac{1}{K} [\otimes Y_{ij}^1 + \otimes Y_{ij}^2 + \dots + \otimes Y_{ij}^K]$$

Where $\otimes Y_{ij}^K$ ($i = 1, 2, \dots, m; j = 1, 2, \dots, n$) is the criteria weight of K^{th} rater and can be described by Grey number $\otimes Y_{ij}^K = [\underline{Y}_{ij}^K, \overline{Y}_{ij}^K]$.

Step 3: Establish the normalized grey decision matrix:

Since we had already normalized the decision matrix in the GRA process, then we should transfer the normalized numbers in the decision matrix into Grey numbers.

$$D = \begin{bmatrix} \otimes Y_{11} & \otimes Y_{12} & \otimes Y_{13} & \dots & \otimes Y_{1n} \\ \otimes Y_{21} & \otimes Y_{22} & \otimes Y_{23} & \dots & \otimes Y_{2n} \\ \otimes Y_{31} & \otimes Y_{32} & \otimes Y_{33} & \dots & \otimes Y_{3n} \\ \vdots & & & & \\ \otimes Y_{m1} & \otimes Y_{m2} & \otimes Y_{m3} & \dots & \otimes Y_{mn} \end{bmatrix}$$

Step 4: Establish the weighted normalized Grey decision matrix

The weighted normalized Grey decision matrix can be derived by the normalized Grey decision matrix and criteria weights by the equation as follows:

$$\otimes V_{ij} = \otimes Y_{ij} \times \otimes W_j$$

Then the weighted normalized Grey decision matrix can be established as follows:

$$D = \begin{bmatrix} \otimes V_{11} & \otimes V_{12} & \otimes V_{13} & \cdots & \otimes V_{1n} \\ \otimes V_{21} & \otimes V_{22} & \otimes V_{23} & \cdots & \otimes V_{2n} \\ \otimes V_{31} & \otimes V_{32} & \otimes V_{33} & \cdots & \otimes V_{3n} \\ \vdots & & & & \\ \otimes V_{m1} & \otimes V_{m2} & \otimes V_{m3} & \cdots & \otimes V_{mn} \end{bmatrix}$$

Step 5: Set ideal solution for the alternatives

$$S^{\max} = \{ [\max_{1 \leq i \leq m} V_{i1}, \max_{1 \leq i \leq m} \bar{V}_{i1}], [\max_{1 \leq i \leq m} V_{i2}, \max_{1 \leq i \leq m} \bar{V}_{i2}], \dots, [\max_{1 \leq i \leq m} V_{in}, \max_{1 \leq i \leq m} \bar{V}_{in}] \}$$

Step 6: Calculate the Grey possibility

Compare the alternatives set $A = \{A_1, A_2, \dots, A_m\}$ with the ideal solution A^{\max} :

$$P\{A_i \leq A^{\max}\} = \frac{1}{n} \sum_{j=1}^n \{\otimes V_{ij} \leq \otimes Y_j^{\max}\}$$

Step 7: Prioritize the industries

Sort the alternative industries based on $P\{A_i \leq A^{\max}\}$ comparison. If A_i value is smaller, the ranking order of A_i is better. Otherwise, the ranking order is worse.

4. Data Collection and Results Analysis

4.1. Evaluation Criteria

Most discussions about e-payment emphasize only technological advancement. However, we suggest that economic and social factors are also critical to people's decisions regarding the use of e-payment schemes. Three major factors affect the performance of e-payment systems are identified: technological, economic, and social factors. We break each of these categories into criteria that are most instructive and mutually exclusive, leading to a total of 12 criteria that influence the performance of a payment system [20].

4.1.1. Technological Factors

(1). Security

Because e-commerce is operated on an open network, encryption technologies must be developed to deter hacker attacks. In particular, security failures reduce people's trust in e-payment systems and hinder the emergence of these systems.

(2). Reliability

The e-payments must be available online 24 hours a day, which means that the operation system of e-payment should not present failures at anytime [21].

(3). Non-repudiation

Acknowledging payment and producing receipts are the basic properties required for any payment system. Such proof of payment can deter the alteration or destruction of transaction information during transmission [21].

(4). Latency (clearing time and frequency)

Even during peak load periods, payments should be transmitted at a steady pace. Customers and merchants should be able to use the e-payment mechanisms without noticeable delays in authorization and clearing [22].

(5). Transaction completeness

Payments must be completed; otherwise, transaction inconsistencies will result. A simultaneous and instant clearing and settlement instrument should be installed in e-payment systems to avoid transaction incompleteness.

4.1.2 Economic Factors

(1). Costs

There are two kinds of costs in adopting e-payment systems: fixed and transaction costs. Fixed costs refer to those of installing payment equipment such as card readers and payment software. Transaction costs are those incurred by merchants and customers every time they undertake a business exchange. As many online transactions involve micropayment, low fixed and transaction costs are essential to the popularity of e-payment systems.

(2). Monetary convertibility

Provided an e-payment system allows the (monetary) value in a digital format to be converted back to real currencies, the utility of the system increases for end-users, and it is more easily accepted [22].

3. Customer base

Compared with other criteria, the customer base by and large determines the performance of e-payment schemes. For a payment system that represents a certain network, its adoption depends on the number of customers and merchants using it. This is the so-called positive network effect (network externality) [23].

4.1.3 Social Factors

(1). Anonymity

Although the ability to make untraceable transactions raises concerns in regard to tax evasion, money laundering, and other criminal uses, transactional anonymity is a basic right of consumers. The identity of a consumer should not be revealed to other parties if she is unwilling to impart this information. Anonymous transactions further protect consumers against price discrimination [24].

(2). Privacy

In addition to a user's identity, her spending patterns and income sources should not be revealed to other parties without his/her permission. The legal requirement of privacy protects a user's transaction information from being revealed to other parties [22].

(3). Convenience

Convenience refers to the ease with which users can spend, store, and transport a currency value via the payment system. The ability to operate e-payment systems on different platforms and network infrastructures (*i.e.*, telephone, modem, or Internet connection) makes online transactions quicker and easier for users [21].

(4). Merchant acceptance

Similar to the concept of convenience, acceptance refers to the number and type of locations where an e-payment system is in use. As use of the payment scheme becomes more widespread, network effects increase the utility of the scheme for users [21].

4.2. Data Collection

A pre-designed observation sheet including the twelve criteria is used to all necessary data, and all criteria are rated with the widely used Little Scale method, *i.e.*, from a scale of 1 (being the worst) to 5 (meaning excellent) accordingly.

The specific original measures are listed in Table 3. The decision problem consists of three levels: the objective of the problem is the highest level, while in the second level, the criteria are listed, and the sub-criteria are listed in the third level.

Table 3. The Original Criteria of Evaluating the Payment Systems over e-commerce

Goal	Aspects	Criteria
Assessment of payment systems over e-commerce	<i>S₁ Technological</i>	<i>OC₁ Security</i> <i>OC₂ Reliability</i> <i>OC₃ Non-repudiation</i> <i>OC₄ Latency</i> <i>OC₅ Transaction Completeness</i>
	<i>S₂ Economic</i>	<i>OC₆ Cost</i> <i>OC₇ Costumer Base</i> <i>OC₈ Convertibility</i>
	<i>S₃ Social</i>	<i>OC₉ Anonymity</i> <i>OC₁₀ Privacy</i> <i>OC₁₁ Conveniency</i> <i>OC₁₂ Acceptance</i>

As shown in Table 3, there are twelve original measures, so GRA is employed for the representative selection. Grey Correlation matrix is derived from the DPS 9.0 (software which can determine the grey correlation matrix) as below:

$$R_{s_1} = \begin{bmatrix} 1.000 & 0.247 & 0.477 & 0.247 & 0.332 \\ 0.285 & 1.000 & 0.324 & 1.000 & 0.322 \\ 0.499 & 0.396 & 1.000 & 0.369 & 0.380 \\ 0.277 & 1.000 & 0.317 & 1.000 & 0.305 \\ 0.417 & 0.385 & 0.383 & 0.374 & 1.000 \end{bmatrix}$$

$$R_{s_2} = \begin{bmatrix} 1.000 & 0.115 & 0.119 \\ 0.119 & 1.000 & 1.000 \\ 0.117 & 1.000 & 1.000 \end{bmatrix}$$

$$R_{s_3} = \begin{bmatrix} 1.000 & 0.457 & 0.136 & 0.241 \\ 0.514 & 1.000 & 0.156 & 0.381 \\ 0.197 & 0.160 & 1.000 & 0.347 \\ 0.311 & 0.367 & 0.335 & 1.000 \end{bmatrix}$$

According to the above matrices and the definitions described earlier, the measures can be grouped into several clusters by threshold value $r = 0.55$. The classification result is shown in Table 4:

Table 4. The Final Measures of Evaluating the Payment Systems over e-commerce

Goal	Aspects	Criteria
Assessment of payment systems over e-commerce	S_1 Technological	C_1 Security C_2 Reliability C_3 Non-repudiation C_4 Transaction Completeness
	S_2 Economic	C_5 Cost C_6 Costumer Base
	S_3 Social	C_7 Anonymity C_8 Privacy C_9 Conveniency C_{10} Acceptance

The important degrees of the above sub-criteria weights are given with linguistic terms shown in Table 1, employed by four experts E_1, E_2, E_3 and E_4 , as shown in Table 5.

Table 5. The Grey Weights given by Four Decision Makers

Criteria	DM ₁	DM ₂	DM ₃	DM ₄	$\otimes w_j$
C_1	H[0.60,0.90]	VH[0.90,1.00]	H[0.60,0.90]	VH[0.90,1.00]	[0.75,0.95]
C_2	H[0.60,0.90]	VH[0.90,1.00]	MH[0.50,0.60]	VH[0.90,1.00]	[0.73,0.88]
C_3	MH[0.50,0.60]	M[0.40,0.50]	M[0.40,0.50]	MH[0.50,0.60]	[0.45,0.55]
C_4	H[0.60,0.90]	ML[0.30,0.40]	M[0.40,0.50]	M[0.40,0.50]	[0.43,0.58]
C_5	H[0.60,0.90]	MH[0.50,0.60]	VH[0.90,1.00]	H[0.60,0.90]	[0.65,0.85]
C_6	ML[0.30,0.40]	ML[0.30,0.40]	VL[0.00,0.10]	L[0.10,0.30]	[0.18,0.30]
C_7	VL[0.00,0.10]	L[0.10,0.30]	L[0.10,0.30]	L[0.10,0.30]	[0.08,0.25]
C_8	L[0.10,0.30]	M[0.40,0.50]	M[0.40,0.50]	ML[0.30,0.40]	[0.30,0.42]
C_9	H[0.60,0.90]	VH[0.90,1.00]	MH[0.50,0.60]	H[0.60,0.90]	[0.65,0.85]
C_{10}	L[0.10,0.30]	L[0.10,0.30]	VL[0.00,0.10]	L[0.10,0.30]	[0.08,0.25]

The normalized decision matrix is shown in Table 6.

Table 6. Normalized Decision Matrix

No.	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
credit card	0.67	0.00	1.00	0.50	0.00	1.00	0.00	0.00	1.00	0.00
stored-value card	0.00	0.00	1.00	0.00	0.00	0.00	1.00	0.50	0.33	0.00
debit card	0.67	0.00	1.00	0.50	0.00	1.00	1.00	0.00	1.00	1.00
COD	1.00	1.00	0.00	1.00	1.00	1.00	1.00	1.00	0.00	1.00

In the next step, the Grey variables discussed in Section 3.3 is applied to transform Table 5 into Table 6 as explained by the following example. If the numeric rating is 0.05, then its Grey variable is “VP” as shown in Table 2. Therefore, the new pair wise comparison matrix is shown in Table 7:

Table 7. Normalized Decision Matrix using Grey Variables

No.	C_1	C_2	C_3	C_4	C_5	C_6	C_7	C_8	C_9	C_{10}
credit card	G	VP	VG	MG	VP	VG	VP	VP	VG	VP
stored-value card	VP	VP	VG	VP	VP	VP	VG	MG	MP	VP
debit card	G	VP	VG	MG	VP	VG	VG	VP	VG	VG
COD	VG	VG	VP	VG	VG	VG	VG	VG	VP	VG

The Grey variables of the above matrix are then transformed into a Grey decision matrix, as shown in Table 8:

Table 8. Part of the Grey Decision Matrix

	C_1	C_2	C_3	C_4	C_5	C_6	C_7
A_1	[0.60,0.90]	[0.00,0.10]	[0.90,1.00]	[0.50,0.60]	[0.00,0.10]	[0.90,1.00]	[0.00,0.10]
A_2	[0.00,0.10]	[0.00,0.10]	[0.90,1.00]	[0.00,0.10]	[0.00,0.10]	[0.00,0.10]	[0.90,1.00]
A_3	[0.60,0.90]	[0.00,0.10]	[0.90,1.00]	[0.50,0.60]	[0.00,0.10]	[0.90,1.00]	[0.90,1.00]
A_4	[0.90,1.00]	[0.90,1.00]	[0.00,0.10]	[0.90,1.00]	[0.90,1.00]	[0.90,1.00]	[0.90,1.00]
$\otimes W_j$	[0.75,0.95]	[0.73,0.88]	[0.45,0.55]	[0.43,0.58]	[0.65,0.85]	[0.18,0.30]	[0.08,0.25]

Following the resulting Grey weighted decision matrix can be derived based on Table 8 and the weights identified before, and the values of ideal value A^{\max} are shown below for our illustration.

$$A^{\max} = \{ [0.68,0.95], [0.65,0.88], [0.41,0.55], [0.38,0.58], [0.59,0.85], [0.16,0.30], [0.07,0.25], [0.27,0.43], [0.00,0.85], [0.07,0.25] \}$$

Then the Grey possibility value for each payment method is given below:

$$P(A_1 \leq A^{\max}) = 0.1563; P(A_2 \leq A^{\max}) = 0.2045; P(A_3 \leq A^{\max}) = 0.1527; P(A_4 \leq A^{\max}) = 0.1156;$$

The e-payment systems over e-commerce are prioritized based on the Grey possibility values:

$$\text{COD} \succ \text{Credit card} \succ \text{Debit card} \succ \text{Store-value card}$$

5. Conclusions

This research is an attempt to compare the current widely used e-payment systems to invest the issues and priority of e-payment over e-commerce from the security and trust perspective in the B2C e-commerce of China. Grey approach is employed to evaluate the security and the current e-payment systems of the B2C e-commerce in China..

According to the criteria weights derived from this section earlier, the relative top four important criteria to evaluate the e-payment system over e-commerce in China are (1) security; (2) reliability; (3) cost and (4) convenience. As such, the e-payment systems over e-commerce shall pay more attention to these criteria when optimize the e-payment systems.

Based on the results of this research, COD is the best e-payment over e-commerce method from the security and trust perspective concerned by customers, which they thing the most security and reliability. However, not all the B2C e-commerce companies supply this kind of service, especially for most small and medium-sized e-commerce enterprises since they don't have self-built logistics. It is suggest that all the B2C e-commerce should supply this kind of service.

References

- [1] F. Owen, "China passes U.S. as world's biggest PC market", *The Wall Street Journal*, vol. 8, pp. 7-12.
- [2] V. Korner and H. Zimmermann, "Management of customer relationships in business media (MCR-BM)", *Electronic Markets*, vol. 10, pp. 162-168.
- [3] G. L. Geissler, "Building customer relationships online: the web site designers' perspective", *Journal of Consumer Marketing*, vol. 18, pp. 488-502.
- [4] S. Jones and J. Hughes, "Understanding IS evaluation as a complex social process: A case study of a UK local authority", *European Journal of Information Systems*, vol. 10, no. 1, pp. 189-203.
- [5] V. Serafeimidis and S. Smithson, "Information systems evaluation in practice: A case study of organizational change", *Journal of Information Technology*, vol. 15, no. 2, pp. 93-105.
- [6] M. Greenstein and T. Feinman, "Electronic commerce: security, risk management and control", New York: McGraw-Hill.
- [7] ECOM (Ed.), *Electronic commerce-An introduction*. <<http://ecom.fov.unimb.si/center/>> Accessed 15.05.1998, (1998).
- [8] C. Weir, J. Anderson and M. Jack, "On the role of metaphor and language in design of third party payments in eBanking: usability and quality", *International Journal of Human-Computer Studies*, vol. 64, no. 8, (2006), pp. 70-784.
- [9] A. S. Lim, "Inter-consortia battles in mobile payments standardisation", *Electronic Commerce Research and Application*, vol. 7, (2008), pp. 202-213.
- [10] A. Fayoumi, J. A. Sattar and A. Mustafa, "Practical E-Payment Scheme", *International Journal of Computer Science*, vol. 7, no. 3, pp. 18.
- [11] J. A. Sattar, "Secure E-payment Protocol", *International Journal of Security*, vol. 3, no. 5, pp. 85.
- [12] X. Chen, "New and efficient conditional e-payment systems with transferability", *Future Generation Computer Systems*.
- [13] A. N. Isfahani, "A study of the effect of E-bank service on E-trust: An E-security approach", *E-Commerce in Developing Countries: With Focus on e-Security (ECDC)*, pp. 1-10.
- [14] J. Wang, "Fair e-payment protocol based on blind signature", *The Journal of China Universities of Posts and Telecommunications*, vol. 16, no. 5, (2009), pp. 114-118.
- [15] S. Ö zkan, "Facilitating the adoption of e-payment systems: theoretical constructs and empirical analysis", *Journal of Enterprise Information Management*, vol. 23, no. 3, (2010), pp. 305-325.
- [16] C. Kim, "An empirical study of customers' perceptions of security and trust in e-payment systems", *Electronic Commerce Research and Applications*, vol. 9, no. 1, (2010), pp. 84-95.
- [17] A. Nayer, "Personalized Security Approaches in E-banking Employing Flask Architecture over Cloud Environment", *Procedia Computer Science*, vol. 21, (2013), pp. 18-24.
- [18] J. L. Deng, "Control problem of grey systems. *Systems and Control Letters*", vol. 1, no. 5, (1982), pp. 288-294.
- [19] T. Yang and C. Hung, "Multiple-attribute decision-making methods for plant layout design problem", *Robotics and Computer-integrated manufacturing*, vol. 23, (2007), pp. 126-137

- [20] Y. Chou, C. Lee and J. Chung, "Understanding M-commerce payment systems through the analytic hierarchy process", *Journal of Business Research*, vol. 57, (2004), pp. 1423–1430.
- [21] B. C. Neuman and G. Medvinsky, "NetCheque, NetCash, and the Characteristics of Internet Payment Services", Paper presented at MIT workshop on Internet Economics, available via URL: <http://www.mit.edu>, (1995).
- [22] C. Schmidt and R. Muller, "A framework for micropayment evaluation", Available via URL: <http://macke.wiwi.hu-berlin.de/IMI/micropayments.html>, (1997).
- [23] M. Katz and C. Shapiro, "Systems competition and network effects", *Journal Econ Perspect*, vol. 8, no. 2, (2009), pp. 93–115.
- [24] S. Y. Choi, D. Stahl and A. Winston, "The economics of electronic commerce", Indianapolis: MTP, (1997).

