

Song, Luona; Qi, Jiayin; Lu, Tingjie; Zhang, Kai

Conference Paper

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30th European Conference of the International Telecommunications Society (ITS): "Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June, 2019

Provided in Cooperation with:

International Telecommunications Society (ITS)

Suggested Citation: Song, Luona; Qi, Jiayin; Lu, Tingjie; Zhang, Kai (2019) : Research on the impact of the blockchain-authenticated information on consumers' perception towards traceable products: Evidence from JD, 30th European Conference of the International Telecommunications Society (ITS): "Towards a Connected and Automated Society", Helsinki, Finland, 16th-19th June, 2019, International Telecommunications Society (ITS), Calgary

This Version is available at:

<https://hdl.handle.net/10419/205214>

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Research on the impact of the blockchain-authenticated information on consumers' perception towards traceable products: Evidence from JD

Luona Song^a, Jiayin Qi^b, Tingjie Lu^c, Kai Zhang^d

a, Beijing University of Posts and Telecommunications, lona82@163.com

b Institute of Artificial Intelligence and Change Management, Shanghai University of International Business and Economics, qijiayin@139.com

c Beijing University of Posts and Telecommunications, lutingjie@buptsem.cn

d Institute of Artificial Intelligence and Change Management, Shanghai University of International Business and Economics, zach621@foxmail.com

Abstract

This paper examines the moderating effect of the blockchain-authenticated information to an individual's perceived level of uncertainty and thus influences personal affection and cognition processes in online shopping behaviors. The perceived level of uncertainty hides in consumers' emotions of online reviews and is captured through the code of TextMind (a simplified Chinese version of LIWC). The study reveals several interesting insights about blockchain-equipped products. First, the blockchain-authenticated information is perceived by final consumers to some extent and thus decreases the level of uncertainty compared with non-blockchain-involved products in the same category. Secondly, the increase of perceived uncertainty is confirmed by the percentage of two negative emotions each relates a different level of uncertainty (anxiety often refers to a higher level of uncertainty while anger is usually expressed when uncertainty is low). Thirdly, the results also show the double-edged effects of blockchain-authenticated information (e.g. traceability assurance of the product) as it may enrage consumers and thus decrease their brand loyalty if the guaranteed quality is not fit with that of actual products. The study provides vivid evidence of blockchain attempts in improving the current supply chain and offering extra values to related parties.

Key words

Online reviews, traceable products, blockchain technology, emotions, anxiety, anger

Introduction

Food traceability, in recent years, has received great attention and governments worldwide have put tremendous manpower and materials in technical supporting to improve food safety and transparency (Aung and Chang, 2014). It was believed that the blockchain technology is able to achieve accurate traceability and trust by providing both complete information flow and non-tampering signature authentication mechanism and thus it is applicable to supply chain management naturally. Furthermore, with the increasing adoption of digital technologies on farm management, blockchain will promote the sharing

of on-farm data among supply chain stakeholders and create multiple benefits and value (Ahmed and Broek (2017). Given these circumstances, scholars and practitioners worldwide actively explore the practical application of blockchain technology in those cases. However, the majority of these attempts are still at either conceptual or trial stages and empirical research is especially rare (Sander 2018; Weinhardt 2017; Mao et al. 2018). But fortunately, some active attempts in applying these new technologies to producing traceable products have begun to commercialize in China. Some consumption products with technical attributes have been found online, which provides scholars interested in the impact of new technologies on individuals with the latest primary data. Since the investment for the blockchain-based system requires multi-party involvement and the value creation mechanisms is still unclear, it is worth to understand consumers' perception towards these blockchain-authenticated products and collect consumers' feedbacks for wiser future decisions of marketing and supply chain management.

Our study focus on whether or not the adoption of blockchain technology in food traceability assurances is perceived by consumers and therefore affect their behaviors (e.g. selecting products or generating online reviews), in terms of the expression of negative emotions, and the exhibition of affective and cognitive language? Grounded in C-A-B model (theory) (Holbrook and Batra 1987), we propose several hypotheses relating technology adoption in traceable products to the cognitive efforts hidden in the linguistic characteristics of online reviews. We analyze an unobserved data set comprised of online reviews in one leading e-commerce platform in China. We capture the linguistic features of the textual review using TextMind (a simplified Chinese version of LIWC) and compare their differences in expressing negative feelings about the products or shopping experiences. Our study reveals previously undocumented differences in consumers' cognitive and affection processes that should be considered by product designers when developing technology-equipped products.

The rest of the paper is organized as follows: in section 2, we will review related literature in topics of blockchain, consumer behavior, online reviews and the theories of emotions and then develop the theoretical framework based on the classical C-A-B model including several hypotheses. In section 3, we will introduce the experiment design and data set which includes traceable products belonging to different categories. The results of emotion analysis from different data set will be discussed and compared in section 4 and the conclusion for the overall impacts of the blockchain-authenticated information on consumers' emotion reactions towards different traceable products will be summarized in section 5.

Literature Review and Hypotheses

The necessity of traceability assurances

The question of how to convey traceable information has gained increasing attention within the discussion of product quality and its communication solutions in both academic and practice contents, and scholars have tested consumers' attitude towards designed or existing traceable products and discovered several interesting insights (Rijswijk and Frewer, 2012; Yin et al. 2017). Jill E. Hobbs et al. (2005) examines the placed value of consumers on traceability assurance and quality assurances (e.g. food safety, and animal welfare). The results of a set of experimental auctions suggest that consumers were willing to pay nonzero amounts for traceability (the willingness is stronger for beef than for pork) and traceability bundled with quality gained the highest bids indicating that ex-ante assurances for quality which is facilitated by traceability may be more credible and therefore has the potential to deliver more value to Canadian consumers (Jill E. Hobbs et al. 2005). An online survey was conducted to investigate if a traceability system can decrease perceived uncertainty and strengthen a consumer's purchase intention on fast foods. The results show that perceived uncertainty is mediated by the degree of involvement: a higher degree of involvement helps the traceability system to weaken the level of uncertainty (Chen and Huang, 2013). Since food consumption is often viewed as very personalized and localized behavior, consumers' perception and understanding of some key terms in food traceability, as well WTP and purchase intention vary from country to country (Cicia and Colantuoni, 2010) and therefore localized studies are needed for better serving consumers in different geographical markets.

Previous studies have confirmed the necessity of providing traceability assurances through experimental tests and surveys from online and face to face, but all failed neither to link blockchain technology to product traceability scenarios (Kassahun et al., 2014; Trienekens et al., 2011) or to consider the impact of traceability assurances beforehand to consumers post evaluation behaviors. Moreover, extensive studies in food traceability are conducted mainly in the early 2000s (e.g. Dickinson and von Bailey, 2002; Verbeke and Ward, 2006) and have generally become outdated with the emergence of new technology attempts in the food industry, especially the blockchain technology. No experimental study has been done to fulfill the gap yet and studies focused on the role of traceability information in consumer post evaluation behaviors. In this paper, we argue that traceability information plays an important role in consumers' ex ante buying decisions and ex post behaviors. If the traceability information is perceived by final consumers, it will decrease the uncertainty of products.

Blockchain in product traceability

Blockchain technology, initially designed for replacing trust authorities of any kind in an electronic money system (Nakamoto 2008), has been widely discussed in supply chain management as a trustworthy and tamper-resistant record tool among in very recent years (Xu et al. 2018). Unlike other ex-post trackback systems (Hobbs et al. 2005), the blockchain-based system is designed for ex-ante production and quality information

disclosure. Sander et al. (2018) considers the blockchain technology as a potential solution in meat traceability and conduct the first attempt to evaluate the potential of blockchain acceptance relying on questionnaires and semi-structured interviews. Xu et al. (2018) shared their experience of building a blockchain-based application in imported product traceability scenarios from the perspective of improving system quality. However, improved quality of software architecture such as high availability may still only be valuable for ex-post trackback demands if blockchain-authenticated information created by the system is not well perceived and learned by its targeting users. In other words, besides numerous advantages of applying this technology into the practice of supply chain management, the neglects of the technology adoption from its service objects (e.g. consumers, users) may eliminate all former efforts.

We argue that the blockchain technology is perceived by the final consumers through different marketing strategies, and thus it creates a trustworthy environment and delaminates information asymmetry to a certain extent. At present, no farming conditions or production details are conveyed to online consumers through certification labels of any types (Hobbs et al. 2005) except for the blockchain-based traceability system. In this case, the blockchain-authenticated information stored in a QR code, as the combination of traceability assurance and quality assurance together, provides consumers a self-led tool to explore the origin and production details of products and thus eradicate perceived uncertainty about the product. Therefore, the technology is addressing the issue of trust between human communities (e.g. product sellers and buyers), however, human's attitudes and perception during the interaction of new technology has not been well detected yet. Given the availability of data, the following study will directly observe online reviews generated by traceable products buyers and therefore obtain the initial understanding of consumers' cognition and affection processes.

Consumer behavior, online reviews and theories of emotion

The Cognition-Affect-Behavior(C-A-B) paradigm, as a fundamental systematic model built during the development of buyer behavior theory (Engel, Kollat, and Blackwell 1968; Howard and Sheth 1969; Nicosia 1966), is often viewed as the prototype for examining emotional reactions (Holbrook and Batra, 1987). In the classical C-A-B model, cognition (C) determines affect (A) and thus result in behavior (B) and many following refinements vary slightly by bringing tiny complications to the basic paradigm (Holbrook,1986). For instance, effects of messages (Lavidge and Steiner 1961; Greenwald 1968; Wright 1973; Holbrook 1975, 1978; McGuire 1978) and product features (Huber 1975; Neslin 1979; Holbrook 1981; Tybout and Hauser 1981) on cognition or perception were introduced as minor interfering factors and we adopted this well-established approach in forming our theoretical framework for investigating the perception of blockchain-authenticated information.

The emergence of online communication channels (e.g. the column of consumer reviews on product pages) provides more direct and vivid materials for researchers to understand consumer preferences and their buying decisions (Li et al.2010). The extensive studies of online reviews in fields of marketing and Information Systems can be separated into two main streams. One category of literature has studied the consequences and effects of online reviews and they focus on features of online reviews, such as volume, valence, ratings and other linguistic characteristics (e.g.Ba and Pavlou 2002; Chevalier and Mayzlin 2006; Dellarocas et al. 2007; Duan et al. 2008; Zhu and Zhang 2010; Mudambi and Schuff 2010; Kwark et al. 2014, Yin et al. 2014, Li and Wu 2018) whereas the other has paid attention to review generation, namely the antecedents or processes of how a review is generated by a reviewer (e.g. Godes and Silva 2012; Luca and Zervas 2013; Huang et al. 2016, Huang et al. 2017). For the purpose of our study, we observe the emotions of online reviews towards products with different technology involvement and therefore examines the influence of technology adoption on review generation in consumer behaviors.

Online reviews of traceable products, or more preciously, blockchain-authenticated products have not been fully studied yet and one reason for negligence comes from the lack of data. Many attempts in blockchian-based applications of food supply chain is still at experimental stage and unavailable for consumers. However, one of China’s leading online shopping platforms, JD, has made several blockchain-involved products on line in very recent years and consumers’ evaluations shared in the products review column enables us to test our hypotheses.

We assume that online reviews enable consumers to express emotions towards certain products or shopping experiences (Yin et al. 2014) and thus generally reflect their cognitive processes interacting with a certain type of information. Many believe that online reviews allow consumers to show and communicate their opinions of products positively to a large number of potential buyers (Lee and Bradlow 2011, Lu et al. 2013, Hong et al. 2016). Furthermore, an online review engagement is driven by several motivations, such as extreme opinions (Anderson,1998), brand loyalty (Bowman and Narayandas,2001), among which cognitive process is generally part of it. In this case, although the textual contents may vary considerably addressing different aspects of consumers’ shopping experiences, emotional reactions behind those texts still reveal the level of perceived uncertainty given the nature of emotion generation (Lerner and Keltner 2000).

Table 1 Sample Emotions Characterized by Valence × Uncertainty(Yin et al. 2014)

		Valence	
		Positive	Negative
Uncertainty	Low	Hope	Anxiety
	High	Happiness	Anger

Inspired by emotion characterization (Roseman 1984; Smith and Ellsworth 1985) in Yin et al. 2014, the study explores the existence of anxiety and anger in online reviews of traceable products. Although scholars may apply different definitions for these two emotions under different research contents, there is no doubt that both anxiety and anger are characterized by low pleasantness according to the appraisal dimensions in previous literature (Yin et al. 2014). However, in terms of certainty and control, these two emotions differ and are supported by independence tests, thus they are usually treated as distinct (Oatley and Johnson-Laird 1987, Yin et al. 2014). According to Lerner and Keltner (2000), anxiety generally arises from situations perceived to be unpredictable while anger arises from more predictable situations.

Our focus on low pleasantness emotions was primarily driven by three motivations. Firstly, in order to investigate a consumer's perceived certainty after exposing to blockchain-authenticated information, it is important to separate and compare emotions with the same polarity. Secondly, negative emotions are chosen not only because they are better differentiated (Fredrickson 2003) but also because they tend to be more influential than positive emotions (Chevalier and Mayzlin 2006) given previous literature of negativity bias (Baumeister et al. 2001 cited in Yin et al. 2014; Fiske 1980). Thirdly, low pleasantness emotions such as anxiety and anger are common in online consumers' reactions. Specifically, anxiety is an emotional reaction to ambiguity regarding online shopping experiences, in contrast, anger often arises from dissatisfactions or unfulfilled expectations, such as poor product performance (Yin et al. 2014). We argue that the perceived certainty contains direct implications for consumer's cognitive efforts towards blockchain-authenticated information and therefore it is required to compare emotions that differ heavily in terms of certainty.

Theoretical Framework

Driven by the above motivations, our primary objective is to understand consumer's attitudes towards these traceable products and whether or not the blockchain-authenticated information affect consumer behavior in terms of the level of perceived uncertainty. In general, the approach we proposed assumes the following theoretical model aimed to portray the role that technology play in influencing consumers' perceptions:

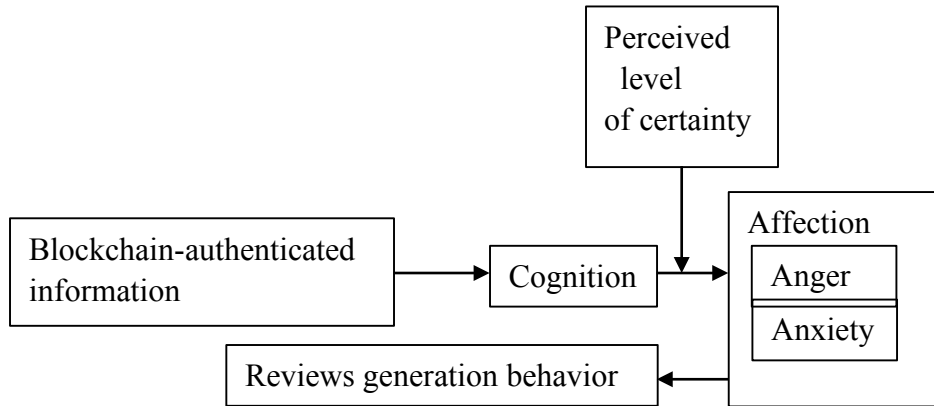


Figure 1 Theoretical Framework

Hypotheses are listed as follows:

Hypothesis 1:

The blockchain-authenticated information affects consumers' cognition process

Hypothesis 1a:

The blockchain-authenticated information affects the cognition of uncertainty.

Hypothesis 1b:

The blockchain-authenticated information increases consumers' cognitive efforts.

Hypothesis 2:

The adoption of the blockchain technology affects consumers' emotional reactions.

Hypothesis 2a:

Online reviews of blockchain-involved products contains more anger emotion than those of non-blockchain-involved products.

Hypothesis 2b:

Online reviews of non-blockchain-involved products contain more anxiety emotion than those of blockchain-involved products.

Experiment design and test

Data collection

The data used for testing our hypothesis were collected from several data sources.

Table 2 Data Source

<i>Data</i>	<i>Source</i>
Online reviews	JD
Review emotion	JD reviews processed by TextMind

According to our investigation, at present, there are generally 4 blockchain-authenticated traceability systems offering food commodities for online consumers in China. The first one is a chicken product developed by JD to address the issue of free-range chicks. This program is online for about three years and generated 37 thousand online reviews from

2017 to 2019. The second one has imported bird's nest products supported by a blockchain-based traceback system developed by China Academy of Inspection and Quarantine(CAIQ). The third one is sea cucumber product come from Dalian (a port city in the Eastern Liaoning peninsula) and the blockchain-based system is developed by JD and the local government. The last one is Wuchang rice, a rice variety in Northeast China famous for its good quality. Because we focus on the difference of negative emotions embedded in online reviews of the above products, based on data richness and requirement for the control group, the paper takes JD RUNNING CHICK product as the study group. Table 3 describe all basic data collected during the study and the number may be different slightly according to the market performance of these products.

Table 3 Introduction of 4 blockchain-authenticated products on JD.com

	<i>Chick</i>	<i>Bird's nest</i>	<i>Sea cucumber</i>	<i>Wuchang rice</i>
<i>Number of shops</i>	1	93	1	3
<i>Average price</i>	\$ 19.4/kg	\$516/100g	\$168/kg	\$4.27/kg
<i>Data collection</i>	1108	12532	328	460
<i>System developer</i>	JD	CAIQ	Local Government	Local Government

Firstly, online reviews were collected from a leading e-commerce platform, JD (www.jd.com) and years were spanned from 2017 to 2019 by using a web crawler. The data included several shops which mainly come from JD's own warehouses. To ensure data accuracy, the paper verifies a random selection set of 1000 reviews based on their richness. Figure 2 presents a screenshot of a Chinese review in JD.



Figure 2 A screenshot of a Chinese review in JD

The paper constructed the panel by collecting the available review history of each product and reordering them according to their time stamps. The unit of analysis is the individual *review text*, not the review author. But for each review, the web crawler also obtained its author (usually anonymous) and author's member level, the star rating, purchased product, time stamp and the number of likes and comments. Next, the paper measured the emotional expression of each review text using TextMind (Rui Gao et al. 2013), a Linguistic Inquiry and Word Count (LIWC)-based Chinese text mining tool, which is developed by the Institute of Psychology, Chinese Academy of Sciences. The use of this Chinese Psychoanalysis System will be explained further in the following section.

Key measures

Dependent variables:

Review emotion: the text analysis software, TextMind, was utilized to identify valance (eg. positive, negative) and emotion in textual reviews. In particular, the paper focuses on affection and negative emotions (eg. anxiety, anger and sad) which are discovered to be related with cognitive efforts (citation) and the perceived certainty(citation) in previous literature. In the English context, LIWC has been used frequently in the fields of information systems and marketing (Dezhi Yin et al.2014 and Nina (Ni) Huang et al. 2017). The paper has removed special characters before using TextMind to measure textual contents.

The review emotion is measured as the percentage of emotional (e.g. negative, anxiety and anger) words out of the total number of words. Across all reviews in the data set of JD RUNNING CHICK and control groups, the average values for anxiety and anger were both low and the reason is that TextMind uses a predefined dictionary and does not take context into consideration. However, the existence of negative emotions is our primary concern at present rather than the context, the TextMind has satisfied our data process demand.

Independent variables:

The level of perceived certainty: JD RUNNING CHICK is the only product that contains a QR Code ring on each chick's foot and consumers can scan the code to review all the information about this chick, including the everyday steps, farm information, and other production related details. By applying this traceability system, JD promise to sell 100% free range chicks and the product information is authenticated by the blockchain technology. While other three chick products sellers also sell free range chicks and introduce days of breeding, farm information in pages of product details. The only difference between JD RUNNING CHICK and other chicks is that JD RUNNING CHICK provides blockchain-authenticated information to final consumers. According to our hypotheses, extra blockchain-authenticated information influences the level of perceived certainty.

Price Effects: price effects were controlled by carefully selecting control groups. The average price of Chick-1 is \$17.67/KG which is about the same as JD RUNNING CHICK(\$19.4/KG). The average prices of Chick-2 and Chick-3 are \$10.14/KG and \$8.69/KG.

Logistics: Logistics service is considered to a very important factors affecting the satisfaction of online shopping experiences and therefore all these products are come from warehouses of JD and are delivered by JD's own logistics system.

Empirical results

We examine a total number of 4000(1000*4) online reviews for both JD Chick and non-blockchain involved Chicks. Table 4 summaries the number of anxiety-embedded reviews and anger-embedded reviews in each group. Generally speaking, the total number of

negative reviews are relatively small compared with our data set. Regarding anxiety-embedded reviews, JD has the smallest number of consumers expressing ambiguity or uncertainty relating to their shopping experiences or products. While all other three control groups show slightly more emotions of anxiety. As for the emotion of anger, the number of reviews increases to 47 which is 5 times larger than anxiety-expressed consumers and is double in size compared with other groups. In terms of percentage, anger-embedded reviews occupy about 83% of the total number of Anxiety-embedded and anger-embedded reviews. While all three other groups show generally even distribution of these two emotions.

Table 4 Numerical Summary of anxiety or anger embedded reviews

	<i>JD</i>	<i>Chick-1</i>	<i>Chick-2</i>	<i>Chick-3</i>
Anxiety(Anx)	9	15	13	14
Anger(An)	47	16	18	25
Total (T)	56	31	31	39
Negative(N)	128	60	139	73
Anx+An/N	0.4375	0.516666667	0.223021583	0.534246575
An/N	0.3671875	0.266666667	0.129496403	0.342465753
An/T	0.839285714	0.516129032	0.580645161	0.641025641
Anx/T	0.160714286	0.483870968	0.419354839	0.358974359

Table 5 compares the number of non-affection embedded reviews (gets 0 value in emotional detection by TextMind) and affection embedded reviews. The non-affection to affection ratio is 4 to 5 in JD group. It is clear that online reviewers for JD Chick products tend to write more rational or non-affection related comments after purchasing than with buyers of non-blockchain involved products. While in the other three groups, the proportion of emotional expression is higher and this may reveal the fact that evaluation of non-blockchain involved products is mainly driven by emotions or feelings towards certain products or shopping experiences. Cognitive efforts may relate to rational online reviews writing because the extra blockchain-authenticated information requires more cognitive efforts.

Table 5 Numerical Summary of Non-affection and affection embedded reviews

	<i>JD</i>	<i>Chick-1</i>	<i>Chick-2</i>	<i>Chick-3</i>
Non-affection(NA)	493	348	285	315
Affection(AF)	615	651	715	685
NA/ AF	0.80	0.53	0.39	0.45

In summary, the increases in the number of anger-embedded reviews as well as non-affection- embedded reviews may be considered as signs of perception to blockchain-

authenticated information. Next, the significance between groups is tested to further confirm our hypothesis 1.

Significance test

The one-way analysis of variance (ANOVA) is widely used to examine whether or not there are any statistically significant differences between the means of independent groups (Laerd Statistics). We applied One-way ANOVA to test the significance of anger detection result of JD and Chick-1 groups (hypothesis 2a) and the results are introduced in Table 6 and Table 7. However, the same test has been down on anxiety detection and statistically there is no significance between these two groups (hypothesis 2b).

Table 6 SUMMARY

<i>Group</i>	<i>Observations</i>	<i>Summation</i>	<i>Average</i>	<i>variance</i>
JD	1000	0.53283683	0.000532837	6.31243E-06
Chick-1	1000	0.19078739	0.000190787	2.65281E-06

In Table 7, there was a statistically significant difference between groups (JD and Chick-1) as determined by one-way ANOVA($F(1,1998) = 13.03$, $p = .0003$).

Table 7 Analysis of variance in JD and Chick-1 groups

<i>Source</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between	0.00005849	1	0.000058498	13.05016739	0.000310747	3.846117225
Within	0.00895627	1998	4.48262E-06			
Total	0.009014769	1999				

However, the same test has been down on groups of Chick-2 and Chick-3 and the data failed to pass the test ($F(1,1998) = 2.06$, $p = .15$). Regarding the slight difference in price within groups (JD and Chick-1, Chick-2 and Chick-3), the results of One-way ANOVA show that the price is not an influential factor in emotion generation of online reviews. In other words, the statistically significant difference between groups is caused by the involvement of blockchain technology.

Table 8 Analysis of variance in Chick-2 and Chick-3 groups

<i>Source</i>	<i>SS</i>	<i>df</i>	<i>MS</i>	<i>F</i>	<i>P-value</i>	<i>F crit</i>
Between	4.42807E-06	1	4.42807E-06	2.066484046	0.150724878	3.846117225
Within	0.004281322	1998	2.1428E-06			
Total	0.00428575	1999				

Discussion

Theoretical Implications

The paper links the application of blockchain technology with effects of information communication and thus conduct an experimental study to test whether the blockchain-authenticated information is perceived by online consumers and the subsequent impacts on consumer behaviors. The theoretical framework is based on the classical C-A-B paradigm; we add the blockchain-authenticated information as an indicator affecting the cognition

process as well as the affection process of consumers and further influencing their behaviors, for instance, writing online reviews. Given the characteristics of blockchain technology, it is very important to understand the conversion of technology adoption (sellers) and technology perception (buyers). However, lack of adequate theories to measure and quantify the role of blockchain technology in information communication between product providers and product consumers hinders its further application in supply chain management and other user-perceived scenarios. The paper provides an approach addressing the current issue and adopts it into the analysis of blockchain-authenticated products in the real world.

Practical Implications

The experimental study confirms the existence of blockchain-authenticated information in the cognition process of online consumers and encourages more wised decisions for information investment related to the blockchain technology. Since consumers' emotion is adjusted by the perceived certainty, the emotional differences between groups, in terms of the quantitative values of anxiety and anger, indicates the adoption of blockchain changes the level of perceived certainty. Emotion analysis of online reviews has been developed by scholars in marketing and information systems for several years but has not been well developed into the field of technology adoption, especially the adoption of blockchain technology. In terms of the helpfulness of online reviews, the adoption of blockchain technology may decrease the overall helpfulness of negative reviews with the decrease of anxiety-embedded reviews. Therefore, web designers may adjust the strategy of a recommendation system for consumer comments.

Limitations and Future Research

To gain a deeper understanding of the influence of blockchain technology, further textual analysis of online reviews should be done. Moreover, the popularity of blockchain technology in different markets, product prices, as well as differences in the added value of different products may all influence the adoption effects of blockchain technology. So far, the paper only examines the effect of blockchain technology during the generation of negative reviews and positive emotions with different level of uncertainty also deserve investigation to strengthen the current discoveries. In the future, we plan to conduct a similar study onto other blockchain-adopted products and compare online reviews in terms of context to reveal more interesting findings.

Conclusion

The paper analyses the negative emotions embedded in consumers' online reviews towards same kind of products but with different level of technology involvements and therefore reveals the impacts of blockchain-authenticated information to consumers' perception of traceable products. The use of blockchain technology in food traceability systems are double-edged. The adoption of blockchain technology decrease the level of perceived

uncertainty and thus consumers become more confident about product quality. However, when gap exists between the blockchain-authenticated quality and the factual conditions of the products, consumers will become angry instead of anxiety and the risk of losing consumers will increase. The results have both theoretical and practical implications in blockchain technology application.

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