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Research article

Determinants of consumers' adoption intention for blockchain technology in E-commerce

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ABSTRACT

Purpose: While blockchain is considered to have many unprecedented characteristics, and its application is recognized as another new opportunity for the development of e-commerce, there is limited evidence on the factors affecting the adoption of blockchain in the commercial e-commerce sector. This study aims to identify determinants influencing consumers' intention to adopt blockchain technology in e-commerce.

Design: /methodology/approachDrawing on the classic technology acceptance model (TAM), a conceptual framework is developed and empirically assessed to present the relationships between the core characteristics of blockchain and consumers' adoption intention. Survey data were collected from 228 users of the blockchain e-commerce system in China. The structural equation modeling (SEM) approach is used to test the hypotheses.

Findings: The results indicate that cost saving and traceability have a positive effect on perceived usefulness while insignificant associations are found between data privacy security and perceived usefulness, and perceived ease of use and consumers' adoption intention.

Research limitations/implications: The research only examined Chinese users, which may affect the generalizability of the findings. Future research is encouraged to conduct comparative studies beyond this region, e.g., emerging markets versus developed economies. It would also be useful to explore mediating and moderating effects of other new technologies that complement the application and adoption of blockchain.

Practical implications: The research results also bring managerial implications with the ways of attracting customers via blockchain technology, including improving system ability to reduce cost and enhance traceability.

Originality/value -: This paper is one of the early empirical endeavors that examines determinant factors affecting individual users towards the adoption of blockchain technology in e-commerce that is absent in the extant research. This study further contributes to the development of the knowledge bank of blockchain via the conceptual framework of its adoption under the e-commerce context, in particular considering its technical features.

1. Introduction

In today's digital era, many emerging technologies, including blockchain, cloud computing, artificial intelligence (AI) and Internet of Things (IoT), have been introduced, and are offering manifold competencies for various applications and different contexts (Ahram

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et al., 2017). Amongst these next-generation technologies, blockchain has received increasing attention from both academia and practitioners due to various benefits such as cost optimization, effective tracking and traceability, verifiable record-keeping, transparency, and ease of collaboration for firms (Sarkis et al., 2021; Morkunas et al., 2019). The business world has begun to embark upon adopting such a rapidly emerging transformative technology to seek opportunities for gaining competitive advantage and performance improvements in various industries and sectors (Saberi et al., 2019). While blockchain technology has been hyped for almost a decade, it has been observed that there is limited evidence on the factors affecting adoption intention of blockchain in the commercial e-commerce sector (Kumar et al., 2021; Clohessy and Acton, 2019; Hughes et al., 2019). Felin and Lakhani (2018) suggested that customers are still doubtful to embrace blockchain technology owing to various concerns and challenges in the e-commerce sector in terms of fraud, opaque prices, limited transparency, limited contact between buyers and sellers and abuse of data privacy (van Heel et al., 2014). However, it is also believed that the adoption of blockchain technology can attenuate these problems in this sector as it offers a shared database, which is characterized by non-tamper, transparency and traceability, enabling users to record and access information accurately and timely (Milani et al., 2021; Kaaniche and Laurent, 2017).

The information in the blockchain is transmitted anonymously and super-encrypted, and can be traced back to the production and transportation process of goods, logistics and supply chain information (Casino et al., 2019). Adopting blockchain technology in e-commerce can bring about a safer, more efficient and cheaper trading environment. Therefore, an opportunity is provided for diverse stakeholders, including companies and consumers, to contemplate the factors of intention for using blockchain technology. This paper aims to explicate the core drivers of blockchain technology adoption and examine whether the advantages of blockchain features can positively influence users' adoption intention. This study contributes to the existing literature by offering an insight into the factors influencing the users' adoption intention to use blockchain technology in the e-commerce sector. Moreover, it has been noted that the extant literature exhibits a tendency to focus on the drivers of blockchain technology adoption as an aggregate organizational construct where the focus was on the organizational level of analysis rather than examining the behaviors of individual actors (Clohessy and Acton, 2019; Sarkis et al., 2021; Saurabh and Dey, 2021). While this is an understandable emphasis given the need to achieve a manageable analysis of complex multi-level phenomena in the e-commerce context, it obstructs a clear understanding of the factors or determinants that drive the individuals' adoption intention to embrace new technologies such as blockchain. This study attempts to provide a micro-level perspective on the drivers of blockchain technology adoption when studying users' adoption intention that is absent in the extant research.

To this end, this paper develops and empirically assesses a conceptual model that draws on the classic technology acceptance model (TAM) developed by Davis (1989) and integrates the core features of blockchain technology as antecedents. The study contributes significantly to the first wave of empirical investigations related to the impact of blockchain features on users' adoption intention in the commercial e-commerce sector. The findings of this study can offer practical implications for companies that seek to initiate their blockchain blueprint and develop their customers' intentions to embrace this technology.

The remainder of this paper is organized as follows. Section 2 reviews relevant literature and presents hypotheses and the conceptual model. Research methods, data analyses and results are provided in Sections 3 and 4. Section 5 describes the discussion of our findings along with the theoretical insights and managerial implications. Thereafter, Section 6 addresses the research limitations and future research opportunities.

2. Literature review and hypotheses development

Recent studies claim that the application of blockchain is able to contribute to many business processes and industries, such as supply chain, logistics, finance agriculture, and healthcare, and may lead to a new disruptive technological revolution (Dhagarra et al., 2019; Gurtu and Johny, 2019; Chang et al., 2019; Ali et al., 2020). This presents the importance of studying the practical problems of blockchain in various applications, such as in the e-commerce. Blockchain has been theoretically proven to have the potential of bringing benefits to e-commerce. The interconnected relationship between blockchain and e-commerce provides a theoretical foundation. In this vein, Subramanian (2018) points out that the e-marketplace based on blockchain has many advantages over current e-marketplaces, such as, efficient matching between buyers and sellers, protected customer information privacy, and reliable transaction information tracking.

It has been observed that there is a growing trend of exploring the effect of blockchain technology in the context of e-commerce (Nuseir, 2021; Gadekar and Chandgude, 2017). For instance, Grover et al. (2019) combines perceived usefulness with technical characteristics of blockchain and propose that some characteristics of blockchain have an important effect on perceived usefulness. Similarly, Kamble et al. (2019) and Chaveesuk et al. (2020) use TAM model to analyze the influence of advantages brought by blockchain on users' adoption intention in supply chain and construction industry. Through the analysis of TAM model, it is shown that the advantages of blockchain can drive the acceptance of blockchain technology and can positively affect the factors related to e-commerce.

2.1. E-commerce and blockchain technology

The development of the world economy is inseparable from and heavily dependent upon e-commerce. One of the major advantages of e-commerce is that it effectively reduces the trade-related cost, which increases the attractiveness of business interaction between countries and promotes the development of the international economy (Lendle et al., 2016; Gomez-Herrera et al., 2014). It could also act as a trade facilitator that eliminates distance costs and reduces information friction of online marketplaces (Leamer, 2007). The recent technological advancement including the promising and disruptive technology of blockchain plays a crucial role in promoting the

growth of e-commerce.

Blockchain was first emerged in 2008 as a peer-to-peer encrypted electronic cash system that records transactions and allows network members dispersed in different places to exchange information (Nakamoto, 2008). Although the blockchain technology was originally designed for cryptocurrencies such as Bitcoin, it has been recently expanded to the e-commerce sector. The disruptive capability of blockchain can raise a powerful storm in the commercial e-commerce sector, further developing the field of e-commerce (Treiblmaier and Sillaber, 2021).

2.2. Advantages of blockchain in e-commerce

On the one hand, the existing studies tend to agree that the application of blockchain technology has the potential to reduce the costs for customers (Chang et al., 2019; Xiong et al., 2020). With the blockchain technology, e-commerce marketplaces can provide unchanged "access" to relevant information following seller's requirements, and each node itself can list prices, goods and previous customer comments and then randomly distribute throughout the Internet. Therefore, each seller is responsible for creating the product information list (Liu and Li, 2020). Non-tampered product information is more likely to provide the reliability for information search, and the blockchain listing algorithm is able to technically provide more accurate choices for consumers (Subramanian, 2018). This leads to the result that blockchain-based e-marketplaces can promote the better match between buyers and sellers and benefit buyers by reducing search costs. On the other hand, such blockchain system can reduce negotiation costs. With blockchain technology, a self-executing program, namely smart contract, can be designed to implement automated transactions agreed by multiple parties (Milani et al., 2021). This means that blockchain technology can allow multiple parties to negotiate and draft contracts digitally, and program coding can help to review the terms of contracts and the degree of implementation of contracts in different places. This technique can eliminate the need to deal with paperwork, reduce errors usually caused by manually completing documents, shorten the time for checking and redrafting contracts, thus reducing the negotiation cost (Wagner et al., 2019).

Moreover, Kshetri (2018) claims that the blockchain traceability feature can positively contribute to e-commerce supply chains in terms of cost, reliability, risk reduction, sustainability and flexibility. Blockchain traceability can build a more transparent logistics system and provide customers with trustworthy information. For instance, some luxury e-commerce platforms have focused on using blockchain technology to provide electronic certification to combat counterfeit goods (Li et al., 2021). It is thus argued that the traceability of blockchain can help e-commerce to establish a more transparent and healthy logistics information system, thus building consumers' trust in e-commerce transaction.

Furthermore, blockchain can help protect customer data privacy and security. The process of e-commerce involves massive data, and the most common risks are information leakage and data tampering (Sicari et al., 2015). In the daily use of platforms and applications, customers may not notice that their personal information is leaked and used, and this could damage the private rights of customers (Wang, 2020). The application of blockchain may be able to solve this e-commerce problem. Su et al. (2020) proposes a new trading method based on blockchain, smart contract and electronic payment, which can ensure data security and build trust between transaction participants. Although there are still vulnerabilities and risks in the blockchain system, such as being attacked by hacker software, user credentials being lost (Li et al., 2020), existing studies mostly suggest that the application of blockchain can bring new solutions for ensuring and enhancing the security of user data.

While blockchain technology can make positive contributions to e-commerce, some potential challenges still exist, such as how to deal with the potential energy waste of computing power by adopting blockchain, and how to establish legal norms and standards to maintain the healthy development of new technologies (Zheng et al., 2018). The essence of the blockchain is a computer data storage method, hence, it needs strong computing power, which could make the blockchain technology difficult for everyone to use (Cao et al., 2019). If the computing power is concentrated to verify and manage the blockchain, it may be contrary to the original intention of decentralization of the blockchain. At the same time, the anonymity of the blockchain could also bring some controversial problems to the supervision of the blockchain. Governments seems to be skeptical of this new technology, and might regulate the adoption of blockchain in the future (Min, 2019). Therefore, companies and customers using blockchain technology should be aware of the possible circumstances and act for the acceptance of such new technology. The application of blockchain seems to have huge potentials, yet this technology is still in its infancy stage, and more research needs to be conducted particularly in the e-commerce sector.

2.3. TAM model

The Technology Acceptance Model (TAM), developed by Davis (1989), has been one of the most effective methods to analyze the acceptance degree of new technology and explain how users tend to accept and apply new technologies. Technology acceptance can refer to whether a user or an organization are willing to embark on a new technology. Drawing on the TAM model (Davis, 1989), the intention of users' adoption is broadly caused by three factors: (1) perceived usefulness; (2) perceived ease of use; (3) attitude towards use. However, the TAM model has been extended to incorporate other constructs such as user training, system features, and user participation (Klopping and McKinney, 2004; Folkinshteyn and Lennon, 2016; Shin and Hwang, 2020) to offer a more comprehensive insights on the attitude of users.

Despite the recent developments in the TAM model, the extant research provides only limited guidance about the influence of society on technology adoption, necessitate the need for further investigation (Chtourou and Souiden, 2010; Huang and Liao, 2015). Moreover, since the classic TAM model does not involve internal factors, the application of TAM may be limited in customer environment where the users accept and adopt a new technology in order to meet their emotional needs (Taherdoost, 2018; Kim, 2012), and therefore is in need of an investigation. This study aims to address the aforementioned research gap by integrating core features of blockchain

technology into the TAM model to explore their effects on users' acceptance that is absent in the current literature (Saberi et al., 2019).

Moreover, previous TAM studies with respect to the blockchain technology often tend to focus on aggregate organizational level (Clohessy and Acton, 2019; Saurabh and Dey, 2021), exploring technology adoption within SMEs for instance (Kumar et al., 2021). This paper contrasts with earlier TAM studies and focuses on individual customers (Huang and Liao, 2015; Kim, 2012), and explores the determinants of blockchain technology acceptance in the e-commerce sector. This could provide developers with the insight of client-specific improvement in their products.

2.4. Hypotheses development

2.4.1. Perceived usefulness and perceived ease of use

In the technology acceptance literature, the perceived usefulness and perceived ease of use are regarded as the individual determinants that can affect the technology adoption intention (Wamba et al., 2020). Perceived usefulness can refer to the degree to which a user believes that using a specific technology or system will improve his/her job performance (Davis, 1989). It has been considered as the main influential determinants to positively induce intention for adopting new technology (Raza et al., 2017). If customers think that blockchain technology is useful to their lives and can enhance their performance when they conduct electronic trading, they will be more likely to give positive rating to blockchain.

Perceived ease of use is described as the degree to which a user believes that a specific technology or system requires less efforts from users (Davis, 1989). The positive association between perceived ease of use and perceived usefulness is well established. For example, Venkatesh and Davis (2000) and Huang and Liao (2015) found that perceived ease of use positively impacts the perceived usefulness. Furthermore, the existing literature reports that perceived ease of use has a positive influence on users' attitudes and behavioral intentions for using a new technology (Sohaib et al., 2019). Both perceived usefulness and perceived ease of use have been widely considered as two major user perceived values that are the significant factors for analyzing customer acceptance of blockchain (Grover et al., 2019). Costumers are more likely to consider the blockchain technology as useful as it is easier to use and thereby, they would have favorable attitudes towards using blockchain. Given the above, the hypothesis is proposed as follows.

H1. perceived usefulness will positively affect the users' adoption intention of blockchain technology in e-commerce.

H2. perceived ease of use will positively affect the users' adoption intention of blockchain technology in e-commerce.

H3. perceived ease of use will positively affect users' perceptions on the usefulness of blockchain.

We note in the most recent review of Treiblmaier and Sillaber (2021), the authors developed 19 high-level research questions, investigating the potential impact of blockchain on e-commerce. The main categories include technological, legal and organizational and quality issues, as well as consumer issues. In our study, we focus the investigation on three key features of blockchain and its impact on e-commerce. These features stem from the technological issues discussed in Treiblmaier and Sillaber (2021), where the authors reviewed how the technological characteristics of blockchain impact the four areas of e-commerce. These four areas are accessibility and traceability, privacy and security, novel technologies, and system development and the corresponding blockchain-induce changes. While our study aims to identify the determinants influencing users' intention to adopt blockchain technology in e-commerce, the most relevant e-commerce areas concerning the users' intention to blockchain technology adoption are twofold.

First, accessibility and traceability of data have been identified as major success factors for e-commerce (Treiblmaier and Sillaber, 2021). For example, e-commerce transactions that are conducted via blockchain store purchase-related data in an ordered and immutable manner, which helps to improve data provenance and traceability (Lo et al., 2017). This can save users' information search costs and eliminate data from being maliciously tampered. Second, the level of users' trust in web-based applications depends to a large extent on the security features in place (Aljukhadar et al., 2010). Fraudulent schemes that steal personal and confidential information are detrimental to the overall success of e-commerce (Zhang et al., 2014; Ramesh et al., 2017). Therefore, the impact of blockchain on data privacy and security is key to boosting and sustaining the confidence in users' blockchain technology adoption. The following Sections 2.4.2–2.4.4 discuss these three key features in more detail.

2.4.2. Blockchain feature 1: cost saving

Currently, e-commerce search engines deal with millions of customers' queries every day, thus requiring an efficient search matching mechanism to save users' search costs (Liu et al., 2017). Blockchain technology can provide new solutions for such issue. Blockchain is a public shared database, which allows the nodes in it to access the information in the database anytime and anywhere. Technically, blockchain technology realizes transparency and openness of information, and promises the security and reliability of information (Yiannas, 2018). From the perspective of its transparency characteristics, blockchain technology can reduce the cost of searching and obtaining information. In addition, the cost of searching can be reduced by eliminating the dependence on third-party institutions and intermediaries (Catalini and Gans, 2020). Similarly, blockchain technology is able to effectively decrease the cost of negotiation for customers. Blockchain can remove third-party central control and build new security mechanisms such as allowing all nodes in the system to replicate the data, using cryptography and a consensus mechanism to prevent data from being maliciously tampered (Yue et al., 2017). In addition, smart contract based on blockchain runs script automated and enforces agreement in a trustless environment (Alharby et al., 2018).

Blockchain enables enterprises to reach trust and conclude contracts without establishing lasting client relationships, thus reducing negotiation costs in an uncertain environment, such as contract design, contract renewal and renegotiation (Xu et al., 2020). In this vein, Kim (2020) explored the motivational factors of Korean consumers in the online open market and reported that cost saving can

significantly and positively affect the customers' intention of purchase. Accordingly, consumers can perceive the benefits of cost savings and the associated time savings, and this can affect users' perceived usefulness in terms of economic and time values.

H4. cost saving will positively affect the intention of users to use blockchain technology in e-commerce.

2.4.3. Blockchain feature 2: traceability

With the development of e-commerce and the intensification of market competition, the upgrade of logistics service has been deeply concerned. The invention of blockchain can help the logistics industry achieve new technological breakthroughs (Perboli et al., 2018). With its unique timestamp, which records the writing-in time of information, blockchain allows the real-time recording and inquiry of information, forming a powerful database that cannot be tampered and forged, and transaction data in it can be traced back to the source through its chain structure (Di Pierro, 2017). Li and Huang (2019) proposed a logistics management system based on blockchain, which can realize centralized management and flexible sharing of logistics resources. Saurabh and Dey (2021) developed a theoretical framework based on TAM model to study technology adoption factors of blockchain in wine supply chain. It is claimed that blockchain traceability can have a positive effect on users' perceived usefulness and technology adoption of blockchain. This is because more and more people have begun to seek information about what they eat and been concerned about food safety. From above point of view, this study attempts to extend the TAM model via considering traceability to determine the influence on the intention of using blockchain, and further proposes hypotheses based on these findings.

H5. traceability will positively affect the intention of users to use blockchain technology in e-commerce.

2.4.4. Blockchain feature 3: data privacy security

For e-commerce users, how their personal information is used and processed by online business has always been a worrying problem (Udo, 2001). This is understandable because consumers' personal and financial data are open to e-commerce retailers in almost every transaction, and consumers will hope that their data must be protected strictly (Limbu et al., 2011). Blockchain allows users to interact with each other in a peer-to-peer manner, which reduces the ability of third parties to collect customers' information, and users of blockchain do not need to disclose their identities (Liang et al., 2018). This provides a significant protection for online privacy, enabling consumers to consciously use and share their information and achieving the integrity of private information (Guan et al., 2020). Lallmahamood (2007) chose privacy and security as one of the influencing factors of TAM model, and found that privacy and security have a positive impact on users' perceived usefulness. Customers regard security and privacy protection as part of the overall service provided by e-commerce service providers, which can help to enhance customers' confidence in the industry and the whole e-commerce environment.

H6. data privacy security will positively affect the intention of users to use blockchain technology in e-commerce.

Fig. 1 delineates the proposed hypotheses. Overall, previous studies conducted research for the users' intention of blockchain, especially in the fields of supply chain and agriculture, mainly focus on the perspective of enterprise practitioners. In the view of the increasing popularity of e-commerce, it is necessary for academics to study the application of blockchain in e-commerce. This study pays particular attention on the perspective of individual users by studying the factors affecting users' adoption intention of blockchain in e-commerce.

3. Methodology

We conducted a quantitative deductive approach to confirm (or reject) the developed hypotheses based on empirical data collected by means of a cross-sectional survey.

3.1. Questionnaire design

The measures operationalized in the questionnaire were pre-validated scales taken from prior research, ensuring a high degree of reliability and content validity. For the blockchain features variables namely, cost saving (CS), traceability (TR), and data privacy

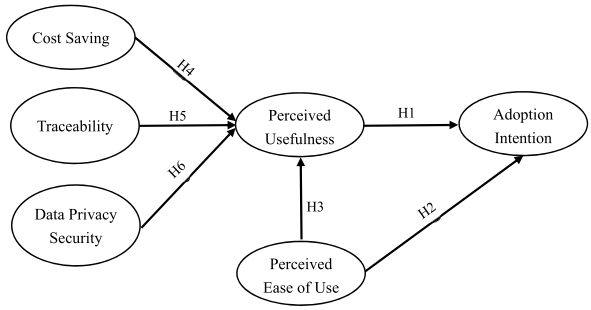


Fig. 1. Conceptual model.

security (DPS), we adopted the scales developed by Kim (2020), Saurabh and Dey (2021) and Lallmahamood (2007). We also adapted the items developed by Kumar et al. (2021) and Venkatesh and Davis (2000) for the perceived usefulness (PU) and perceived ease of use (PEOU) constructs. For the dependent variable, we drew on three items developed by Taylor and Todd (1995). A five-point reflective Likert type scale was applied to each measure, ranging from 'strongly disagree' (1) to 'strongly agree' (5). Several scale items were combined or rephrased due to overlapping in meaning and a few items were dropped as a result of feedback from independent researchers and practitioners. The questionnaire was first developed in English and then translated into Chinese to explore Chinese customers' intention to embark on the blockchain technology. The translation was made and cross-checked by a number of experts who are bilingual in Chinese and English (Esfahbodi and Zhang, 2020). Table 1 presents the constructs and measurement items used in the questionnaire.

3.2. Data collection

Because of concerns related to a lack of knowledge of blockchain, convenience sampling was employed to target potential users of the blockchain e-commerce system, recruiting respondents with some knowledge of blockchain (Fowler, 2009). The surveys were conducted via an online crowdsourcing platform in August 2021. A brief description of blockchain technology was included in the online survey to give respondents a certain knowledge background before answering questions. According to Mohammed et al. (2018), just-in-time, on-demand, bite-sized form of information delivery that appears to be a new nature of the way people learn. Short videos are capable of providing visualization and are better at capturing the attention of audiences (Manasrah et al., 2021). In addition to the online survey, a 2-min video related to the features of blockchain technology was distributed to participants in the form of hyperlink to provide further background for blockchain in the e-commerce context. To avoid the problem of social desirability, respondents' anonymity and data confidentiality were maintained. A total of 251 questionnaires were returned, but 23 of these were discarded as they had incomplete responses, resulting in 228 useable responses. In order to ensure that the samples were representative, participants were chosen from a variety of occupations such as students, teachers, and corporate staff within different regions. The sample demographic is shown in Table 2.

4. Results

4.1. Measurement assessment

We first assessed the potential for common method bias associated with our use of self-report measures. To this end, we conducted Harman's single-factor test to check the existence of common method bias (Podsakoff et al., 2003). The factor analysis integrating all measurement items revealed that no single-factor accounted for most of the variance, indicating that that common method variance was not a major problem in this study (Podsakoff et al., 2003).

We also assessed the internal consistency of the constructs with IBM SPSS Statistics 26. The values of Cronbach's α for each construct exceeded the minimum threshold of 0.70 (Hair et al., 2014), indicating that all the scales delivered satisfactory reliabilities. We then performed confirmatory factor analysis (CFA) with IBM SPSS AMOS 21 to analyze the unidimensionality for all constructs and examine their validity (Thompson, 2004). This allows all scales to be assessed within the context of the full measurement model, demonstrating how well the model reflects reality (Sanderson et al., 2022; Esfahbodi et al., 2023). Several fit indices are estimated to assess the

Table 1
Indicators of the research model.

Constructs	ID	Measurement items	Sources
Cost Saving (CS)	CS1	With blockchain, the search costs for buyers are reduced	Kim (2020)
	CS2	With blockchain, the negotiation costs for buyers are reduced	
	CS3	With blockchain, the long-term cost savings for buyers are improved	
Traceability (TR)	TR1	Blockchain track the logistics accurately	Saurabh and Dey (2021)
	TR2	Blockchain track the logistics reliably	
	TR3	Blockchain enable real-time tracking and tracing of product/service movement	
Data Privacy Security (DPS)	DPS1	Blockchain provides protection for customer data	Lallmahamood (2007)
	DPS2	Blockchain prevents from customer information leakage and abuse	
	DPS3	Blockchain ensure that customers' transactional information is protected from being altered or destroyed accidently during an e-commerce transmission.	
	DPS4	Blockchain implement appropriate security measures to protect customers' personal information and preference.	
Perceived Usefulness (PU)	PU1	Using blockchain enhances my effectiveness in EC transaction	Kumar et al. (2021)
	PU2	Using blockchain improves the performance of e-commerce	
	PU3	I find the blockchain technology to be useful in e-commerce	
Perceived Ease of Use (PEOU)	PEOU1	My interaction with the blockchain system is clear and understandable	Venkatesh and Davis (2000)
	PEOU2	Interacting with the blockchain system does not require a lot of mental effort	
	PEOU3	I find it easy to get the system to do what I want it to do.	
Adoption Intention (AI)	AI1	I intend to use the blockchain-based system.	Taylor and Todd (1995)
	AI2	I intend to use the blockchain-based system as much as possible.	
	AI3	Compared to other systems, I prefer to use the blockchain system.	

Table 2
Demographic profile.

Demographic profile		
Age		
18–24	124	54.4%
25–30	70	30.7%
31–35	25	11.0%
36–40	5	2.2%
Above 40	4	1.8%
Educational Background		
High school or below	15	6.58%
Bachelor's degree	108	47.37%
Master's degree	93	40.79%
Above	12	5.26%

(n = 228).

measurement model (see Table 3). Table 4 presents the CFA results.

As shown in Table 3, the chi-square value divided by the degrees of freedom (χ2/DF) is 2.354, which is lower than the threshold value of 3 (Kline, 2015). Meanwhile, the RMSEA value of 0.077 is below the recommended maximum of 0.08 suggested by Browne and Cudeck (1992). These indices indicated good model fit. Moreover, results for the Normed Fit Index (0.911), Comparative Fit Index (0.983), Tucker–Lewis Iindex (0.970) and Incremental Fit Index (0.984) provided further evidence for a good fit between the measurement model and the data (Hair et al., 2014).

The composite reliability (CR) and the average variance extracted (AVE) were measured to examine the convergent validity (shown in Table 5). The values of Cronbach's α for each construct were greater than the minimum threshold of 0.60 (Taber, 2018), and all AVE values exceeded the recommended 0.50 benchmark except for the PEOU construct, which was marginally below the preferred cut-off point. According to Fornell and Larcker (1981), if composite reliability is higher than 0.60 when the AVE value is greater than the minimum threshold of 0.40, the convergent validity of the construct is still adequate (Lam, 2012), suggesting sufficient convergent validity.

Lastly, we assessed discriminant validity to test the unidimensionality of each construct following the procedure proposed by Fornell and Larcker (1981). According to Fornell and Larcker (1981), the independence of each construct is determined when the square root of the average variance extracted (AVE) of each construct is greater than the correlation coefficient of each pair of latent variables. By comparing the correlation coefficient of each pair of latent variables with the square root of AVE (see Table 6), it was found that all the square root of AVEs exceeded the correlation coefficients of all pairs of variables, in support of the desired discriminant validity.

4.2. Hypothesis testing results

Structural Equation Modelling (SEM) analysis was performed with partial least squares to test the posited hypotheses. SEM is recommended as it allows the estimation of a series of causal relationships between latent variables simultaneously (Kline, 2015). The research model (see Fig. 1) contains six latent variables. The structural model was built in IBM SPSS AMOS 21 and structural estimates were then examined. Fig. 2 presents the structural model with the SEM results specified in the AMOS 21 output.

The proposed hypotheses were tested by adopting standardized regression weights, which is shown in Table 7. The structural model in Fig. 2 shows that 4 paths out of the 6 paths are significant (at least at level of $p < 0.05$). Therefore, the hypotheses concerning cost saving (H4, $p < 0.001$), traceability (H5, $p < 0.001$) are supported. As expected, these features of blockchain technology have significant impacts on the users' perceived usefulness in e-commerce. Cost saving, which means that users think that blockchain technology can help them reduce the cost of participating in e-commerce transactions, has a positive impact on their perceived usefulness. Similarly, traceability, which means that users believe that blockchain technology can help them obtain e-commerce process information reliably and efficiently, can make users feel that blockchain technology is useful. Conversely, the hypothesis related to the blockchain feature of data privacy security (H6, $p = 0.567$) is not supported. Moreover, the results indicate that the path coefficients for H2 ($p = 0.320$) is not significant. However, H1 ($p = 0.011$), H3 ($p = 0.00.001$) can be accepted at significance level of ** and *.

Table 3
Model fit indices.

Model fit statistic	Recommended value	Obtained value
Chi-square (χ2)/degree of freedom (DF)	≤3.0	131.827/56 = 2.354
Root mean square error approximation (RMSEA)	≤0.08	0.077
Normed Fit Index (NFI)	≥0.90	0.911
Comparative Fit Index (CFI)	≥0.95	0.983
Tucker–Lewis Index (TLI)	≥0.90	0.970
Incremental Fit Index (IFI)	≥0.90	0.984

Table 4
CFA results.

Construct	Item Code	Mean	Standard Deviation	Standardized Loading
Cost Saving (CS)	CS1	3.88	0.74	0.88
	CS2	3.75	0.73	0.82
	CS3	–	–	–
Traceability (TR)	TR1	3.92	0.72	0.85
	TR2	3.87	0.77	0.83
	TR3	–	–	–
Data Privacy Security (DPS)	DPS1	3.60	0.85	0.77
	DPS2	3.61	0.91	0.79
	DPS3	–	–	–
	DPS4	–	–	–
Perceived Usefulness (PU)	PU1	3.91	0.68	0.79
	PU2	3.93	0.62	0.85
	PU3	3.95	0.66	0.84
Perceived Ease of Use (PEOU)	PEOU1	3.76	0.67	0.81
	PEOU2	3.74	0.70	0.78
	PEOU3	–	–	–
Adoption Intention (AI)	AI1	3.61	0.72	0.83
	AI2	3.60	0.68	0.80
	AI3	–	–	–

Fit indices: $\chi 2 = 131.827$; D.F. = 56; RMSEA = 0.077; NFI = 0.911; CFI = 0.983; TLI = 0.970; IFI = 0.984.
Note: Items in italics were dropped in CFA (measurement items with loadings less than 0.70).

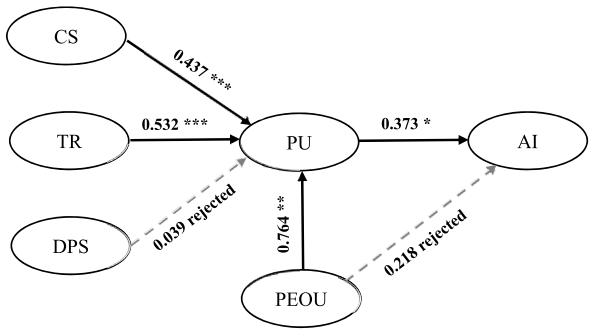
Table 5
Convergent validity tests.

Measure	Average variance extracted (AVE)	Composite reliability (CR)
Cost saving (CS)	0.511	0.676
Traceability (TR)	0.654	0.789
Data privacy security (DPS)	0.509	0.668
Perceived usefulness (PU)	0.549	0.785
Perceived ease of use (PEOU)	0.483	0.649
Adoption intention (AI)	0.721	0.835

Table 6
Discriminant validity test.

Latent variable	CS	TR	DPS	PEOU
CS	0.51			
TR	0.50	0.65		
DPS	0.58	0.29	0.51	
PEOU	0.68	0.71	0.47	0.48
The square root of AVE	0.71	0.81	0.71	0.69

Notes: CS (Cost Saving), Traceability (TR), Data Privacy Security (DPS), Perceived Ease of Use (PEOU).



(Note: significant level: *** p<0.001; ** p<0.01; *p<0.05)

Fig. 2. Structural model with SEM results.
(Note: significant level: ***p < 0.001; **p < 0.01; *p < 0.05).

Table 7
Standard path coefficient estimates and hypothesis testing.

Hypotheses tests	Standardized path coefficients (β)	CR	P-value	Results
H1: perceived usefulness → adoption intention	0.373	2.546	0.011	supported at level *
H2: perceived ease of use → adoption intention	0.218	0.994	0.320	Not supported
H3: perceived ease of use → perceived usefulness	0.764	3.205	0.001	Supported at level **
H4: cost saving → perceived usefulness	0.437	4.490	***	Supported
H5: traceability → perceived usefulness	0.532	6.897	***	Supported
H6: data privacy security → perceived usefulness	0.039	0.572	0.567	Not supported

5. Discussion and implications

This research investigated the interaction between blockchain characteristics and users' intention to adopt this technology. The research model is extended from the TAM model, and its constructs represent three main features of blockchain technology. The empirical results indicated that four of the six hypotheses are supported.

5.1. Features of blockchain technology and the perceived usefulness

It is found that the features of blockchain technology, such as cost saving and traceability, have significant impact on the TAM model constructs of perceived usefulness. The path coefficients of H4 and H5 are 0.437 and 0.532, respectively. This indicates that the lower cost that blockchain can bring to users, the more users would think that blockchain is useful, and the more accurate and reliable the information tracked by blockchain, the more users would perceive the useful value of blockchain technology.

Cost saving. In the previous research on blockchain, the advantage of cost reduction brought by blockchain has a strong influence on users' perceived usefulness. This result is consistent with the findings of existing research (Liu et al., 2017; Kim, 2020; Catalini and Gans, 2020; Ullah et al., 2020). Cost directly reflects the efforts that consumers may spend, which is undoubtedly one of the important factors that consumers care most. The cost saving brought by blockchain mainly lies in two aspects: (1) reducing search cost; (2) reducing negotiation cost.

Regarding reducing search cost, blockchain's powerful database function and listing algorithm can help match buyers and sellers faster, and non-tampered data can help consumers obtain more reliable product information. Our finding reflects the observation reported in Lo et al. (2017) that e-commerce transactions, conducted via blockchain, store purchase-related data in an ordered and immutable manner, which helps to improve data provenance and traceability. In addition, the blockchain system is considered to have the ability to eliminate third-party intermediaries, which can reduce the extra commission fees paid by consumers. If considering the online shopping experience of customers, information search is often the first step. When customers choose products, they usually scan, filter, collect and integrate products from different sources, and compare the quality of related products and services (Liao et al., 2006). Utilizing the unique ID and listing algorithm of blockchain could match the products customers demand more quickly, thus shortening the search time and cost. Moreover, the commodity information registered in the blockchain transaction system cannot be tampered with, which increases the buyer's purchasing confidence and improve the matching quality between buyers and sellers. Our finding is supported by the insights reported in Zhang et al. (2019) that is blockchain technology, implemented via consensus mechanisms, chained storage and sophisticated signature and verification systems, enables the security feature of data tamper-resistance. This tamper-resistance feature improves the concerns caused by information asymmetry between buyers and sellers, for example, concealment (withholding negative information), equivocation (providing vague information) and falsification (selling non-existing products) (Xiao and Benbasat, 2011).

Bahga and Madisetti (2016) show data provenance in combination with the immutability of blockchain can significantly contribute to the overall quality of available data, which in turn leads to better decisions based on that data. In line with Bahga and Madisetti (2016), to reduce negotiation cost and maintain the overall quality of data when the contract items need to be revised or re-formulated, the digital contract based on blockchain can reduce the time of manual contract review and preparation. Once the e-commerce transaction is concluded, the contract is automatically executed following the conditions agreed by both parties. Such digital and automated applications do not need to deal with paperwork and to consume the time to reconciling errors that often arise from manually filling in documents. Customers who are dissatisfied with the products they receive always want to return them, which is a common experience in online shopping. Imagine, if buyers do not need to return the goods to the designated post office or logistics station, only put them in front of the house, and then the courier will come to collect and scan the QR code. The system will automatically identify the return process and send the refund to the buyer's account quickly. This can greatly improve the e-commerce experience of customers.

Our observation raises the attention being considered in Szabo (1997) who presents the idea of smart contracts as a predefined set of operations to be executed under certain conditions that can help to re-engineer existing processes as well as to design new ones. In B2C relationships, our finding agrees with Waltl et al. (2019) that such contracts enable decentralized business models and processes that are automatically executed and may help to efficiently settle disputes.

Traceability. The result of data analysis also finds that the feature of blockchain traceability plays an important role in enhancing users' perceived usefulness. This is in congruence with the findings from previous research (Francisco and Swanson, 2018; Li and Huang, 2019; Zhang et al., 2020; Saurabh and Dey, 2021). Blockchain system provides timestamps to record information in real time, which improves the accuracy of information, and the information recorded in blockchain cannot be changed, which makes the information

more reliable. To solve the problem of logistics information delay and find out the source of products, especially the certification of luxury goods, food and drug safety, a safer and more reliable system is required. The application of blockchain can help solve these problems and bring consumers a safer and more reliable e-commerce environment.

However, there is no significant effect found for the path from data privacy security to perceived usefulness. This finding corresponds with the findings by AlSuwaidan and Almegren (2020), stating that current digital Internet system is composed of open and interconnected devices, which might be exposed to the possibility of attacks by cybercriminals. This makes the data protection of blockchain less believable. Indeed, there are also several possible reasons for this finding. First, users are skeptical whether blockchain can achieve data privacy. The distributed ledger means that every node participating in blockchain transactions is able to access transaction data of each node. For example, in bitcoin and other cryptocurrencies, the blockchain system is publicly available, and every transaction can be traced back to the data source (Atzori, 2017). Therefore, users would be concerned that a malicious cybercriminal who tries to steal their information for economic benefits. Secondly, users could be doubtful about the ability of blockchain to protect data. For example, people may associate hacking attack and cryptocurrency fraud with blockchain technology.

5.2. Perception and adoption intention

The results indicated that the perceived usefulness has impacts on the adoption intention with the hypothesis H1 accepted at the significant level * of $p < 0.05$. This reflects the fundamentals of the TAM model and it has also been approved that the more the users can perceive the value of this technology, and the more they intend to use it (Liu and Ye, 2021). Following the results discussed in the above section, the overall results highlighted that more cost saving and traceability users feel about the blockchain technology, the more they can perceive the useful value of this technology, and more they intend to use it in the e-commerce context.

For another, the results rejected the hypothesis H2, which means perceived ease of use has no significant impacts on the adoption intention. This surprising finding is counter-intuitive to our conceptual model and contradicts the findings of previous TAM based research (Liu and Ye, 2021). However, there is also some evidence that the perceived ease of use has no significant influence on intention to use blockchain technology in small and medium enterprises (SMEs) (Kumar et al., 2021).

However, with the accepted hypothesis H3 at the significant level **$p < 0.01$, it not only indicated that perceived ease of use will influence the perception of usefulness of the blockchain technology, but also highlighted an indirect impact of perceived ease of use on the adoption intention via the mediating role of the perceived usefulness. Similar results, however, have been found in previous studies. Shrestha and Vassileva (2019) identify that there is little influence of perceived usefulness and perceived ease of use respectively on users' intention of adopting blockchain.

There might be several reasons for this finding. First of all, users could consider blockchain technology as a complex technology from the perspective of using and understanding and this inference is consistent with the existing research results that complex technology has a negative impact on users' acceptance. Secondly, customers are satisfied with the current e-commerce system. Compared with the traditional system, the e-commerce system based on blockchain has few revolutionary changes, and could not bring high-quality output, so customers do not have a strong desire to use it. Thirdly, blockchain technology is still in its infancy, and users have reservations about the development of such new technologies.

5.3. Theoretical implications

The first contribution of this study is that it manages to conduct an empirical research to examine the main technical features of blockchain applications for e-commerce consumers, thus providing theoretical advice for the development of blockchain technology. There have been numerous studies on blockchain adoption from the perspective of corporate users, especially on the acceptance behavior of small and medium enterprises in supply chains (Francisco and Swanson, 2018; Kumar et al., 2021; Saurabh and Dey, 2021). However, few previous studies assess the influence of technical characteristics of blockchain technology from the point of view of individual users. This study narrows the literature gap by exploring the connection between blockchain's technical characteristics and the behavior of adoption intention by users.

Secondly, this study contributes to the literature on introducing different constructs from existing research to measure their effects on users' adoption. In contrast to exsitng research on blockchain acceptance, such as the empirical study by Liu and Ye (2021), this study selects ‘trust’ as blockchain's technical feature to examine users' acceptance. The results of this study indicate that *cost saving* and *traceability* importantly affect the willingness of consumers to use blockchain. Particularly, these findings shed light on some interesting aspects of how consumers may perceive more usefulness from relatively physical objective features, while they may pay less attention to subjective feelings. For example, they are more likely to feel the usefulness of the reduced cost and reliable information sources. But they may become less aware of the usefulness of protected data security and privacy.

5.4. Managerial implications

The results of this research provide managerial implications for companies that seek to adopt blockchain technology with respect to what kind of marketing strategies they can use to promote their blockchain-related products and services and to increase consumers' willingness to use.

The results show that cost saving is an important factor that consumers perceive useful. Therefore, the companies should focus on improving the system's ability to reduce costs (in particular *search cost* and *negotiation cost*) and emphasize those characteristics during marketing process, thus persuading consumers to use their products. Firstly, when advertising or introducing blockchain-related

applications, companies could show their users reducing search costs as one of the characteristics of blockchain. Secondly, companies could also present to customers that the application of blockchain could reduce the negotiation costs. Following these results, blockchain companies are suggested to constantly upgrade their buyer-seller matching algorithms to provide consumers a faster and better experience.

Apart from cost saving, traceability is also a useful determinant that consumers would take into consideration when deciding whether to use blockchain technology. It is suggested that companies adopting blockchain technology can explain to consumers that this technology is more transparent and open, and the application with blockchain traceability can provide customers with more reliable and accurate logistics information of items. Counterfeit and shoddy products have always been a concern for consumers, especially in the food, luxury goods and pharmaceutical industries. Companies can use blockchain technology to store product information, and customers can easily access the data on the chain, thus verifying the source of goods, avoiding the loss of paper documents and the frustration of being unable to prove authenticity. Another example is that with the rise of short video online platforms, such as Tik Tok, many people have been getting paid for content creation. This may involve the issue of digital copyright, so companies can mark the original authors of content by using blockchain, resolve disputes that may arise between buyers and sellers, and build a more complete system.

6. Conclusions

This study discusses the important factors of blockchain technology adoption in e-commerce based on TAM model. Due to scarce research on the relationship between blockchain characteristics and individual users' adoption, we measure to what extent the characteristics of blockchain influence users' intention to adopt blockchain. Our results confirm that two key blockchain features, including cost saving and traceability, have significant influence on perceived usefulness. Regarding the third key blockchain feature, our empirical evidence shows no impact of data privacy security on perceived usefulness. Our model confirms the perceived usefulness has a strong impact on the adoption intention. The perceived ease of use influences the perception of usefulness of the blockchain technology. Such impact intensifies through the mediating role of the perceived usefulness. Despite the mentioned contributions, this study has the following limitations where the future research could be further developed on.

First, while the user intention of blockchain can be measured by different models, this study only includes three characteristics of blockchain to explain user adoption. Future studies may adopt different models such as the Diffusion of Innovation (DOI) model and incorporate other characteristics related to blockchain as constructs, such as efficiency and government support, offering a more comprehensive insight into the determinants impacting blockchain adoption. In light of this, another avenue for future research would be to expand the blockchain constructs to include other characteristics such as data immutability, shared access, and decentralization.

Second, this study only investigates the intention of individual users to adopt blockchain. However, in the adoption of new technologies, there are not only individual users but also organizational users, such as small and medium-sized companies. Future research may thus focus on researching different types of users, so as to explain more fully the users' adoption. In addition, blockchain should not be regarded as an independent technology. It relies heavily on big data collection and analysis. Therefore, it is suggested that the application and adoption of blockchain technology can be analyzed together with other popular technologies and fields, such as artificial intelligence (AI), Internet of Things (IoT), supply chain management, smart cities, agriculture, and healthcare. It would then be useful to incorporate constructs that represent other new technologies and assess their mediating or moderating effects in this context. Another future direction suggested by our research is to explore the mediating effect of perceived usefulness on the relationships between perceived ease of use and adoption intention.

Third, although the sample size was acceptable for the aim of this study, it is important that future research verify our findings using data from additional samples. In addition, data was mainly collected from Chinese users, which may affect generalizability beyond this region. Future research is encouraged to conduct comparative studies beyond this region to increase the generalizability of this research, e.g., emerging markets versus developed economies.

Finally, because blockchain is a new technology, it is still in its infancy, so many institutions and organizations are skeptical about it, especially the government. The government's support plays a significant role in formulating regulatory and rules for blockchain transactions, which is important for the success of adoption of blockchain in e-commerce. The study has not considered the impact of such supports on the adoption of blockchain. Therefore, future research may need to make a comparative study on the adoption of blockchain in countries where the government is allowing the use of blockchain and countries where the government is skeptical.

Ethics statement

Ethics approval was obtained from the Ethics Committee of University of Birmingham. In addition, the participants provided their informed consent to participate in this study.

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