An empirical study on the adoption of blockchain-based games from users’ perspectives

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Abstract

Purpose – The purpose of the research is to investigate users’ adoption of blockchain-based games in China.

Design/methodology/approach – This research applied existing technology diffusion theories to develop a research model to examine users’ adoption of blockchain-based games. As a result, a research model with nine research hypotheses was developed. The developed research model was empirically tested using data collected from a survey of 210 blockchain-based games users. Structural equation modeling was applied to analyse the collected data.

Findings – The results indicated that seven of nine research hypotheses were supported. It was found that trust, perceived usefulness, perceived enjoyment and perceived ease of use were key determinants for users’ behavioural intention to use blockchain-based games. The most influential relationship in the research model appeared to be the effect of perceived usefulness on users’ behavioural intention to use blockchain-based games. However, subjective norms did not have significant positive impacts on users’ behavioural intention to use blockchain-based games.

Practical implications – The regulatory support from governmental authorities is essential to provide additional legal certainty to build users’ trust in playing blockchain-based games. Blockchain-based games providers should arrange the training program targeted to the general users to enhance their understanding of the key features associated with blockchain-based games. Blockchain-based games developers should come up with good design solutions to maximize user enjoyment with blockchain-based games by considering additional entertainment elements.

Originality/value – To the best of the authors’ knowledge, this study is first of its kind in investigating the adoption of blockchain-based games from users’ perspectives. This study contributes to the existing literature on the adoption of blockchain technology.

Keywords Technology adoption, TAM, Perceived enjoyment, Trust, Subjective norms, Blockchain technology, Blockchain-based games

Paper type Research paper

1. Introduction

Blockchain technology has been considered as one of the most disruptive innovative technologies. Blockchain has gained increasing attention from academia and industry since...
the debut of Bitcoin in 2008. Bitcoin is an entirely digital distribute currency, launched through a white paper by Nakamoto (2008). One of Bitcoin’s key innovations is the creation of a decentralized public transaction ledger, called the blockchain, which is transparent and immutable, being cryptographically verifiable by all participants in the Bitcoin network (Folkinshteyn and Lennon, 2016). Transactions are denominated in units of its own currency, termed Bitcoin, so the system is not dependent on any particular national currency or geographical location; hence, it is completely digital and international in scope.

The disruptive potential of blockchain technology enabled the possibility to expand the application of this technology into a number of contexts (e.g. supply chain management, healthcare, gaming, digital authentication, asset trading). However, previous studies on the individual adoption behaviour of blockchain technology tended to focus on the context of supply chain management. For instance, Kamble et al. (2019) examined the adoption of blockchain technology in supply chain in India. Queiroz and Fosso Wamba (2019) investigated the individual blockchain adoption behaviour in the supply chain field in both India and the USA based on a revised unified theory of acceptance and use of technology (UTAUT) model (Venkatesh et al., 2003). Queiroz et al. (2020) studied the driving factors and barriers to the adoption behaviour of blockchain technology in operations and supply chain management in Brazil. Little empirical investigation has been conducted to understand the adoption of blockchain technology on gaming.

Researchers have not systematically assessed the influence of blockchain technology on gaming because it has been only a few years since blockchain technology applied to online games. Before the wide implementation and adoption of blockchain technology in the gaming industry, it is important to have a better understanding of potential factors that would influence the adoption of blockchain-based games from the end users’ points of view.

To bridge the research gap, this study aims to provide insights into understanding the adoption of blockchain-based games. This study develops a research model to examine user adoption of blockchain-based games. As a result, a research model with nine research hypotheses was developed. The research model is empirically tested using survey data collected from 210 users of blockchain-based games in China.

This study contributes to the adoption of blockchain technology in two ways. First, this study is one of the first empirical studies focusing on the adoption of blockchain-based games. By building a research model based on previous technology diffusion theories, the perspectives of end users on the adoption of blockchain-based games have been examined. Second, this study contributes to practice by providing some insights for game developers and providers to better promote the use and diffusion of blockchain-based games.

The rest of this paper is organized as follows. Section 2 presents the theoretical background. Then, the research model and hypotheses are presented in Section 3. After that, an empirical study with blockchain-based games users are described in Section 4. Finally, the conclusion and a discussion of the findings of this study are presented in Section 5.

2. Theoretical background

2.1 Blockchain technology

Blockchain technology refers to a distributed system for cryptographically capturing and storing a consistent, immutable, linear event log of transactions between networked actors using a consensus mechanism (Risius and Spohrer, 2017). The blockchain constitutes a set of protocols and cryptographic methods applied to a network of nodes that collaborate to achieve the secure recording of data within a distributed database that comprises encrypted blocks that encapsulate the data (Macrinici et al., 2018). The blockchain technology
underlying Bitcoin and other cryptocurrencies allows for a shared digital ledger that is a continually updated list of all transactions (Morisse, 2015).

Bitcoin is the first application of blockchain technology. Bitcoin offered a new, enhanced way of capital circulation, new markets and new decentralised autonomous organisations (Hsieh et al., 2018). Ethereum (Buterin, 2014) is another well-known implementation of blockchain, which is designed to facilitate smart contracts. A smart contract can be used to eliminate the interference of any third party and further enhances the decentralization of a network. Blockchain technology is able to offer a solution to the problem where there is a need for a reliable ledger in a decentralized environment where not all parties, whether humans or machines, can be fully trusted (Tshering and Gao, 2020). Blockchain technology has been successfully applied in application scenarios, such as education (Bdiwi et al., 2017), logistics (Christodoulou et al., 2018), health care (Dagher et al., 2018), energy (Hou et al., 2018), supply chain management (Kshetri, 2018) and games (Min et al., 2019).

2.2 Blockchain-based games
Blockchain-based games are online games that use blockchain technology. In other words, these games are online and designed on the basis of blockchain technology. For instance, cryptocurrencies, such as Bitcoin or Ethereum, can be used as one of the ways for conducting financial transactions within online games. Blockchain technology has been regarded as a disruptive innovation in many application areas, such as financial services, supply chain management and governance models (Campbell-Verduyn and Goguen, 2017). Blockchain technology can be applied to financial transactions in online games to ensure the openness and fairness of financial transactions.

A blockchain-based game is able to offer the true ownership of a digital game asset, as the link to the owner of the asset can be written on an immutable blockchain in terms of smart contracts. Smart contracts are open source programs written on the Ethereum blockchain platform. Smart contracts are constantly being calculated as digital game asset transactions are verified by the involved game players. The digital game asset ownership can be tracked via a smart contract on the blockchain. The smart contracts on the blockchain can also be used to enable instant transfer of ownership of a digital game asset securely without involving any third parties. As a result, smart contracts help to enforce digital game asset ownerships and ensure the openness of digital game asset transactions.

Released in 2017, CryptoKitties is one of the most popular games based on blockchain technology, namely, the Ethereum network. Blockchain is capable of building a clear and reliable digital ownership through mining where a user can claim ownership of new tokens contributing with a node. Any transaction data of the blockchain is visible, reliable and accessible to the involved participants of blockchain (Lu, 2019). Users can breed, trade and gift different types of virtual cats with CryptoKitties. The blockchain technology helps to both guarantee the ownerships of virtual cats with CryptoKitties and ensure the validity of various financial transactions on CryptoKitties. The associated financial transactions with CryptoKitties, such as selling or breeding, are enforced by smart contracts. Each cat is unique and cannot be handled by anyone other than its owner. The cat’s ownership is tracked and proven by smart contract associated with CryptoKitties.

Gods Unchained is another popular blockchain-based game. It is a turn-based collectible digital card trading game that operates on the Ethereum blockchain. The ownership of each card is guaranteed by a smart contract. Smart contracts enable users to trade and sell their cards freely with the true ownership of the cards. In addition, there are other examples of existing blockchain-based games (e.g. Etheremon, HyperSnakes, HyperDragons).
2.3 Technology diffusion theories
One of the important and long-standing research questions in information systems research is user adoption of information systems (DeLone and McLean, 1992). Several models, such as the technology acceptance model (TAM) (Davis, 1989), UTAUT (Venkatesh et al., 2003), theory of planned behavior (TPB) (Ajzen, 1991) and innovation diffusion theory (Rogers, 1995), have been developed to test user attitude and intention to adopt new technologies.

As listed in Table 1, TAM has been widely used in previous studies on the adoption of blockchain technology. For instance, an extended TAM model has been used to examine the adoption of cryptocurrencies (Shahzad et al., 2018) and smart lockers (Lian et al., 2020). TAM has been expanded to investigate different study objects by taking into consideration the characteristics of the study object in previous studies. For example, research on the adoption of online games indicated that perceived enjoyment and subjective norms have a significant impact on users’ behaviour intention to use online games (Lee and Tsai, 2010). Trust has been identified as one predicting factor for the adoption of blockchain technology in supply chain in previous studies (Queiroz et al., 2020). This study aimed to extend TAM with additional factors, such as trust, perceived enjoyment, subjective norms, security and privacy, to examine user adoption of blockchain-based games. The research model and research hypotheses are presented in Section 3.

2.4 Adoption of blockchain technology
Compared to the rapid development of blockchain technology, the research on the adoption of this technology is still in its infancy stage. Based on the literature review, some existing research on the adoption of blockchain technology is summarized in Table 1. It appears that

| Article                          | Object studied                                      | Applied theory | Findings                                                                                                                                 |
|---------------------------------|-----------------------------------------------------|----------------|------------------------------------------------------------------------------------------------------------------------------------------|
| Folkinshteyn and Lennon (2016)  | Bitcoin                                             | TAM            | It was found that perceived usefulness mainly comes from the feature of openness with Bitcoin, which improves the transaction efficiency. However, at the same time, users are exposed to transaction risks |
| Kamble et al. (2019)            | Blockchain technology adoption in supply chains     | TAM, TRI, TPB  | Perceived usefulness, attitude, and perceived behavioural control affect behavioural intention. Subjective norm has a negligible impact on behavioural intention. Discomfort and insecurity in the TRI model do not have a significant impact on the user |
| Shahzad et al. (2018)           | Cryptocurrencies                                    | TAM            | It was found that awareness, perceived ease of use, perceived usefulness, and perceived trustworthiness had significant impacts on the intention to use Bitcoin among people in China |
| Queiroz and Fosso Wamba (2019)  | Blockchain technology adoption in the logistics and supply chain field | UTAUT          | It was found that performance expectancy positively affected the behavioural intention to adopt blockchain in the logistics and supply chain in both India and the US. The influence of facilitating conditions on the adoption of blockchain was the case only in the US |
| Lian et al. (2020)              | Blockchain-based smart lockers                     | TAM            | It was found that perceived usefulness and perceived ease of use are the critical factors. It also indicated that safety was not the major concern when using a blockchain-based smart locker |

Table 1. Previous studies on the adoption of blockchain technology
most previous studies on the adoption of blockchain tended to focus on digital currencies (Folkinshteyn and Lennon, 2016; Shahzad et al., 2018) and applications in the field of supply chain (i.e. Kamble et al., 2019; Queiroz and Fosso Wamba, 2019).

Most existing studies on blockchain-based games tended to focus on the value and fairness aspects. For instance, Serada et al. (2020) studied the value created through blockchain-based games. They found the following three major factors determining the value of cryptogame tokens: blockchain as a sociotechnical infrastructure, perceived materiality of tokens and pseudo true ownership (Serada et al., 2020). In addition, Sako et al. (2021) examined the fairness of markets in blockchain-based games. Furthermore, Li and Gao (2019) explored the values of blockchain-based games from users’ perspectives in China. However, the research on the adoption of blockchain-based games from users’ perspectives has not yet been explored. This study is an early effort to explore the adoption of blockchain-based games.

3. Research model and research hypotheses

According to the findings in Table 1, TAM has been mostly applied in previous studies on the adoption of blockchain technology. Therefore, TAM has been selected as a base model to explore the adoption of blockchain-based games in this study. The proposed research model for studying the adoption of blockchain-based games is presented in Figure 1. The research model is an extended model based on TAM. In addition to perceived ease of use, perceived usefulness and behaviour intention to use from TAM, the model includes trust, perceived security, privacy, perceived enjoyment and subjective norms as factors to study user adoption of blockchain-based games. Nine research hypotheses based on the research model have been proposed in this research model. Each hypothesis as labelled and elaborated in Figure 1.

3.1 Perceived security

Perceived security has different definitions in various contexts. In the context of e-commerce, Kalakota and Whinston (1996) defined security as a threat which creates the “circumstance, condition, or event with the potential to cause economic hardship to data or network resources in the form of destruction, disclosure, modification of data, fraud, and abuse”. Previous studies (Salisbury et al., 2001) proved that security was crucial when consumers conducted a transaction online. Moreover, perceived security has been proposed as an antecedent of trust together with perceived privacy (Shin, 2010; Yousafzai et al., 2009).

Figure 1. Research model
Security is also one of the significant considerations when users decide to use the new technology and new applications, especially among early adopters. Security issues must be settled before it would become a feasible and viable option to adopt blockchain technology (Angelis and da Silva, 2019). The distributed trust mechanism of blockchain can help users reduce cybersecurity-related risks, which has been found in supply chain management (Kshetri, 2018). Distributed branches of blockchain reduce the likelihood that the system will crash under attack. Additionally, blockchain technology also enables open rules and transparent transactions, which increase the security of game assets. Thus, the following hypothesis has been proposed:

**H1.** Perceived security has a positive effect on user trust of blockchain-based games.

### 3.2 Privacy

In traditional online trades, consumers often worried about privacy issues (Liu et al., 2005). In today’s mobile internet environment, while mobile users increasingly rely on the use of various mobile applications for their daily activities, the processing of personal data through these applications poses significant risks to user privacy. Data has been collected by various applications to facilitate people’s daily lives. Arnott et al. (2007) found that the privacy features of a website along with shared values were the key antecedents of trust. Using smart contracts helps to conduct a transaction automatically, avoiding manipulation by others (Angelis and da Silva, 2019). An anonymous mechanism can be used to protect user privacy (Cuccuru, 2017). Yue et al. (2016) proposed a blockchain-based application to enable a patient to own, control and share their own data easily and securely without violating privacy, which provided a new potential way to improve the intelligence of health-care systems while keeping patient data private. Similarly, when users use blockchain-based games, their identity information and data can also be protected, which would in turn positively affect user trust on blockchain-based games. Thus, the following hypothesis has been proposed:

**H2.** Privacy has a positive effect on user trust of blockchain-based games.

### 3.3 Trust

Trust has been a topical subject with technology acceptance in previous literature. Gefen et al. (2003) integrated trust into the TAM (Davis, 1989) and found that trust had a positive impact on intended use and trust was influenced by perceived ease of use. Moreover, Hoffman et al. (1999) found that distrust of security was the main reason for early users not adopting online shopping. In addition, trust has been proven to have a significant impact on users’ behaviour intention to play online games (Wu and Liu, 2007).

Playing blockchain-based games involves frequent transaction confirmation processes in terms of invoking smart contracts. Fleischmann and Ivens (2019) found that trust was a key driver in the adoption of blockchain-based applications which spans across both functional (economic and system-related/process-related) and emotional benefit (social and personal) dimensions. Furthermore, Folkinshteyn and Lennon (2016) indicated that trust was essential in the adoption of digital currency because users have distinctive trust patterns in blockchain-based applications where they have no intermediary or control centre. Because of the encryption and anonymity brought by blockchain technology, blockchain-based games inherit these technical characteristics, enabling users to be more trustworthy of the
trading behaviour in blockchain-based games than traditional games. Thus, the following hypothesis has been proposed:

\[ H3. \text{Trust has a positive effect on users' behaviour intention to use blockchain-based games.} \]

3.4 Perceived ease of use and perceived usefulness from the technology acceptance model

In the classical technology adoption model, both perceived ease of use of the technology and perceived usefulness of the technology used positively affect users’ intention to use the technology. Also, the perceived usefulness of the technology is positively affected by perceived ease of use of the technology. In addition, according to Gefen et al. (2003), a user’s perceived ease of use of online shopping will affect their trust in online shopping. The easier the users grasp the usage of new technology, the easier they will generate trust behaviour of new technology. Blockchain-based games can be seen as the new innovations. It is believed the hypotheses presented above would apply to blockchain-based games as well. Thus, the following hypotheses have been proposed:

\[ H4. \text{Perceived usefulness has a positive effect on users' behaviour intention to use blockchain-based games.} \]

\[ H5. \text{Perceived ease of use has a positive effect on trust of blockchain-based games.} \]

\[ H6. \text{Perceived ease of use is positively related to perceived usefulness of blockchain-based games.} \]

\[ H7. \text{Perceived ease of use has a positive effect on users' behaviour intention to use blockchain-based games.} \]

3.5 Perceived enjoyment

Hedonic products have the characteristics of providing users with the value of self-satisfaction. The psychological experience is influenced by the content of products, such as pictures, sounds, layout and so on. By contrast, users of utilitarian products are mostly driven by the purpose of completing a specific task or by the improvement of efficiency. Users mainly use utilitarian products as tools. Hence, there is a fundamental difference between perceived enjoyment and perceived usefulness (Van der Heijden, 2003). When the purpose of the system is utilitarianism, the reliability coefficient of scale of perceived ease of use and perceived usefulness is better than that of hedonism (Hess et al., 2014).

Perceived enjoyment is defined as the extent to which the activity of using a specific system is perceived to be enjoyable in its own right, aside from any performance consequences resulting from system use (Van der Heijden, 2003). Users can have fun when they are playing blockchain-based games. Previous studies indicated that perceived enjoyment had a positive impact on user intention to use a technology. For instance, Ha et al. (2007) found that perceived enjoyment affected the adoption of mobile games in a mobile broadband wireless access environment in a positive way. Moreover, Liu et al. (2005) conducted a study to investigate the driving factors of mobile game adoption in China and found that perceived enjoyment is one of the key driving factors of a person’s willingness to play mobile games. Furthermore, Alzahrani et al. (2017) found that perceived enjoyment is an important driving factor for the actual use of online games among Malaysian undergraduate students. Thus, the following hypothesis has been proposed:
H8. Perceived enjoyment has a positive effect on users’ behaviour intention to use blockchain-based games.

3.6 Subjective norms
Subjective norms are generated by the normative beliefs that the person attributes to what a relevant other expects them to do with respect to adopting a technology as well as their motivation to comply with those beliefs (Karahanna et al., 1999). The previous literature suggested that subjective norms would have a positive impact on the intention to use the technology (Pavlou and Fygenson, 2006). For instance, TAM2 (Venkatesh and Davis, 2000) suggested a positive relationship between subjective norms and intention to use. In addition, Bhattacherjee (2000) found that subjective norms had a positive effect on users’ behaviour intention to use e-commerce services. It is expected that there is a positive relationship between subjective norms and intention to use blockchain-based games. Therefore, the following hypothesis has been proposed:

H9. Subjective norms has a positive effect on users’ behaviour intention to use blockchain-based games.

4. An empirical study
To investigate user adoption of blockchain-based games in China, the proposed research model and hypotheses were empirically tested using the structural equation modelling (SEM) approach (Bollen, 1998) with subjects in China.

4.1 Instrument development
The validated measurement items from previous studies (Davis, 1989; Kim et al., 2008)) were used as the foundation to create the instrument for this study. For instance, the scales on perceived usefulness, perceived ease of use and behaviour intention came from pre-validated TAM measures (Davis, 1989). Privacy was measured by adapting the scales from Kim et al. (2008). Perceived security was measured by adapting the scales from Kim et al. (2008) and Vatanasombut et al. (2008). Trust was measured by adapting the scales from Jarvenpaa et al. (2000). Perceived enjoyment was measured by adapting the scales from Van der Heijden (2003). Subjective norms were measured by adapting the scales from Pavlou and Fygenson (2006) and Wu and Chen (2005). As a result, 27 measurement items (Appendix) were included in the instrument survey. A five-point Likert scale, with one being the negative end of the scale (strongly disagree) and five being the positive end of the scale (strongly agree), was used to examine participants’ responses to the survey items.

4.2 Data collection and sample
The questionnaire consisted of two parts. In the first part, the respondents were asked to fill out their demographic information (i.e. age, gender, educational level). The online survey was developed on Sojump which was the largest Chinese service provider engaged in online questionnaires in March 2019. A survey weblink including all the survey questions was distributed on a major Chinese social networking platform in November 2019 in China. When the participants opened the weblink, they were briefed about the purpose of the survey before being asked to complete the online questionnaire. Each participant received approximately US$1 as the incentive for participation. The participants had also been
informed that the results would be reported only in aggregate form so that their anonymity would be assured. A total of 328 questionnaires were collected, including 210 valid questionnaires, and the effective questionnaire response rate was 64.02%. Among the participants, 38.93% of the participants were male and 61.07% were female. Concerning the educational level, 90.95% of the respondents were either university students or who had at least earned a bachelor’s degree. Thus, the respondents’ education level was quite high in general. Table 2 presents the demographic information of the respondents.

### 4.3 Test of measure

Convergence validity and discriminant validity were tested first. In the confirmatory factor analysis, the factor loadings are all above the minimum acceptable value of 0.70, as shown in Table 3.

To test the reliability and validity of each construct in research model, the internal consistency of reliability of each construct was tested with Cronbach’s alpha coefficient. Convergent validity was assessed through the average variance extracted (AVE) and composite reliability (CR). Furthermore, Bagozzi and Yi (2012) proposed the following measurement criteria: the CR should exceed 0.7 and the AVE of each construct should exceed 0.5. As shown in Table 3, all constructs are in acceptable ranges. Furthermore, Cronbach’s alpha values range from 0.881 to 0.932. All the constructs are above 0.70. Consequently, the scales are deemed acceptable to continue.

As for discriminant validity, the square roots of AVEs by the constructs were more than correlations among variables in Table 4. The rest in Table 4 is the correlation coefficient of the latent variable. The correlation coefficient was greater than the square root of the mean variance extraction value of the corresponding variable, which proved the good discriminate validity.

In this study, the goodness-of-fit of the measurement model was examined by using five widely-used fit indices: the chi-square/degrees of freedom ($\chi^2$/d.f.), the normed fit index (NFI), the comparative fit index (CFI), the root mean square error of approximation (RMSEA) and the standardized root mean square residual (SRMR). The fitness measures in Table 5 indicated that all measures were within acceptable ranges.

| No. (%) | No. (%) |
|---------|---------|
| Gender Male | Male | 123 | 38.93 |
| Female | Female | 87 | 61.07 |
| Age Below 25 | Below 25 | 81 | 50.00 |
| 25–30 | 25–30 | 78 | 32.55 |
| 31–40 | 31–40 | 46 | 10.07 |
| Over 40 | Over 40 | 5 | 7.38 |
| Educational level Upper secondary school or below | Upper secondary school or below | 19 | 9.05 |
| University students or above | University students or above | 191 | 90.95 |
| Familiarity with blockchain-based games Very familiar | Very familiar | 94 | 44.76 |
| Heard before | Heard before | 91 | 43.33 |
| Never heard | Never heard | 25 | 11.90 |
| Frequency of use 2–3 times per day | 2–3 times per day | 34 | 16.19 |
| 2–3 times per week | 2–3 times per week | 55 | 26.19 |
| 2–3 times per month | 2–3 times per month | 44 | 20.95 |
| Hardly use | Hardly use | 77 | 36.67 |

Table 2
Demographic information of the respondents
| Construct                  | Scale item | Factor loading | CR    | AVE    | Cronbach's alpha |
|---------------------------|------------|----------------|-------|--------|------------------|
| Perceived security        | SE1        | 0.837          | 0.916 | 0.732  | 0.916            |
|                           | SE2        | 0.902          |       |        |                  |
|                           | SE3        | 0.842          |       |        |                  |
|                           | SE4        | 0.840          |       |        |                  |
| Privacy                   | PR1        | 0.848          | 0.908 | 0.712  | 0.905            |
|                           | PR2        | 0.878          |       |        |                  |
|                           | PR3        | 0.858          |       |        |                  |
|                           | PR4        | 0.788          |       |        |                  |
| Trust                     | TR1        | 0.896          | 0.934 | 0.824  | 0.932            |
|                           | TR2        | 0.948          |       |        |                  |
|                           | TR3        | 0.878          |       |        |                  |
| Perceived usefulness      | PU1        | 0.889          | 0.901 | 0.754  | 0.900            |
|                           | PU2        | 0.892          |       |        |                  |
|                           | PU3        | 0.822          |       |        |                  |
| Perceived ease of use     | PE1        | 0.773          | 0.882 | 0.651  | 0.881            |
|                           | PE2        | 0.849          |       |        |                  |
|                           | PE3        | 0.819          |       |        |                  |
|                           | PE4        | 0.784          |       |        |                  |
| Perceived enjoyment       | EN1        | 0.884          | 0.904 | 0.758  | 0.903            |
|                           | EN2        | 0.876          |       |        |                  |
|                           | EN3        | 0.852          |       |        |                  |
| Subjective norms          | SN1        | 0.804          | 0.903 | 0.757  | 0.901            |
|                           | SN2        | 0.885          |       |        |                  |
|                           | SN3        | 0.917          |       |        |                  |
| Behaviour intention to use| BI1        | 0.860          | 0.922 | 0.797  | 0.921            |
|                           | BI2        | 0.933          |       |        |                  |
|                           | BI3        | 0.883          |       |        |                  |

Table 3. Item loadings, CR, AVE and Cronbach’s alpha for each construct

| SE    | PR    | TR    | PU    | PE    | EN    | SN    | BI    |
|-------|-------|-------|-------|-------|-------|-------|-------|
| 0.856 | 0.269 | 0.347 | 0.302 | 0.325 | 0.412 | 0.089 | 0.263 |
| PR    | 0.844 | 0.281 | 0.249 | 0.427 | 0.356 | 0.0580| 0.0860|
| TR    |       | 0.908 | 0.868 | 0.441 | 0.356 | 0.030 | 0.401 |
| PU    |       |       | 0.908 | 0.441 | 0.356 | 0.003 | 0.459 |
| PE    |       |       |       | 0.807 | 0.356 | 0.074 | 0.477 |
| EN    |       |       |       |       | 0.871 | 0.057 | 0.483 |
| SN    |       |       |       |       |       | 0.870 | 0.172 |
| BI    |       |       |       |       |       |       | 0.893 |

Table 4. Discriminant validity of constructs

| Measures                  | Recommended criteria | Measurement model | Suggested by authors |
|---------------------------|----------------------|-------------------|----------------------|
| Chi-square/d.f.           | <3.0                 | 1.288             | Hayduk (1988)         |
| NFI                       | >0.9                 | 0.913             | Bagozzi and Yi (1988) |
| CFI                       | >0.9                 | 0.979             | Bentler (1992)        |
| RMSEA                     | <0.09                | 0.037             | Bagozzi and Yi (1988) |
| SRMR                      | <0.08                | 0.057             | Hu and Bentler (1998) |

Table 5. Fit indices for the measurement model
4.4 Results of hypotheses testing

To test the hypotheses proposed above, data were collected and analysed using the SEM (Bollen, 1998). AMOS 22.0 was used to test the structural model. The result of the structural model is shown in Figure 2.

The results of hypotheses testing are presented in Table 6. The $p$-value indicates the significant degree of correlation between the two measured variables. According to the results in Table 6, seven ($H_1$, $H_3$, $H_4$, $H_5$, $H_6$, $H_7$ and $H_8$) of the proposed nine hypotheses were supported.

5. Discussion and conclusion

5.1 Conclusion

This study aimed to investigate user adoption of blockchain-based games in China. To address this, a research model based on previous technology diffusion theories was developed and empirically tested with 210 participants in China. According to the results, seven of the developed nine hypotheses were supported. It was found that trust, perceived usefulness, perceived enjoyment and perceived ease of use were key determinants for users’ behavioural intention to use blockchain-based games. The most influential relationship in the research model appeared to be the effect of perceived usefulness on users’ behavioural intention to use blockchain-based games. However, subjective norms did not have significant positive impacts on users’ behavioural intention to use blockchain-based games.

5.2 Theoretical contributions

From a theoretical perspective, the major contribution of this research is the proposed research model which is useful in explaining users’ behaviour intention to use blockchain-based games. This study is the first of its kind in investigating the adoption of blockchain-based games from users’ perspectives. Previous studies tended to focus on the value created through blockchain-based games (Li and Gao, 2019; Serada et al., 2020). However, there is a research gap on the adoption of blockchain-based games from users’ perspectives. This research filled this gap by carrying out an empirical study on the adoption of

Figure 2. Results of the structural model
blockchain-based games from users’ perspectives in China. This research extended and enhanced the understanding of the adoption of blockchain-based games. It contributed to current literature on the adoption of blockchain technology.

The results indicated that perceived usefulness was the most significant influential factor to users’ behavioural intention to use blockchain-based games. The use of blockchain-based games was helpful to solve potential problems associated with online game assets trading. Compared with traditional online games, blockchain-based games have the advantage of making the process of online game assets trading more transparent. For instance, a decentralized, open and transparent trading market through smart contracts can be established with blockchain-based games. This is consistent with the findings on the adoption of bike sharing systems (Gao et al., 2019) and the adoption of Bitcoin (Shahzad et al., 2018).

Perceived enjoyment was the second most significant influential factor to users’ behavioural intention to use blockchain-based games. A well-designed blockchain-based game would motivate users to play the game. This is in line with the findings from Alzahrani et al. (2017). Alzahrani et al. (2017) found that perceived enjoyment in the game was one of the major motivations for a user to play the game.

The positive influence of trust on users’ behavioural intention to use blockchain-based games has been supported in this study. There are many game assets transactions within blockchain-based games. Trust is one of the important elements involved in these transactions. Unless sufficient trust have been accumulated by blockchain-based games among users, users would not choose to trade within these games. This finding is consistent with the findings on the adoption of mobile payment systems (Srivastava et al., 2010), and the adoption of blockchain in operation and supply chain management (Queiroz et al., 2020).

A user’s perceived ease of use can promote the formation of user trust in blockchain-based games. At present, most of the blockchain-based games are built on the basis of Ethereum. An open-source blockchain plugin is required to be installed on the blockchain-based gaming platform to enable players to trade assets with their wallets in games. This would give users the ability to link their blockchain wallets to their servers. To trade assets

Table 6. Results of hypotheses testing

| Hypothesis                                                                 | Path Coefficient | Results   |
|---------------------------------------------------------------------------|------------------|-----------|
| H1: Perceived security will have a positive effect on trust               | 0.245***         | Supported |
| H2: Privacy will have a positive effect on trust                          | 0.104            | Not supported |
| H3: Trust will have a positive effect on behavioural intention to use blockchain-based games | 0.168***         | Supported |
| H4: Perceived usefulness will have a positive effect on behaviour intention to use blockchain-based games | 0.269***         | Supported |
| H5: Perceived ease of use will have a positive effect on trust            | 0.438***         | Supported |
| H6: Perceived ease of use will have a positive effect on perceived usefulness | 0.613***         | Supported |
| H7: Perceived ease of use will have a positive effect on behaviour intention to use blockchain-based games | 0.248***         | Supported |
| H8: Perceived enjoyment will have a positive effect on behaviour intention to use blockchain-based games | 0.252***         | Supported |
| H9: Subjective norms will have a positive effect on behaviour intention to use blockchain-based games | 0.092            | Not supported |

Note: ***p < 0.05
on the blockchain-based gaming platform, users need to install the plugin on the platform. The results from this study indicated that, if the installation process of the plugin on the platform is easy, it would have a significant positive impact on users’ behavioural intention to use the games on the platform. Furthermore, it was also found that perceived ease of use had a positive impact on user trust of blockchain-based games. In other words, the improvement on the perceived ease of use of the blockchain-based game by users would be helpful to increase players’ trust in the game.

Subjective norms did not have a significant positive influence on users’ behavioural intention to use blockchain-based games. This finding is consistent with the finding on the adoption of blockchain technology in supply chains (Kamble et al., 2019). Some users indicated that they often heard of the concept of blockchain. However, they did not have a good understanding of the principles behind applications of blockchain technology. Although blockchain technology is booming in China, some users might misunderstand the concept of blockchain and applications of blockchain technology. Several major newspapers in China have promoted the development of the blockchain industry by introducing and describing the concept of blockchain, as well as describing innovative blockchain-based applications. However, these newspapers also pointed out users’ improper behaviour with blockchain-based applications and recommended that the use of blockchain-based applications should be regulated. Therefore, this would have a negative impact on users’ willingness to use blockchain-based applications (e.g. blockchain-based games) from the perspective of subjective norms.

Perceived security had a significant positive impact on user trust of blockchain-based games. Blockchain has inherent characteristics that provide the means for security. For instance, advanced cryptographic techniques are used to secure transactions on blockchain. Kshetri (2017) indicated that the use of blockchain-based systems is secure and can avoid attacks common in present security mechanisms due to the fact that the systems do not have a single point of failure. A secured blockchain-based gaming platform is of help to build user trust in playing games on the platform.

However, privacy did not have a significant positive effect on user trust of blockchain-based games. Some users did have some concerns with the privacy of data transactions on blockchain-based applications. As the transaction data is disclosed on the blockchain and can be viewed by other users, the privacy of the transaction party cannot be guaranteed. One of the appealing aspects of blockchain technology is the degree of transparency that it can provide. In other words, it means transactions within the blockchain wallets owned by one user might be searchable through public transaction records. It implies that it is possible to reveal transaction parties’ private transactions on blockchain-based applications. Moreover, it could also be due to users’ knowledge on privacy protection mechanisms of blockchain-based applications. For instance, some users might not be aware of or may lack the knowledge of privacy protection mechanisms of blockchain-based applications (e.g. blockchain-based games). Previous studies (Krombholz et al., 2016) also revealed that the majority of users were not aware of backup mechanisms and the inbuilt privacy designs of blockchains.

5.3 Practical implications
This study also provides some practical implications. It is of help for practitioners to gain a better understanding of the factors surrounding the adoption of blockchain-based games.

First, trust was found to have a significant positive impact on user intention to use blockchain-based games. The significant effect of trust on user intention to use blockchain-based games should be a focus of attention for developers and providers of blockchain-based games. A good understanding of security protection mechanisms of blockchain technology is essential to build user trust on blockchain-based games. Therefore, it is important for the providers of blockchain-based
games to dedicate their time and efforts in enhancing users’ knowledge on various security issues with blockchain technology. For instance, providers of blockchain-based games can offer some interesting video clips to introduce key security protection mechanisms of blockchain technology in an easy-to-understand manner. Moreover, developers of blockchain-based games should also improve their understanding of trust-related concerns from users’ perspectives to better fulfill user expectations with playing blockchain-based games. Furthermore, regulatory support from governmental authorities would provide additional legal certainty to build user trust in playing blockchain-based games. For instance, the government can issue regulatory guidance to regulate various issues with financial transactions associated with blockchain-based games.

Second, perceived ease of use was another predictor for maximizing the adoption of blockchain-based games. Some users might face problems with installing relevant plugins on the gaming platform to play blockchain-based games due to the lack of required knowledge. Developers of blockchain-based games should design a good solution to ease users’ efforts with plugin installation for playing blockchain-based games. Furthermore, some users might lack knowledge of blockchain technology when playing blockchain-based games. Providers of blockchain-based games should arrange the training program targeted to the general users to enhance their understanding of key features associated with blockchain-based games.

In addition, the findings indicated that perceived enjoyment did have a positive impact on users’ behavioural intention to use blockchain-based games. The users of blockchain-based games would like to have an enjoyable and fun experience when playing blockchain-based games. Developers of blockchain-based games should create good design solutions to maximize users’ enjoyment with blockchain-based games by considering additional entertainment elements.

5.4 Limitations
There were some limitations with this study. First, the research model and hypotheses were only tested in one country (i.e. China). Therefore, the generalizability of the results to other countries remains to be determined. Second, the findings of this study may be limited due to the relatively small sample size. This sample may not be fully representative of the entire population in China. Third, all the data were collected using self-reported scales in this study. This may lead to some cautions because common method variance may account for some of the results. Fourth, it was found that $H2$ and $H9$ were not supported in this study. Thus, this needs to be further investigated in additional studies. Last but not least, there might exist other factors that influence user adoption of blockchain-based games.

5.5 Future research recommendations
There exist some recommendations for future research. First, this study found some potential barriers for the adoption of blockchain-based games. For instance, some users had problems with playing blockchain-based games due to a lack of knowledge of blockchain technology. Some users did not have a good understanding of security issues based on blockchain technology. Future studies can look further into these barriers by interviewing users of blockchain-based games. This would provide additional opportunities to further understand the adoption of blockchain-based games from users’ perspectives. Second, as the development of blockchain-based games is yet in an early stage, there will be more and more blockchain-based games in the near future. Future studies can further explore the adoption of blockchain-based games with these new blockchain-based games. Third, generalizability of the findings in this study can be further explored by expanding the subjects of this study to other countries. Furthermore, some mediating factors (e.g. gender) may provide new opportunities for future research.
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## Table A1. Measurement items

| Constructs                  | Items                                                                                                           | Sources                                      |
|-----------------------------|---------------------------------------------------------------------------------------------------------------|----------------------------------------------|
| **Perceived security**      | SE1. I feel safe playing blockchain-based games<br>SE2. I believe that blockchain-based games offer a secure way through which to play games<br>SE3. I feel secure managing my game assets with blockchain-based games<br>SE4. I believe that blockchain-based games implement security measures to protect players | Kim *et al.* (2008) Vatanasombut *et al.* (2008) |
| **Privacy**                 | PR1. I am concerned that blockchain-based games are collecting too much personal information from players<br>PR2. Blockchain-based games will use my personal information for other purposes without my authorization.<br>PR3. Unauthorized persons (i.e., hackers) have access to my personal information when I am playing blockchain-based games<br>PR4. I am concerned about the privacy of my personal information when I am playing blockchain-based games | Kim *et al.* (2008) |
| **Perceived usefulness**    | PU1. Playing blockchain-based games would enable me to accomplish my goal of playing games quickly<br>PU2. Playing blockchain-based games would enable me to accomplish my goal of playing games effectively<br>PU3. Playing blockchain-based games would increase my life quality | Davis (1989)                                  |
| **Perceived ease of use**   | PE1. Learning to play blockchain-based games is easy for me<br>PE2. It is easy for me to become skilful at playing blockchain-based games.<br>PE3. My interactions with blockchain-based games would be clear and understandable<br>PE4. I would find blockchain-based games easy to use | Davis (1989)                                  |
| **Trust**                   | TR1. Blockchain-based games are trustworthy<br>TR2. Blockchain-based games well keep game rules<br>TR3. Blockchain-based games’ behaviour meets my expectations | Jarvenpaa *et al.* (2000)                     |
| **Perceived enjoyment**     | EN1. I find blockchain-based games entertaining<br>EN2. I play blockchain-based games for pleasure.<br>EN3. Playing blockchain-based games is an agreeable way of passing time | Van der Heijden (2003)                        |
| **Subjective norms**        | SN1. People who are important to me would think that I should play blockchain-based games<br>SN2. People who influence me would think that I should play blockchain-based games<br>SN3. People whose opinions are valued to me would prefer that I should play blockchain-based games | Wu and Chen (2005) Pavlou and Fygenson (2006) |
| **Behaviour intention to use** | BI1. Given that I have access to blockchain-based games, I predict that I would play them<br>BI2. I am likely to play blockchain-based games in the near future<br>BI3. I am willing to play blockchain-based games in the near future | Davis (1989), Venkatesh and Davis (2000)      |