FACTA UNIVERSITATIS
Series: **Electronics and Energetics** Vol. 37, Nº 1, March 2024, pp. 75 - 91
https://doi.org/10.2298/FUEE2401075S

Original scientific paper

ASSESSING THE ADOPTION AND UTILIZATION OF BLOCKCHAIN TECHNOLOGY AMONG SOFTWARE DEVELOPERS

Tatjana Stojanović[1], Saša D. Lazarević[1], Miloš Radenković[2], Tamara Naumović[1], Aleksa Miletić[1]

[1]Faculty of Organizational Sciences, University of Belgrade, Serbia
[2]School of Computing, Belgrade, Serbia

ORCID iDs:		
	Tatjana Stojanović	https://orcid.org/0000-0001-7191-6444
	Saša D. Lazarević	https://orcid.org/0000-0002-5588-4195
	Miloš Radenković	https://orcid.org/0000-0002-1708-9799
	Tamara Naumović	https://orcid.org/0000-0001-9849-7665
	Aleksa Miletić	https://orcid.org/0000-0001-8940-9897

Abstract. *This paper aims to assess factors affecting the adoption and utilization of blockchain technology among developers, extending and adapting the traditional Technology Acceptance Model. Blockchain technology has become increasingly popular in the last years, with the number of journal articles and posts on social media increasing, and many conferences being organized for sharing knowledge about blockchain, to the point where even news has started reporting about events in the blockchain world. But still, there remains the noticeable lag in the growth of blockchain developers relative to the technology's recognition. The adapted Technology Acceptance Model is used to determine how much factors such as perceived usefulness, social influence and personal engagement affect the intention of IT professionals to use blockchain-based applications and finally to use blockchain for development (or to develop it). This research dissects behavioral intention and usage behavior into two distinct domains: application use and development engagement, providing a nuanced understanding of developer interactions with blockchain. Results suggest that social influence positively affects both personal engagement and interest in blockchain technology and perceived usefulness. Additionally, while perceived usefulness and personal engagement strongly motivate the use of blockchain-based application, they also have, but lesser impact on intention to use blockchain in development. The interest in using blockchain applications greatly influences the intention to develop blockchain technology.*

Key words: *technology acceptance model, blockchain-based application, blockchain development, blockchain*

Received December 1, 2023; revised January 30, 2024 and February 29, 2024; accepted March 03, 2024
Corresponding author: Tatjana Stojanović
University of Belgrade, Faculty of Organizational Sciences, Jove Ilića 154, Belgrade, Serbia
E-mail: tatjana.stojanovic@fon.bg.ac.rs

1. INTRODUCTION

Blockchain has become immensely popular, not only among IT professionals, but also there are many people with no IT experience, who have become blockchain enthusiasts. Many blockchain applications, such as in cryptocurrencies, NFTs, DeFi and smart contracts are becoming widely spread, but still its adoption is slow-going. Regardless of its popularity in wider audience, many programmers and organizations are reluctant to adopt and use blockchain, whether that means using blockchain-based applications or blockchain in development. There are many barriers which decelerate adoption of this technology such as high energy consumption, scalability, regulatory issues, etc. Apart from mentioned barriers, further expansion of blockchain technology and its growth can be slowed because of the lack of qualified developers, since number of developers and IT experts who have competence and knowledge about blockchain haven't gone along with its extensive influence through news and social media. This study seeks to identify the key factors driving the adoption and utilization of blockchain technology among IT professionals. It aims to unravel what primarily motivates these professionals to engage with blockchain, not just through its diverse applications but also in its development, considering its widespread popularity and the vast potential for its use across various sectors. To determine variables, Technology Acceptance Model (TAM) was used, which was adapted for acceptance of blockchain technology among IT professionals in general. The survey was conducted among IT professionals, mainly developers, based on adapted TAM model in order to determine factors which affect them to adopt and use blockchain-based applications and to use blockchain in development. Besides perceived usefulness, the study introduced personal engagement as a variable, with social influence considered an external factor. Behavioral intention and use behavior regarding blockchain technology were categorized into two distinct groups: use of blockchain-based applications and use of blockchain in development. This separation aimed to investigate whether and to what extent perceived social influence on blockchain technology impacts the intention and usage of blockchain in both areas, examining any potential effects one might have on the other and their interconnectedness.

1.1. Blockchain technology

Blockchain represents a distributed database system which enables recording data in the form of a public ledger of transactions. The transactions need to be verified by nodes which are participating in a blockchain before they can be added to the ledger. [1] Blockchain technology has been created to address the need for faster settlement, security, transparency, and immutability. It stores data in blocks, which are used as a container, where BCT (blockchain technology) consists of chain of those blocks of transactions. Blockchain network is a peer-to-peer, distributed network, where each peer contains a copy of the ledger. Blocks are interconnected, where adding a new block must be validated by set of protocols and consensus of each participant, called node. BCT was first used by Satoshi Nakamoto in 2008, as the foundation of Bitcoin, and started rapidly gaining popularity ever since [2]. Its main benefits include anonymity, immutability, and transparency. Anonymity is achieved by assigning public keys to users, which are then used in transactions. Every transaction can be traced by a public key, but the identity of the user behind that key is unknown. Immutability is the benefit which is embedded in the design of the blockchain. Each new generated block contains information from all the previous blocks in the chain, and each node can verify if the new block is created correctly, so changing a single piece of information in already processed blocks is virtually impossible with contemporary processing power. This can, of course, be viewed as a disadvantage since any errors in transactions cannot be corrected. Transparency means that in public blockchains all users can access and read the whole list of transactions that have occurred. In some domains, this can be seen as an issue, but it should be estimated if such systems are suitable for blockchain at all [3].

The initial version of blockchain was focused on transactions, as it was primarily used for deployment of cryptocurrencies, and is referred to as Blockchain 1.0. Utilization of BCT in such systems allowed recording and processing of digital payments and transactions without the need for central entity or a middleman to govern the entire process. The expansion of the first version was focused mostly on privacy, smart contracts and non-native asset token and abilities. This version is referred to as Blockchain 2.0 and most notable platform to emerge is Ethereum. Blockchain 3.0 allowed creation of decentralized applications, which are implemented on decentralized blockchains using cryptographic tokens. Blockchain 4.0 is the most recent version of blockchain which aims to incorporate AI capabilities in blockchain systems [4].

The important thing to note here is that an organization incorporating blockchain technology in the system doesn't have to implement the versions in order of their appearance, nor does it have to implement all the versions. Different systems have different needs, and the most important thing to consider is the value which is generated from the used technology. Later stages of BCT offer more possibilities but are more expensive and harder to implement. BCT shouldn't be introduced in the existing systems unless it is estimated that such implementation will bring concrete benefits [4].

1.2. The adoption of blockchain in various domains and its challenges

Over the years, BCT found many different domains which were suitable for its application, and which managed to utilize its benefits. According to [2] and [3] the domain which utilized these technologies the most is supply chain management, followed by education, finance, voting systems, internet of things, agriculture, etc. Smart contracts are an important concept which allows blockchain technologies to broaden their use and to solve a wider array of problems. They are defined as a computer program that automatically executes the terms of the contract, which provides full confidence that both parties will fulfill their side of the agreement once certain conditions are met. Smart contracts eliminate the need for middleman who will oversee the process and make sure that it is valid. Despite many benefits, blockchain faces many problems such as the lack of standards and validation, interoperability, scalability, initial cost, energy consumption, security and privacy, lack of skill sets, etc. [5] The adoption of BCT among IT professionals is not yet widely prevalent. According to Batubara et al. [6], trust and auditing are challenges that need to be considered while adopting blockchain applications and organizational readiness is an important factor in the adoption process. Sadhya and Sadhya [7] found 16 barriers to adoption of blockchain technology. They pointed out knowledge of blockchain as the most significant barrier, followed by regulatory issues, privacy and security, initial cost, lack of standards and trust. Also, implementation problems such as implementation dilemma about interoperability with the legacy system, transaction scalability and high energy consumption [7]. Lack of industry standards and mentioned technical limitation, and the relative novelty of the technology suggest immaturity of technology. In [8], besides mentioned problems, it is mentioned that many organizations lack awareness of the potential of BCT. Organizational readiness, challenges related to changes in business processes and organizational culture, lack of leadership and vision are identified as key factors hindering the adoption of BTC.

In [2] it is stated that the most important factors which affect the use of blockchain are trust, perceived cost and social influence, while security and privacy risks, high energy and investment costs, organizational culture and lack of knowledge are seen as main risk of implementing such systems. It is also concluded that half of the people who participated in blockchain adoption research belong to the top management layer. One of the important factors which also influence adoption is significant social attention. It seems that sometimes the emphasis tends to be on the technology itself, rather than the value which the technology brings. Blockchain technology can be rather problematic to implement or too expensive, especially in the smaller organizations. All the above implies that it is crucial to define an appropriate technology adoption path which is most suitable to the system at hand [4].

In [9] a Blockchain Adoption Model is proposed, which is an extended Technology-Organization-Environment framework. They have identified six constructs - relative advantage, observability, organizational age, external stakeholder pressure, regulatory uncertainty, and scope of business ecosystem, discussing that ecosystem readiness is the most important factor for the adoption of blockchain. In order to adopt blockchain, ecosystem should be: large enough, it should have at least one stakeholder which is pressuring other members to adopt blockchain and it should be capable of developing and enforcing regulations. In [10] model was extended with perceived trend construct. Perceived trend refers to the perception of current and future popularity or acceptance of technology, showing that it has a positive effect for adoption of blockchain. A systematic review on blockchain adoption conducted by AlShamsi et al. [11] identified technology acceptance model and technology-organization-environment as the most used models. They have reported that existing studies at the time have examined the adoption of BTC from the organizational point of view, with little attention paid to the individual level. Na Liu and Zuoliang Ye [12] explored the effects of blockchain technical features on user acceptance, which showed that users accept blockchain because they have increased understanding and approval for the characteristics of blockchain technology. Trust was added as a construct that affects user acceptance which was proved to have an important effect on adoption of blockchain. Pieters et al. [13] suggest that intrinsic motivation has an important role in the adoption of blockchain technology, while effort expectancy was not.

Unlike previous research that mainly looked at blockchain adoption from broader organizational or technological perspectives, this study delves into the individual motivations of IT professionals, especially developers, focusing on personal motivations and the distinct differences between using and developing blockchain applications. By exploring personal engagement and the effects of age on adoption, our research brings novel insights into the individual factors influencing blockchain adoption among developers.

1.3. Technology acceptance model

In this study, model for determining factors influencing use and adoption of blockchain technologies is mainly based on Technology Acceptance Model (TAM), which has been adapted for determining acceptance of blockchain technologies among developers. The concept of Technology acceptance model was proposed by Davis in 1985 [14], which was revised in 1989 also by Davis [15]. Two main concepts are identified – Perceived Usefulness and Perceived Ease of Use. Perceived usefulness is determined as a person's belief whether it would enhance one's job performance [15], while perceived ease of use is defined as belief that using the system is free of effort [15]. These two concepts were considered to have a direct influence on the attitude toward using, which led to actual system use. One of the main advantages of the TAM model is that provides factors which lead to acceptance of technology, and it can be extended for a better fit of technology. The TAM model has also been criticized for its simplicity and inability to fully explain the reason behind the acceptance and use of technology in the business environment, but its rather suitable for determining individual use and acceptance of technology [16]. Also, it's not applicable for determining use and acceptance through usefulness or ease of use. For example, usefulness of online gaming is not a factor, because it's used for entertainment. Also, organizations may be subscribed to platforms, complying employees to use that technology, which disputes influence of perceived ease of use. The TAM has been applied to a wide range of technologies, including end-user computing technologies, mobile applications [17], digital payment systems [18], metaverse [19], etc.

Later, TAM was modified, as it was found by Davis in 1989 [15] that attitude did not fully mediate the perceived usefulness and ease of use, and behavioral intention was used as a new variable. It was suggested that there are cases where the system is perceived as useful, which would lead the individual to use the system without forming any attitude. Additional changes included external variables influencing perceived usefulness and perceived ease of use into the model. Venkatesh and Davis proposed TAM2 model [20], which is an extension of the previous model, including variables concerning social factors, that represent individual's subjective perception about the importance of certain behavior, and cognitive instrumental influence, which relates to the individual's day-to-day work [21]. Voluntariness is a moderating factor defined as the extent to which users perceive that adoption decision is non-mandatory. Additionally, experience and voluntariness were included as moderating factors of the subjective norm. Image is defined as the degree to which adopting technology will enhance one's image which will have positive effect on perceived usefulness. Job relevance, a belief that the system is applicable to one's job, output quality, how well the system performs its tasks and result demonstrability, to what extent are the outcomes and benefits of using the system are visible and easily understandable, will all have a positive effect on perceived usefulness. Many extensions of the model occurred, leading to UTAUT and UTAUT2 model.

The Unified Theory of Acceptance and Use of Technology 2 (UTAUT2) model is a theoretical framework that aims to explain and predict individuals' acceptance and use of technology. It is an extension of the original UTAUT model and incorporates additional constructs to provide a more comprehensive understanding of technology adoption [21]. The UTAUT model considers four core constructs: performance expectancy, effort expectancy, social influence, and facilitating conditions [22]. Performance expectancy refers to the degree to which individuals believe that using the technology will enhance their performance. Effort expectancy relates to the perceived ease of use and the level of effort required using the technology. Social influence captures the impact of social factors, such as subjective norms and social influence, on individuals' intention to use the technology. Facilitating conditions refer to the availability of resources and support that enable technology use. The UTAUT2 extends the UTAUT model by adding three additional constructs: hedonic motivation, price value, and habit [21]. Hedonic motivation refers to the pleasure or enjoyment individuals derive from using the technology. It recognizes that technology adoption is not solely driven by utilitarian factors but also by the desire for enjoyment and entertainment. Price value considers the perceived value or benefits individuals associate with the cost or price of using the technology. Habit reflects the automatic and routine behaviors individuals develop through repeated use of technology.

2. Extending TAM to Explore Blockchain Adoption

As said before, TAM has several main concepts: perceived usefulness, perceived ease of use and behavioral intention which led to use behavior. In this paper, TAM model will be adapted and extended to address the unique characteristics and application of blockchain technology. New variable, personal engagement, is introduced in model due to the significant personal interest blockchain has garnered, highlighting the role of self-motivation and personal interest in the technology. Behavioral intention and use behavior are separated into two aspects – using blockchain applications and using blockchain in development offering nuanced view of user engagement and allowing a more detailed analysis of the factors influencing developers' willingness to adopt blockchain. Behavioral intention and behavioral use of blockchain-based applications and BI and BU for using blockchain for development should be separated and examined as different variables since the motivations, required user skills and knowledge and perceived usefulness are different for both aspects. Still BI and BU of blockchain-based applications can be expected to have strong influence on BI and BU of blockchain in development since positive experience using the application can motivate users to explore and learn about the blockchain further. If users perceive blockchain-based applications as something useful and beneficial it can enhance their overall perception of blockchain technology. Additionally, being active in blockchain community can lead to increased awareness of development tools and practices, influencing both the intention and use behavior related to blockchain development.

Perceived usefulness (PU) in terms of blockchain will be determined through perception of its applicability in various industries and whether participants believe that usage of blockchain is profitable for organizations due to its many benefits. Since blockchain technology is a broad technology with many different applications in various industries, determining *ease of use* isn't applicable in this context. In this study, intention is to determine both usage of blockchain applications and using blockchain in development which includes many different applications with very variable ease of use. Following these conceptual elucidations, we propose two research hypotheses:

H1: *Perceived usefulness* will have a positive effect on *intention to use blockchain-based applications*.

H2: *Perceived usefulness* will have a positive effect on *intention to use blockchain in development*.

Another construct defined as a variable is *personal engagement* (PE). Personal engagement will be defined as how much is an individual motivated to be informed and learn about blockchain due to personal interest and it will include its self-motivation for learning and being informed about important topics about blockchain. According to Pan [23], learning motivation is contributing to students readiness, wilingness and intention to use technology for learning, which suggests interconnection between self-motivation for learning and technology acceptance, which is why is this variable constructed. *Personal engagement* captures personal motives for engaging with technology. Here, *personal engagement* includes whether the user is informed about fundamental concepts of blockchain, regulatory issues and whether user has personal interest about this technology. Based on this understanding of Personal Engagement, the following hypotheses are proposed:

H3: *Personal engagement* will have a positive effect on *intention to use blockchain-based applications*.

H4: *Personal engagement* will have a positive effect on *intention to use blockchain in development*.

Furthermore, the adoption of blockchain technology is influenced by factors such as the perceived social pressure (so called "hype") around the technology, resistance to change, top management support, and trust among parties involved [24], which is why *social influence* (SI) has been considered as external factor. *Social influence* is used as an external factor due to the increasing number of articles about the blockchain on the news, social media, journals, conferences etc., which will help capture effects of immense popularity. *Social influence* is defined as an external variable which affects perceived usefulness and personal engagement. *Social influence* will be measured by determining whether participants feel *peer pressure* and do they perceive that to be knowledgeable about blockchain technology is a necessary skill for the future. Accordingly, the following hypotheses are proposed:

H5: *Increased peer pressure* will have a positive effect on *perceived usefulness*.

H6: *Increased peer pressure* will have a positive effect on *personal engagement*.

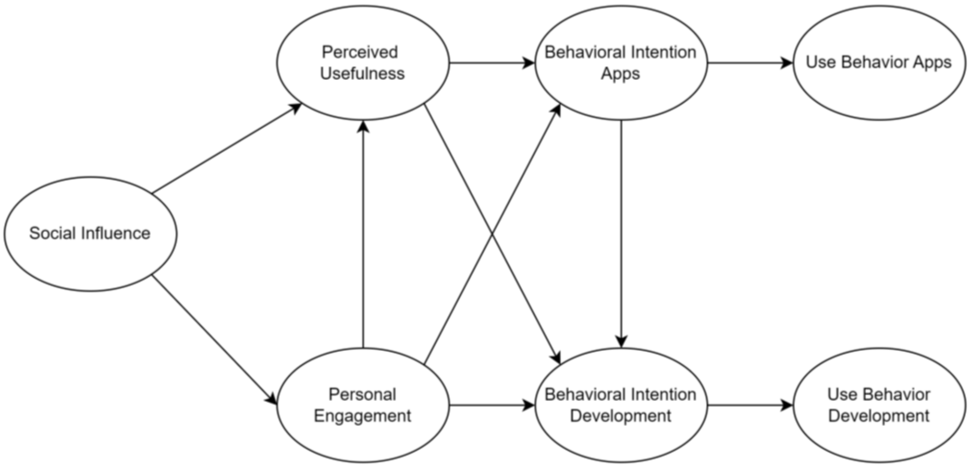

Fig. 1 The adapted model for determining acceptance and use of blockchain among IT professionals

As said before, behavioral intention has been separated in two parts: *intention to use blockchain-based applications in professional or personal purposes* and *behavioral intention to use blockchain technologies in development*, including developing blockchain technology. For both constructs PU and PE have influence on both types of behavioral intention. *Perceived usefulness* has been determined by six indicators, which include different aspects of usefulness. *Behavioral intention* and *use behavior* have been separated on behavioral intention and use behavior *for using blockchain-based applications*, such as smart-contracts, identity verifications, cryptocurrency etc., while the other dependent variables are used to determine behavior intention and use behavior for *using blockchain in development*. Lastly, these additional hypotheses address aspects of behavioral intention in the use of blockchain technology:

H7: *Behavioral intention to use blockchain-based applications* will have a positive effect on *behavioral intention to use blockchain in development*.

H8: *Behavioral intention to use blockchain-based applications* will have a positive effect on actual usage of those applications.

H9: *Behavioral intention to use blockchain for development* will have a positive effect on actual usage of blockchain in development.

The final adapted model for determining the acceptance and use of blockchain technology can be seen in Fig. 1.

3. Structural Equation Modeling of Blockchain Technology Acceptance

The survey is conducted among people working in IT industry – developers and IT professionals, through an online questionnaire. The questionnaire was distributed in October 2023 through multiple channels, including mailing lists of IT developers, ISACA members, and a crowdsourcing platform. Total of 197 participants have filled in the questionnaire. Data was analyzed using a method intended for an analysis of complex relationships of multivariate data, representing structural equation modeling. Structural theory illustrates the relationships among latent variables, also referred to as constructs. Constructs are variables that cannot be directly measured while indicators (or items) are the directly measured variables. Links between indicators and constructs make the measurement (or outer) model and relationships between constructs make a structural (or outer) model. Constructs are connected with single headed arrows, which define causal relationship. Latent variable can be independent (exogenous), dependent or both independent and dependent (endogenous) variables. Partial least squares SEM is used to estimate equation model, it focuses on explaining the variance in the model's dependent variables (Chin et al., 2020) Analysis has been done using SmartPLS 4.0. Bootstrapped analysis has been performed on 10.000 subsamples. Hair et al. offer suggestions and guidelines for reporting and interpreting results of SEM method and suggest that PLS-SEM method works better for more complex theoretical frameworks where the main objective is the exploration of increased complexity [25]. Smaller sample sizes are recommended, with the remark that characteristics of the population have a significant impact on the size of the sample. PLS-SEM is often used in studies relying on nonnormal data; however, this type of data alone is not sufficient enough to justify the use of PLS-SEM. This model offers great statistical power, which is particularly useful for identifying significant relationships. Also, it is suggested that different approaches are needed for reflective and formative measurement models, but that for both models, the crucial step is assessing the structural model, as well as assessing the out-of-sample predictive power. For this purpose, it is recommended to use a novel approach called PLSpredict. And lastly, robustness checks should be conducted using appropriate methods. [25]. SEM-PLS analysis is usually used for analyzing TAM and UTAUT models because it can handle complex models with multiple constructs, it is suitable for exploratory research and predictive studies, and it can be applied to smaller sample size, and it doesn't require data to be normally distributed.

Variable *perceived usefulness* (PU) of blockchain technology has several indicators:

PU1: I believe that blockchain technology will enhance data security and reduce fraud.

PU2: I strongly agree that adopting blockchain will lead to cost saving in the long run for IT projects.

PU3: I believe that implementing blockchain will lead to more transparent and verifiable transactions in IT processes.

PU4: I believe that using blockchain will improve the efficiency of IT processes.

Variable *personal engagement* has three indicators:

PE1: I am well-informed about data protection regulations related to blockchain, such as the GDPR's implications for blockchain applications.

PE2: I find it easy to understand the fundamental concepts of blockchain technology.

PE3: I often find myself discussing or reading about blockchain in my free time due to genuine interest.

Additional construct, which has effect as an external variable has been defined as social influence. Social norm has two indicators:

SI1: I think that not adopting or understanding blockchain technology might make me lag behind in the IT community.

SI2: I feel that there's a growing expectation in my professional circle for IT experts to be knowledgeable about blockchain.

Indicators for variable behavioral intention to use blockchain-based applications are:

BIAPP1: I intend to use blockchain-based applications (cryptocurrency, smart-contracts, identity verification etc.) in the near future.

BIAPP2: Given the opportunity, I would adopt using blockchain-based applications (cryptocurrency, smart-contracts, identity verification etc.) for relevant tasks.

Indicator for variable behavioral use of blockchain-based applications is:

UBAPP1: How frequently do you currently use blockchain-based applications in your professional tasks?

Indicator for variable behavioral use of blockchain in development:

UBDEV1: How frequently do you currently use blockchain for development?

4. RESULTS

Total number of participants is 197. Most of the participants are in age group of 25-34 and 35-44 (Table 1). Participants are asked if they are familiar with the concept of blockchain (Table 2). Over 60% of participants are somewhat familiar with blockchain technology, while over 20% are very familiar. Only around 15% of participants are not familiar with concepts of blockchain or have never heard of it. This shows that blockchain technology has become an unavoidable topic in the IT community.

Table 1 Age of participants

Age	Frequency
25-34	91
35-44	40
45-54	16
55-64	7
65 and above	1
under 25	42
Total	197

Table 2 Familiarity with the concept of blockchain of participants

Familiarity with the blockchain	Frequency
Heard of it but don't know much	29
Never heard of it	1
Somewhat familiar	122
Very familiar	45
Total	197

All participants are working in the IT industry, where most of the participants are front-end, back-end or full-stack developers.

Table 3 Area of expertise of participants

	Frequency	Number of responses	Number of cases
Front-End Development	42	11%	21%
Back-End Development	67	17%	34%
Full-Stack Development	60	15%	30%
Data Science & Machine Learning	45	12%	23%
Database Administration	36	9%	18%
DevOps	26	7%	13%
QA & Testing	24	6%	12%
Other	91	23%	46%
Sum	391		

Total of 14 indicators were used to build the constructs. All indicators were based on Likert's scale. As shown at Table 1, all indicators have moderate to high variation in answers. Lowest median value has use behavior for development and for blockchain-based applications, meaning that most of the participates don't actually use blockchain in their professional or personal tasks, confirming problems with adoption of blockchain technology.

Based on the characteristics of PLS-SEM [25], it is evident that this analysis method can work effectively with smaller sample sizes, especially when dealing with models comprising numerous constructs and a large number of items. However, it's important to note that the acceptability of a smaller sample size in PLS-SEM analysis depends on the nature of the population being studied [25].

Table 4 Mean, median and standard deviation of indicators

Indicator	Mean	Median	Standard deviation
BIAPP1	2.990	3.000	1.290
BIAPP2	3.269	3.000	1.206
BIDEV1	2.741	3.000	1.302
BUDEV1	1.812	1.000	1.052
PE1	2.807	3.000	1.244
PE2	3.579	4.000	1.013
PE3	2.863	3.000	1.289
PU1	3.893	4.000	1.029
PU2	3.152	3.000	1.148
PU3	3.980	4.000	0.923
PU4	3.538	4.000	1.078
SI1	3.112	3.000	1.233
SI2	3.091	3.000	1.227
UBAPP1	1.772	1.000	1.044

SEM-PLS analysis

Indicator loadings determine absolute contribution of an indicator to the construct. As shown at Table 5, all indicator loadings are above recommended 0.708 [25]. All indicator loadings are statistically significant, with high T-values.

Table 5 Indicator loadings

	Loadings	T statistics	P values
BIAPP1 ← Behavioral Intention Apps	0.936	91.051	0.000
BIAPP2 ← Behavioral Intention Apps	0.936	95.788	0.000
BIDEV1 ← Behavioral Intention Dev	1.000	n/a	n/a
BUDEV ← Use Behavior Dev	1.000	n/a	n/a
EOU1 ← Personal Engagement	0.726	13.227	0.000
EOU2 ← Personal Engagement	0.712	11.694	0.000
EOU3 ← Personal Engagement	0.828	27.886	0.000
PU1 ← Perceived Usefulness	0.757	16.591	0.000
PU2 ← Perceived Usefulness	0.831	39.211	0.000
PU3 ← Perceived Usefulness	0.736	15.462	0.000
PU4 ← Perceived Usefulness	0.892	64.472	0.000
SI2 ← Social Influence	0.873	35.149	0.000
SI3 ← Social Influence	0.901	51.242	0.000
UBAPP1 ← Use Behavior Apps	1.000	n/a	n/a

Cronbach's alpha, composite reliability (rho_a) and composite reliability (rho_c) for all variables are above 0.7, except for *personal engagement*. For *personal engagement*, Cronbach's alpha is 0.634, rho_a is 0.663, while rho_c has value of 0.801 which is above recommended value. Values of Cronbach's alpha and composite reliability are higher than 0.6 which can be acceptable. Hence, the variable will be retained.

Average variance extracted (AVE) explains how much of the variance of the constructs items is explained by that construct. For each construct AVE should be at least 0.5. AVE for all constructs is shown in Table 2.

Table 6 Average variance extracted of variables

	AVE
Behavioral Intention Apps	0.876
Personal Engagement	0.650
Perceived Usefulness	0.573
Social Influence	0.786

Discriminant validity explains how much the constructs differ from each other and whether they measure different things. For determining discriminant validity Heterotrait-Monotrait ratio (HTMT) is used. For each construct pair HTMT should be below 0.9, which shows whether those constructs measure different aspects. For each construct pair HTMT is below 0.815, which shows adequate discriminant between them. After assessing reflective measurement models, results of assessing formative measurement models will be shown. Variance Inflation Factor (VIF) is used for evaluation of collinearity of the formative indicators. As suggested in [25], VIF values should be below 5, ideally close to 3 and lower. Variance Inflation Factor for every indicator is below 3, which suggest there is no multicollinearity between indicators.

Table 7 Outer weights of indicators

	Outer weights	P values
BIAPP1 ← Behavioral Intention Apps	0.535	0.000
BIAPP2 ← Behavioral Intention Apps	0.533	0.000
BIDEV1 ← Behavioral Intention Dev	1.000	n/a
BUDEV ← Use Behavior Dev	1.000	n/a
EOU1 ← Personal Engagement	0.384	0.000
EOU2 ← Personal Engagement	0.376	0.000
EOU3 ← Personal Engagement	0.548	0.000
PU1 ← Perceived Usefulness	0.269	0.000
PU2 ← Perceived Usefulness	0.359	0.000
PU3 ← Perceived Usefulness	0.246	0.000
PU4 ← Perceived Usefulness	0.355	0.000
SI2 ← Social Influence	0.531	0.000
SI3 ← Social Influence	0.596	0.000
UBAPP1 ← Use Behavior Apps	1.000	n/a

Lastly, results of assessing structural models will be presented, using the coefficient of determination (R^2). R^2 represents the model's explanatory power, which measures the variance and is explained by the constructs [26]. R^2 is in-sample predictive power [27].

Table 8 Explained variance

	R^2	P values
Behavioral Intention Apps	0.557	0.000
Behavioral Intention Dev	0.628	0.000
Perceived Usefulness	0.455	0.000
Personal Engagement	0.185	0.000
Use Behavior Apps	0.212	0.000
Use Behavior Dev	0.477	0.000

In this model, for Behavioral Intention to develop (using) blockchain 62.8% of variance is explained and 55.7% of variance for behavioral intention to use blockchain-based applications is explained, which can be considered moderate to high explanatory power. Perceived Usefulness and Use Behavior in development have, respectively, 45.5% and 47.7% of variance explained which is just below 50%, and can be considered moderate. Personal Engagement and Use Behavior for using blockchain-based applications have values of 21.2% and 18.5% which means that more factors could be affecting these values.

Stone-Geisser's Q^2 is based on the blindfolding method. It combines out-of-sample and in sample explanatory power [17]. As recommended in [25], blindfolding is performed with 10 folds and 10 repetitions. For each indicator Q^2 is higher than 0, which means that this model has predictive power. When performing RMSE, majority (7 of 12) has lower prediction error than naïve (linear regression model), which means that this model has a moderate prediction power. When performing MAE only three of twelve indicators have performed better than naïve benchmark, meaning that model has low predictive power.

Table 9 Predictive power (Q^2, RMSE and MAE)

	Q^2predict	PLS-SEM_RMSE	PLS-SEM_MAE	LM_RMSE	LM_MAE
PU4	0.379	0.855	0.661	0.859	0.663
BIDEV1	0.378	1.031	0.850	1.014	0.815
PU2	0.361	0.922	0.759	0.922	0.754
BIAPP2	0.272	1.036	0.860	1.036	0.848
BIAPP1	0.244	1.129	0.948	1.135	0.945
BUDEV	0.230	0.927	0.717	0.909	0.692
EOU3	0.196	1.161	0.964	1.163	0.945
PU1	0.178	0.939	0.751	0.941	0.751
UBAPP1	0.135	0.976	0.758	0.957	0.705
PU3	0.082	0.890	0.707	0.883	0.697
EOU2	0.043	0.996	0.816	1.002	0.829
EOU1	0.038	1.227	1.039	1.230	1.048

After assessing results from models, path coefficients will be analyzed. The highest path coefficients are *behavioral intention* to develop (using) blockchain on actual use of blockchain for development. As shown at Table 10, *perceived usefulness* has more effect on behavioral intention to use blockchain-based application, while its effect on intention to develop blockchain technologies is not as strong. Path coefficients and p-values for the model are seen in Fig. 2, which shows the complete model, strength, and significance of each construct. *Social influence* has a high effect on *perceived usefulness* and also on *personal engagement*. *Personal engagement* is statistically significant but has low effect on both PU and BID. These effects don't have practical implications, which are suggested by f^2 values, which are not statistically significant. Intention of using blockchain-based applications has effect on actual using those kind applications, but also influences intention to use blockchain in development. For other relationships, f^2 values are statistically significant. Based on presented results, all ten previously determined hypotheses are proven.

Table 10 Path coefficients

	Path coefficient	P values
Behavioral Intention Dev → Use Behavior Dev	0.691	0.000
Perceived Usefulness → Behavioral Intention Apps	0.658	0.000
Social Influence → Perceived Usefulness	0.536	0.000
Behavioral Intention Apps → Use Behavior Apps	0.461	0.000
Behavioral Intention Apps → Behavioral Intention Dev	0.439	0.000
Social Influence → Personal Engagement	0.430	0.000
Perceived Usefulness → Behavioral Intention Dev	0.285	0.000
Personal Engagement → Perceived Usefulness	0.238	0.000
Personal Engagement → Behavioral Intention Dev	0.189	0.000

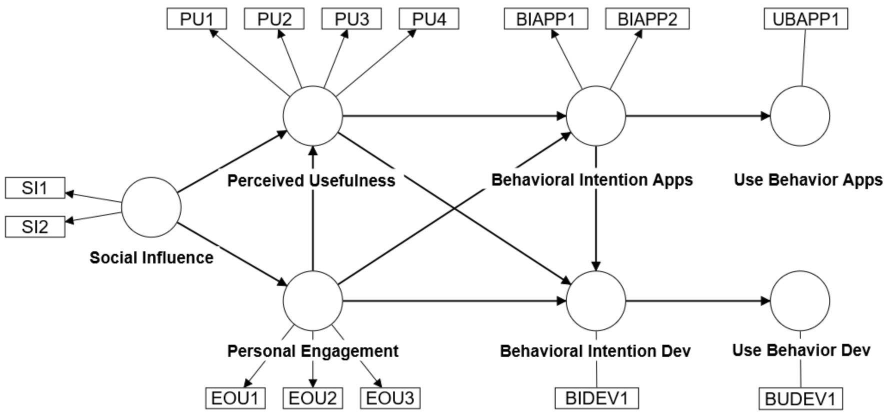

Fig. 2 Results of SEM-PLS analysis

Additionally, influence of moderating variables is determined. Age is used as moderating variable, to determine how significant age in adopting blockchain is. Moderating variable is added to the model and connected to each relationship. Lastly, analysis was run once more.

As seen at Table 11, moderating variable Age has a statistically significant small to moderate negative effect on behavioral intention to use blockchain based application and to use blockchain for development, statistically significant moderate negative effect on use behavior of both aspects, while it doesn’t have a statistically significant effect on the perceived usefulness and personal engagement. It can be noticed that older age has a negative effect on intention to use as well as use behavior. Also, age has a statistically significant moderating effect of moderate size on relationship between social influence and perceived usefulness, indicating that older individuals are more influenced by social factors in finding technology useful. Age also has a strong negative and significant moderating effect on the relationship between the intention and actual use of blockchain technology, which weakens as age increases.

Table 11 Path effects of moderating variables

	Original sample (O)	Sample mean (M)	Standard deviation (STDEV)	T statistics (|O/STDEV|)	P values
Age -> BIA	-0.099	-0.096	0.043	2.298	0.022
Age -> BID	-0.106	-0.103	0.044	2.413	0.016
Age -> PU	0.06	0.059	0.056	1.069	0.285
Age -> PE	0.056	0.054	0.055	1.02	0.308
Age -> UBA	-0.161	-0.16	0.054	2.958	0.003
Age -> UBD	-0.16	-0.158	0.047	3.429	0.001
Age x SI -> PU	0.165	0.165	0.054	3.029	0.002
Age x SI -> PE	0.012	0.017	0.073	0.17	0.865
Age x BID -> UBD	-0.204	-0.203	0.048	4.292	0
Age x BIA -> BUA	-0.132	-0.131	0.059	2.216	0.027
S x PE -> BID	-0.09	-0.084	0.078	1.145	0.252
Age x PU -> BIA	0.014	0.009	0.046	0.313	0.754
Age x PU -> BID	-0.074	-0.073	0.052	1.436	0.151
Age x PE -> BIA	0.018	0.023	0.052	0.354	0.723
Age x PE -> BID	-0.046	-0.046	0.051	0.918	0.359

5. Concluding Remarks

Blockchain technology is encountering many challenges in its adoption. Many studies determined how technical, organizational, and environmental factors affect blockchain adoption. Technical factors as maturity of the technology, scalability, and security concerns impact developers' willingness to adopt blockchain. Organizational factors, such as leaderships support, corporate culture and resource availability can greatly influence blockchain adoption within an organization. Environmental factors, including regulatory clarity, market demand and industry standards are also determined to be important for developers' intention to use blockchain.

While numerous studies address what motivates employees to adopt blockchain or how is blockchain adopted in organization, in this study, it's determined what influences developers as individuals to use blockchain. Given the rising popularity of blockchain-based applications, especially among developers, this research separately observes their intentions and usage of blockchain in development, in order to determine the specific factors that drive developers towards adopting and using blockchain technology for development purposes. This distinction allows detailed analysis of the motivations, challenges, and expectations that developers have regarding blockchain technology.

Furthermore, this approach enables the investigation of how external factors such as social influence and technological complexity impact developers' decisions to engage with blockchain technology, both in terms of developing new applications and integrating blockchain into existing solutions. These insights can be important to organizations for understanding the barriers to adoption, what is motivating developers to learn and adopt blockchain in their work, in order to support developers in overcoming these challenges.

Three main constructs are used to determine intention to use blockchain: perceived usefulness, social influence and personal engagement. Among these variables, the ones which had the most significant impact on blockchain are social influence and perceived usefulness. Perceived usefulness and personal engagement have a very strong and positive influence on

Behavioral Intention to use blockchain-based applications and mild to moderate influence on intention to use blockchain in development. But the intention to use blockchain-based applications has a strong positive influence on intention to use blockchain in development. The practical implication of these findings is that IT professionals' perceived usefulness and intention and to use blockchain-based applications will encourage them to integrate blockchain technology into their development processes, especially if they perceive blockchain as useful and are motivated to learn about and engage with it.

Limitation of the study is relatively small number of participants. Still, the model did capture how the perceived social pressure regarding blockchain, personal enthusiasm to learn and be engaged with the news about the blockchain affect behavioral intention to use blockchain applications and to use blockchain in development. However, it is possible to adapt the model so it can address how each of different aspects of these variables influences its adoption.

In conclusion, IT professionals and developers who believe that adopting blockchain technology is mandatory for future development perceive blockchain as more useful and are motivated to keep "up-to-date" with information about it. The vast potential for blockchain utilization and its capacity to enhance IT processes, diverse use-cases, as well as being motivated to regularly be informed about development of blockchain have led to intention to use blockchain-based applications, which will motivate users to consider using blockchain in development. Understanding factors which influences individual alongside with other factors (environmental, organizational etc.) can provide a more comprehensive perspective on the blockchain adoption landscape, highlighting the need for a holistic approach to address these challenges and support developers and organizations in addressing the complexities of blockchain adoption.

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