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PREDICTING KEY PREDICTORS OF PROJECT DESERTION IN BLOCKCHAIN: EXPERTS' VERIFICATION USING ONE-SAMPLE T-TEST

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ABSTRACT

Aim/Purpose	The aim of this study was to identify the critical predictors affecting project desertion in Blockchain projects.
Background	Blockchain is one of the innovations that disrupt a broad range of industries and has attracted the interest of software developers. However, despite being an open-source software (OSS) project, the maintenance of the project ultimately relies on small core developers, and it is still uncertain whether the technology will continue to attract a sufficient number of developers.
Methodology	The study utilized a systematic literature review (SLR) and an expert review method. The SLR identified 21 primary studies related to project desertion published in Scopus databases from the year 2010 to 2020. Then, Blockchain experts were asked to rank the importance of the identified predictors of project desertion in Blockchain.
Contribution	A theoretical framework was constructed based on Social Cognitive Theory (SCT) constructs; personal, behavior, and environmental predictors and related theories.

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Findings	The findings indicate that the 12 predictors affecting Blockchain project desertion identified through SLR were important and significant.
Recommendations for Practitioners	The framework proposed in this paper can be used by the Blockchain development community as a basis to identify developers who might have the tendency to abandon a Blockchain project.
Recommendations for Researchers	The results show that some predictors, such as code testing tasks, contributed code decoupling, system integration and expert heterogeneity that are not covered in the existing developer turnover models can be integrated into future research efforts.
Impact on Society	This study highlights how an individual's design choices could determine the success or failure of IS projects. It could direct Blockchain crypto-currency investors and cyber-security managers to pay attention to the developer's behavior while ensuring secure investments, especially for crypto-currencies projects.
Future Research	Future research may employ additional methods, such as a meta-analysis, to provide a comprehensive picture of the main predictors that can predict project desertion in Blockchain.
Keywords	blockchain project, open source software, project desertion, expert review

INTRODUCTION

Blockchain technology exhibits core properties of digital information system (IS) artifacts that were first developed for crypto-currency (Banafa, 2020). The interest in Blockchain projects has been increasing since the idea was coined in 2008 by an anonymous individual or group of developers who presented Bitcoin (Bosu et al., 2019). Shortly after that, it depended on the global Open Source Software (OSS) community of contributors (Arruñada & Garicano, 2018; Bosu et al., 2019; Islam et al., 2019). Therefore, Blockchain projects are often based on open-source software (OSS), which refers to software developed by diverse communities (Mahmod & Dahalin, 2012). For example, Bitcoin is a public decentralized database project whose source codes are often free to modify. That is what associates it with the OSS concepts found in the literature. Reboucas et al. (2017) explain the idea of OSS as software that requires diverse individual development contributors. Similarly, Song and Kim (2018) describe OSS as software that contributors can use, modify, and redistribute. Furthermore, Blockchain OSS communities rely upon the voluntary collaborative actions of thousands of developers (Mahmod & Dahalin, 2012). The core developers, also known as committers, have direct authority to commit edited source code such as patches to the project version control system (Arruñada & Garicano, 2018; Garagol & Nilsson, 2018). Therefore, they constitute essential actors in the successful evolution of the Blockchain project (Bosu et al., 2019). The prominent examples of Blockchain OSS projects include Bitcoin and Ethereum, representing peer-to-peer networks (Biais et al., 2019). As a result, Blockchain projects have gained considerable interest in the industry (Yli-Huumo et al., 2016). This is reflected by dramatic growth in the crypto-currencies market capitalization industry. For instance, Bitcoin rose from 611 million US Dollars in market capitalization in 2014 to 1 trillion and was expected to be worth 10 trillion by 2021 (CoinMarketCap, 2019). Most importantly, the current value is anticipated to rise (Awoke et al., 2021; Gurrib et al., 2022).

Despite its extreme significance, vast market growth, investment, and attention from thousands of companies globally, the development and maintenance of the project code ultimately rely on a small number of highly skilled committers who play vital roles in the platform's design. At this time, it is unclear whether the understanding of this technology will spread enough to attract sufficient numbers of committers/developers and reach the critical mass of a stable OSS project. However, the impact of few committers on the sustainability and success of the project continues to unfold (Islam et

al., 2019). These pose the need to understand the current state of project desertion research. Eventually, research gaps could be determined by analyzing the existing knowledge. Abundant literature indicates that Blockchain and OSS projects frequently experience various developer involvements (Iaffaldano et al., 2019; Islam et al., 2019; Reboucas et al., 2017; Schilling et al., 2012), participation (Barcellini et al., 2014; Qiu et al., 2019), and desertion as well as other relevant determinants, which have important relationships with project failure or success.

However, in a distributed autonomous community context, the lack of centralized formal authority makes it impossible to balance the interests of all developers (Dirose & Mansouri, 2018; Islam et al., 2019; Yi et al., 2021). The coordination issue often leads to the desertion or abandonment of necessary governance mechanisms by a more significant number of developers (Arrunada & Garicano, 2018; Pelt et al., 2021). However, there is limited review analysis on the Blockchain project desertion from the perspective of theories and models at the individual level. Consequently, this study includes a thorough evaluation of the literature and expert verification by focusing on the Social Cognitive Theory (SCT) constructs and personal, behavioral, and environmental perspectives. This review offers a detailed summary of Blockchain and OSS studies from 2010 to 2020, presenting the recent evolution of relevant theories/models and critical determinants contributing to the substantive recommendations. The suggested structure would direct industry practitioners to consider appropriate determinants and theories in selecting the highest priority by understanding the actual developers' participation behavior in a Blockchain project. It can also help academicians and practitioners effectively work within the theoretical field (Tiwana, 2014).

This paper aims to discuss the Blockchain and OSS project and explore the predictors that influence desertion. The review also answers the following questions: "What are the predictors that influence project desertion?" and "What are the most relevant theories in the literature regarding the significant predictors that influence project desertion?". In addition, this paper presents the results of project desertion in the Blockchain implementation to add to the literature on the Blockchain project. The article comprises eight sections, deliberating the concepts and tenets that shape the project desertion in Blockchain. The first section introduces the study subject and reviews the literature on project desertion in OSS over the past decade. The subsequent sections of this essay are structured as follows. The second section describes the applied methodology, Systematic Literature Review (SLR) results, and experts' evaluation. The third section provides the survey results on the predictors' evaluation. The fourth section discusses the construction of the conceptual framework and SCT dimensions. The fifth and sixth sections discuss the theoretical and practical implications, respectively. The research limitation and possible recommendations are discussed in section seven. Finally, section eight concludes the review.

LITERATURE REVIEW

Several large-scale OSS including Blockchain projects depends on the continuity of their development communities to remain sustainable (Calefato et al., 2022). Understanding how and why developers stop contributing to the project can help project communities prevent project abandonment and incentivize developers to retain their contributions. Therefore, significant efforts have been deployed by OSS researchers toward understanding the developer turnover phenomenon with respect to joining, role evolution, and abandoning projects (Chen, 2017; Constantinou & Mens, 2017; Iaffaldano et al., 2019; Li et al., 2021; Nyman & Lindman, 2013). For example, Avelino et al. (2019) provide empirical evidence using a mixed-methods approach to investigate the frequency of abandonment projects, the differences between abandoned and surviving projects, and the problems faced by abandoned projects. The study selected 1,932 popular OSS projects on GitHub and the findings revealed that 315 projects (16%) were abandoned while 128 of these projects (41%) moved forward because of the inclusion of a new committer to the project. Similarly, Rastogi and Nagappan (2016) empirically analyzed the influence of forking on the sustainability of the developer community participation in the original project. Using a large-scale of 2,217 projects hosted on GitHub, the study

found that 1 out of 5 projects observed a decline in developer participation. In other words, developers abandoned a project after forking. The study further found that the negative effect is more pronounced in projects transferred to GitHub from other development platforms (20%), compared to GitHub-developed projects (9%). At the time of forking, the characteristics of the rival projects increase the original project's maturity by a year, which reduces the likelihood of developer abandonment by 23%. On the other hand, Schilling et al. (2012) analyzed the contribution behavior of OSS developers. The study revealed that the level of development experience is strongly associated with developer retention. Surprisingly, the analysis reveals that developers with abilities that are underrepresented in the project and developers with higher academic education do not remain considerably longer in the OSS project. The study further reveals that approximately 80% of OSS projects have failed due to developer turnover-related issues which have a significant adverse effect on the quality of the project.

In the context of individuals abandoning a project, Li et al. (2021) manually examined 321 abandoned OSS projects on GitHub and quantified the manual observations by surveying 710 OSS developers. Findings reveal that developer time and interest are significant factors that deter developers from continuing to contribute to OSS projects. Miller et al. (2020) proposed a mixed-methods study, combining surveys and survival modeling, to identify the predictive factors behind developers abandoning OSS projects. The study found that different groups of established developers tend to abandon projects for different reasons. The most common factor is job transition. Other factors include a decline in the popularity of the projects and how much individual work is required. Calefato et al. (2022) proposed a novel method to identify developers' inactive periods by quantitatively analyzing the individual time of developer contributions to the projects using 18 OSS projects hosted on GitHub. The study found that about 94% of the core developers agreed with their state model of inactivity; while 71% and 79% of them acknowledged their breaks and state transition, respectively.

Furthermore, core developers took breaks (at least once), and about half of them (45%) have completely abandoned the project for at least one year. The study examined the likelihood of transitions from states of activity to states of inactivity and discovered that developers who suspend their work have a 35%-55% chance of coming back to an active state; however, if the break lasts for a year or longer, the likelihood of resuming work drops to 21%-26%, with a 54% chance of complete abandonment.

In the aspect of the project being abandoned, Khondhu et al. (2013) present an analysis of OSS projects on SourceForge.net. The study describes how OSS projects are being abandoned by their developers and the attributes and characteristics of these abandoned projects. The results demonstrate that there is a distinction between projects that experienced maintainability issues and those that are inactive or abandoned for other reasons. The study further reveals that there is a common characteristic to the failure of these projects. Islam et al. (2019) conducted a study using actor-network theory to investigate how the Blockchain project split using the Bitcoin project as a case study. The study found several human actors, such as miners, developers, merchants, and investors, as well as non-human actors including ideologies, exchanges and computer programs involved in Bitcoin splits. Furthermore, the study shows that actors' behavior and their heterogeneity, play a key role in engagement or abandonment of Blockchain project. Similarly, Bosu et al. (2019) investigate the motivations, needs, and challenges of Blockchain software developers to join the project. The study did not look at why developers abandoned the project. Additionally, the factors affecting an individual's motivation and technical challenges are identified and investigated.

The prevalence of OSS project abandonment and its impact on the sustainability of the project and community has generally been studied in previous research. Some of these studies have focused in particular on the causes of individual developers' project abandonment in traditional OSS projects. However, little is known about individual developers' abandonment in the context of Blockchain. Findings from those studies may not be generalized to Blockchain. While most Blockchain projects are OSS by definition, they differ from traditional OSS in that they place a greater emphasis on

security and reliability than traditional OSS, as well as on managing defects in a hostile, decentralized environment. These differences were sources of challenges to developers. For Blockchain projects to sustain, it is important for the community to not only identify predictors to attract developers to contribute but also to understand the predictors that cause developers to abandon a project. In this paper, we, therefore, want to address this knowledge gap by focusing on the factors that influence individual developers to abandon Blockchain projects.

METHODOLOGY

The literature review represents a thorough method that provides the basis for every research that helps advance science incrementally based on prior findings (Kitchenham & Charters, 2007). SLRs are a means of synthesizing empirical data to address a specific research question in a simple and repeatable way while seeking to incorporate all published evidence on the subject and evaluate its validity (Okoli & Schabram, 2010). Therefore, it is critical to understand where to push the knowledge boundary. The scope and intensity of the current body of work are recognized by analyzing important publications and identifying gaps to investigate (Xiao & Watson, 2019). This strategy effectively reveals references relevant to a subject under review and contributes to the research's significance. This systematic review follows the procedures recommended by Okoli and Schabram (2010). The procedures refer to a set of guidelines for conducting SLR. The main reason for sticking to these rules is that they offer evidence-based support for the issue under investigation. The rules also served as a well-known direction for many systematic reviews (Xiao & Watson, 2019).

The current study conducted an SLR to identify the crucial factors that affect developers' participation in a Blockchain project and propose a framework encompassing the relationships between the relevant determinants. In addition, it reveals relevant subject matter on a given topic to be examined deeply and let other unknown concepts become known. Figure 1 depicts the methodological procedures to develop the study's framework using SLR and expert evaluation. The following sub-sections detail the procedure used in this SLR.

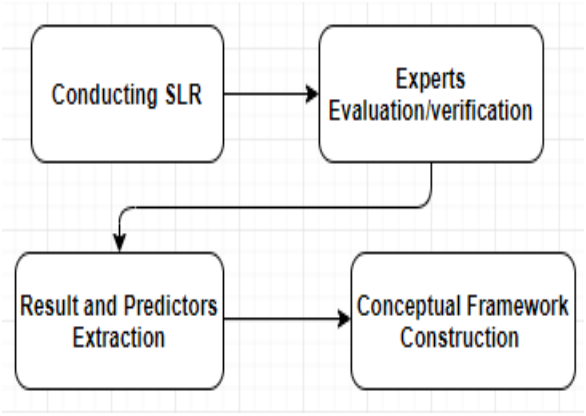

Figure 1. Methodological steps

DATA COLLECTION FOR SLR

This study used six databases as data sources (Emerald, Elsevier, IEEE, AIS, Taylor & Francis, and Springer). These databases were regarded as the significant and all-inclusive existing databases of peer-reviewed high-impact journals. The following keywords and search queries were utilized in the study, both combined and separate, utilizing the Boolean operators "AND" and "OR" and advanced search: "Blockchain project"; "Project desertion"; "developer participation"; "Open source software project"; "Pull request abandonment"; "developers take breaks from contributing"; "Developer turnover in Blockchain"; "Developer turnover on quality in open-source software"; and "Developer motivation".

Criteria for Inclusion

The papers were carefully selected only to include significant pieces of evidence in the review. As for the years of publication, the review only considered articles published between 2010 to 2020. To ensure that the study is of high quality, the authors chose only publications published in the Web of Science (WoS) indexes journals or Scopus. The selected articles encompassed studies related to Blockchain OSS projects, such as Mozilla OSS. Moreover, the included empirical or conceptual frameworks were those published in English. Other types of articles, such as systematic reviews, were also included.

Extraction of Data

Checking for redundant data was one of the first steps conducted in the study. The abstracts were then evaluated against the inclusion criteria. The methodology and the discussion sections were read and summarized if the article were still relevant. Excel and Mendeley tools were used to implement open coding. Figure 2 depicts the applied SLR framework. In Step 1, the study identified 210 articles (IEEE, 53; Springer, 35; Elsevier, 29; AIS, 13; Emerald, 38; Taylor & Francis, 42). In Step 2, 84 articles were considered irrelevant due to either non-English writings or a lack of abstracts, notes, and editorials. Further exclusion includes those generic reports without any description of the desertion issue. In Step 3, the abstracts' assessment of the remaining 126 Blockchain/OSS project-related articles that were not software-oriented was conducted, which resulted in the removal of another 45, leaving 81. In Step 4, each article's introduction and full text were thoroughly examined against the inclusion criteria. Those without non-projects or developer community aspects were excluded, too, resulting in the rejection of 47 more articles. The quality of the remaining 34 was then appraised, based on publications, resulting in the exclusion of another 13 articles. In Step 5, the remaining 21 articles that fully met the inclusion criteria were chosen. The definitions and items used to measure the predictors were examined to ensure that a consistent description of the predictors influencing Project desertion was employed. The pool of articles matched in terms of the research question, aim, frameworks adopted, and finding.

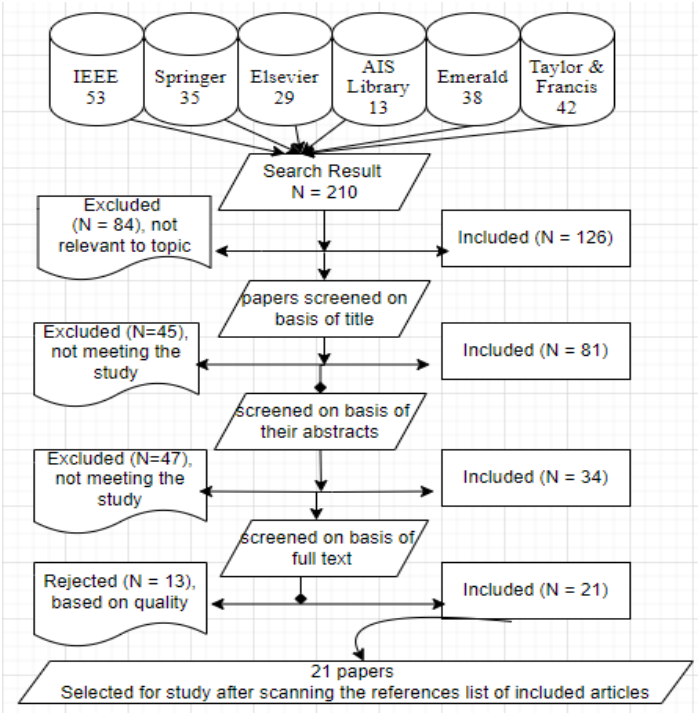

Figure 2. SLR framework

The adopted definitions and their conformity with the employed measurement were evaluated to ensure that the project desertion predictors were similar to those investigated by previous researchers. The 21 chosen articles highlighted the relationships between the predictors and project desertion of respective organizations, which is similar to the context of the current study. Based on those relationships, the key predictors that may affect project desertion were assembled. Table 1 shows the 21 selected articles from the six databases classified according to their quality, either from Scopus or WoS.

Table 1. Results of the SLR

Database	Authors	No. of papers selected	Quality of papers
IEEE	Barcomb et al., 2019; Bosu et al., 2019; Li et al., 2021	3	SCOPUS and Web of Science
Springer	Miller et al., 2020; Tsay et al., 2014	2	SCOPUS and Web of Science
Elsevier	Daniel et al., 2020; Ferreira et al., 2020; Foucault et al., 2015; Izquierdo-Cortazar et al., 2009; Lenarduzzi et al., 2021; B. Lin et al., 2017	6	SCOPUS and Web of Science
AIS Library	Bian, et al., 2018; Ke & Zhang, 2007; Qiu et al., 2019; Tamburri et al., 2018; Walsh et al., 2016	3	SCOPUS and Web of Science
Emerald	Balali et al., 2018; Daniel et al., 2020; Ferreira et al., 2020; Huang & Shiau, 2017; Asfar & Umrani, 2019	3	SCOPUS and Web of Science
Taylor & Francis	Daniel et al., 2011; Hann et al., 2013; Tamburri et al., 2018; Tiwana, 2015	4	SCOPUS and Web of Science

Predictors Extraction

The study examined the 21 identified articles and extracted 12 essential predictors and one project desertion construct, an aspect of a hard fork that may split in the Blockchain project and development community. These include the intention to learn, financial gain intention, Blockchain project leadership, technical contribution norm, contributed code decoupling, code testing task, Blockchain system integration, network management knowledge, expertise heterogeneity, developer involvement, decision right delegation, Blockchain archetype, and project desertion.

Expert Review

In this SLR-expert verification stage, the following steps were taken: (1) identify relevant experts, (2) prepare questionnaires and seek permission to use them, and (3) expert verification and analysis of the results.

Identification of Relevant Experts

At this stage, looking for more experienced individuals in Blockchain projects from academia and industry was challenging. However, the decision was to identify Blockchain experts from academia and industry using the following criteria:

1. Industry developer expertise in Blockchain/OSS projects
2. Academic knowledge expertise in Blockchain/OSS project
3. Theoretical knowledge in Software engineering
4. Theoretical knowledge in Information systems project

This study adopted judgment sampling – a form of purposive sampling method – to select the experts. The industry experts' contacts came from the email list for Bitcoin development, social media platforms like Facebook and LinkedIn, and friends who work in the Blockchain software sector in various nations, including the United Kingdom, the United States, the United Arab Emirates, Nigeria, Yemen, and South Africa. These experts were selected based on the criteria that they are OSS or Blockchain practitioners and have more than three years of experience contributing to OSS or Blockchain projects (Mohamed, 2015; Tran et al., 2019). Meanwhile, the academic respondents were introduced by senior faculty advisors and friends based on their excellent reputations in the development of OSS and Blockchain initiatives. The following criteria were used to determine their selection, as proposed by Hallowell and Gambatese (2009), Rogers and Lopez (2002), Mohamed (2015), and Rajaram et al. (2021): (i) currently lecturing in the field of study, (ii) holds a doctorate in information systems, information technology management or software engineering, (iii) teaching at a recognized university, (iv) publishing on software testing, and (v) having at least five years of experience in IS projects development.

Once the experts were identified, the instrument was distributed through email. Only 22 experts responded. However, six questionnaires were incomplete. Four of the 16 experts were from the industry and had contributed to OSS/Blockchain projects, while 12 were academics who had published widely on the same topic. Table 2 presents the detailed background of each expert.

Table 2. Experts' background

Expert type	ID	Qualification	Institution/ Organization	Gender	Position	Academic/ Industry (yrs)
Industry Experts	Ex1	Masters	Zebitech-IT Solution	Male	Blockchain Developer	6
	Ex2	Bachelor	Blockchain forum	Female	Blockchain Developer	4
	Ex3	Masters	Bitcoin mailing list	Male	Blockchain Developer	14
	Ex4	PhD	Blockchain forum	Male	Project leader	10
Academic Knowledge Experts	Ex5	PhD	University Dutse, West Africa	Male	Blockchain Developer	21
	Ex6	PhD	Southern Illinois University, USA	Male	Project leader	5
	Ex7	PhD	Bayero University Kano, Nigeria	Male	Blockchain Developer	12
	Ex8	PhD	Kaduna Polytechnic Nigeria.	Male	Blockchain Developer	15
	Ex9	PhD	Polytechnic Kazaure, Nigeria	Male	Blockchain Developer	6
	Ex10	PhD	University of Technology, Wudil	Male	Blockchain Developer	5
	Ex11	PhD	University of Bari, Italy	Female	Blockchain Developer	4

Expert type	ID	Qualification	Institution/ Organization	Gender	Position	Academic/ Industry (yrs)
	Ex12	PhD	University of New York, USA	Male	Project Leader	5
	Ex13	PhD	Hadhramout University	Female	Blockchain Developer	5
	Ex14	PhD	University of East London	Female	Blockchain Developer	8
	Ex15	PhD	University Teknikal Malaysia, Melaka	Male	Project Leader	18
	Ex16	PhD	University of East London	Male	Blockchain Developer	5

Questionnaires Development and Predictor Description

A web-based survey tool was employed to create, develop and obtain the responses from the experts. The survey contains a brief overview of Blockchain and project desertion, descriptions of each predictor that were adopted from previous studies (Bian et al., 2018; Tiwana, 2015), and instructions on how to complete the survey. Furthermore, the experts were asked to anonymously rank the importance of each predictor based on a 5-point Likert scale (1 = very low relevance to 5 = very great importance). The experts were also invited to provide feedback on how to improve the survey and to suggest additional predictors that they think are relevant to the Blockchain project desertion.

Expert Verification Process

According to Mosweu et al. (2016), experts' know-how and honesty are critical in determining key predictors influencing human behavior with new technologies. In addition, the use of the verification process by the experts to investigate potential behavior predictors of the OSS/IS projects' developers yielded promising results (Ahl et al., 2019; Rajaram et al., 2021). After identifying the experts and developing the questionnaire, invitation emails were sent to them to participate in the verification process. Official letters were also provided for those requested. For instance, two experts, Ex6 and Ex15, had insisted on an appointment letter as a condition for participating. All respondents were experts in the IS, SE, and IT fields with at least three years of experience in their respective disciplines. The experts from academia were all PhD holders and had published at least one article indexed in either the WoS or Scopus. The process resulted in retaining 13 predictors that were used to construct the framework of the study (Figure 3).

Results and Discussions

General Findings

Overall, several conclusions can be drawn from the structured literature review. First, the present study identifies several different predictors that might predict abandonment (on an individual, project, or both levels). To date, some factors of abandonment that have been studied include individual level abandonment (Calefato et al., 2022; Li et al., 2021; Miller et al., 2020), project level abandonment (Arruñada & Garicano, 2018; Islam et al., 2019; Khondhu et al., 2013), and both individual and project level abandonment (Balali et al., 2018; Bosu et al., 2019; Izquierdo-Cortazar et al., 2009).

Second, the comprehensive review of literature also indicates that there is evidence of bias and self-selection. According to the findings, some studies may be affected by a self-selection bias because developers who declined to complete the survey could have had different reasons for project abandonment (Daniel et al., 2020; Miller et al, 2020). This is typical for survey research. Some studies in experimental research (Calefato et al., 2022; Li et al., 2021) may be affected by bias in the selection of study projects since those projects use various collaborative code review approaches in GitHub.

Furthermore, the majority of projects are diversified in terms of programming language and application domain, popularity and maturity level, and years of development history.

PREDICTOR RESULTS

The data collected from the experts were analyzed using SPSS and tested using the one-sample t-test (see Table 3). This test was used to compare the mean of the population (X) to the hypothesized value (X mean) = 3, indicated by the high importance value in the 5-point Likert scale (1 = very low importance to 5 = very high importance). Therefore, the testing value sets for the predictors are as follows:

1. Included: if the mean of the proposed predictor is >3, the predictor is considered significantly important, i.e., influences the project desertion in Blockchain (Hawash et al., 2020).
2. Excluded: if the mean of the proposed predictor is ≤3, the predictor is considered unimportant, i.e., it does not influence the project desertion in Blockchain and will be excluded in the framework (Hawash et al., 2020).

Table 3. Result of the experts' verification/evaluation

Predictors	Mean	One-Sided p	Two-sided p	Lower	Upper	Result & decision
Intention to learn	4.25	<.001	<.001	.79	1.71	Significant & included in the framework
Financial gain intention	4.19	<.001	<.001	.79	1.59	Significant & included in the framework
Blockchain project leadership	3.81	.004	.007	.25	1.37	Significant & included in the framework
Technical contribution norm	3.81	.007	.014	.19	1.43	Significant & included in the framework
Contributed code decoupling	4.00	<.001	<.001	.52	1.48	Significant & included in the framework
Code testing task	4.13	<.001	.002	.48	1.77	Significant & included in the framework
System integration	3.94	<.001	<.001	.48	1.39	Significant & included in the framework
Network management knowledge	3.75	.017	.035	.06	1.44	Significant & included in the framework
Expertise heterogeneity	3.81	.005	.010	.22	1.40	Significant & included in the framework
Developer involvement	3.81	<.001	<.001	.85	1.78	Significant & included in the framework
Decision right delegation	4.31	<.001	<.001	.52	1.48	Significant & included in the framework
Blockchain archetype	3.69	.008	.016	.15	1.23	Significant & included in the framework
Project desertion	3.81	.001	.003	.33	1.30	Significant & included in the framework

Test Value = 3
Significance: 95% Confidence Interval

In Table 3, experts ranked all the identified 12 predictors and project desertion constructs as essential and significant in influencing a project desertion decision in Blockchain. From Table 3, a predictor with a mean value of >3, p-value <0.05, t-value >1.96, and confidence intervals, which did not

contain zero in-between, were considered for inclusion (Hawash et al., 2020). The results show that the decision right delegation construct had the highest mean, and the Blockchain archetype construct had the lowest.

Experts' Comments and Suggestions

Ex13 remarked that a Blockchain project is a decentralized autonomous community. Therefore, developers may choose to leave or abandon a Blockchain project because they need to gain expertise in a new community (intention to learn). Similarly, Ex6 commented that collaborating with more diverse Blockchain teams, regardless of the project's direction, could offer new opportunities for learning to develop Blockchain systems. However, depending on what the developer seeks to understand, they might choose to stay in the project or join others to increase their learning. Ex2 commented that most developers contributed to Blockchain projects to earn money. Therefore, developers, who hold crypto-currency, are naturally motivated to increase its value. Ex11 strongly disagreed with their comments and said that many developers, who enjoyed writing code, contribute to Blockchain projects. In contrast to prior literature, some contribute to the Blockhain project due to technical attraction (Bosu et al., 2019). Ex14 commented that some of the characteristics of the Blockchain projects are very rare among conventional OSS projects that could be sources of challenges for developers. He suggested the inclusion of high costs of defects, Blockchain innovativeness, and perceived trust predictors.

Ex7 commented that, due to the Blockchain project's decentralization, there are likely to be collaboration issues and difficulties reaching an agreement among the community members. Islam et al. (2019) and Bosu et al. (2019) emphasized that communities run most Blockchain projects. However, since many of the projects have hundreds of millions of US dollars in investment, the community members often face disputes in deciding on a project roadmap. He also acknowledged that most of the predictors that could influence project desertion are covered in the questionnaire. Ex10 noted that the primary motivation of developers is to create a decentralized currency that cannot be manipulated by a central authority since prior studies from the psychology domain suggest that a person's behavior may vary based on personal and environmental predictors (T. Zhou, 2018). Ex3 mentioned that Blockchain development challenges are related to testing, module integration, security, and reviewing code promptly. He also said that the testing of Blockchain software is challenging because the project is distributed, decentralized, and potentially hostile environment. As for Ex4, Blockchain represents an immature project. Many of the innovative aspects of Blockchain technology are relatively new. Although they have grown exponentially, many tools and libraries that may support Blockchain project development are still unavailable. Ex14 and Ex 15 suggested the inclusion of Blockchain innovativeness and perceived trust predictors respectively as they think they could influence project desertion in Blockchain. But these two experts represent only 12.5% of the participants in the study, therefore their suggestion was not considered from the framework construction. Intention to learn and Financial gain intention predictors were initially suggested and added by information systems experts during 2020 international Pacific Asia conference of information systems (PACIS).

Theories and Models in Blockchain and OSS Studies

Several theories and models were employed to investigate various OSS phenomena based on the publications contained in this review and expert verification. The use of theories can be characterized from three perspectives (Lindman, 2021): motivations for OSS contributions (Bosu et al., 2019; Dahlander & McKelvey, 2005; Roberts et al., 2006; Xu et al., 2009; Xu & Jones, 2010); governing in OSS (Dirose & Mansouri, 2018; Garagol & Nilsson, 2018; Linåker et al., 2019); and competitiveness (Abualloush et al., 2016). However, most of these studies focused primarily on the motivation of developers' participation instead of the abandonment of a project. Furthermore, most studies looked into the traditional OSS compared to the limited attention on Blockchain (Islam et al., 2019). The most commonly used theories include involvement theory, motivational theories, competitive

strategy, diffusion of innovations theory, and modular system theory (Adams & Tomko, 2018; Bosu et al., 2019; Poba-Nzaou & Uwizeyemungu, 2019; Xu et al., 2009). In contrast, the social cognitive theory (SCT), which integrates personal, behavior, and project environment constructs, was hardly utilized.

Therefore, based on the review of the related OSS theories and models, as shown in Figure 2, the 12 identified predictors were classified into three dimensions using the SCT (Carillo, 2010) personal (9 predictors), behavior (2 predictors), and environment/technological (2 predictors). The predictors were considered to be important in anticipating project desertion in Blockchain. SCT posits that individual developer behavior is part of an inseparable triadic structure in which the environmental context contributes to a better understanding of the Blockchain project's success (Bian et al., 2018). The theory emphasizes that behavior, personal factors, and environmental predictors constantly influence and reciprocally determine each other (C. P. Lin, 2010). The environmental characteristics in the SCT theory integrate the social (encouragement of technology service providers, such as developers in the Blockchain project) based on system characteristics (Islam et al., 2019). Therefore, the environmental context aids in offering better insight into the success of the Blockchain project (Bian et al., 2018).

Environmental characteristics have long been recognized as motivating innovation in OSS projects, as cited in several published OSS literature (Bosu et al., 2019; Cheng et al., 2017; M. Zhou & Mockus, 2012). The environmental factors include project outcome or direction (Steinmacher et al., 2019). The Technology Acceptance Model (TAM) (Alkharusi & Al-Badi, 2016), Theory of Planned Behavior (TPB) (Awa et al., 2015), and Diffusion of Innovations (DOI) (Rogers, 1995) have been particularly insightful in IS research. TAM and DOI theories focus solely on beliefs about technology, whilst TPB integrates the notion of perceived outcomes when forecasting behavior. Both theories claim that a person's decision to use a particular technology is driven by his/her belief that it would help them attain desirable outcomes. SCT differs from TAM, DOI, and TPB in that the latter three theories adopt a unidirectional perspective toward causal relationships. On the contrary, SCT relies on the bidirectional nature of causation, in which behavior, personality, and environmental factors can mutually influence each other.

In the context of Blockchain projects, developers' contributions are critical to the project's success, and project leaders have little formal authority to control the developers' behaviors. Therefore, behavioral involvement is essential in inducing a contribution to the project and is referred to as an individual's beliefs or feelings about an object. It has been used to describe a subjective psychological state reflecting the importance of a product (Daniel et at., 2020). In such a case, involvement is different from participation (Jiang et al., 2018). Involvement refers to a psychological state, while participation refers to actions (Bian et al., 2018). Involvement is often recognized as a determinant of the level of desertion (Tiwana, 2015). By playing the role of a predictor in influencing an individual's intention of deserting a project, the behavior construct creates a vast research avenue. In general, this study examines the environmental, personal, and behavioral characteristics of project desertion in Blockchain implementation (see Tables 4, 5, and 6 for the definitions).

PROPOSED CONCEPTUAL FRAMEWORK

This part explains the three classified definitions of the constructs required to develop the proposed conceptual framework, as shown in Figure 3.

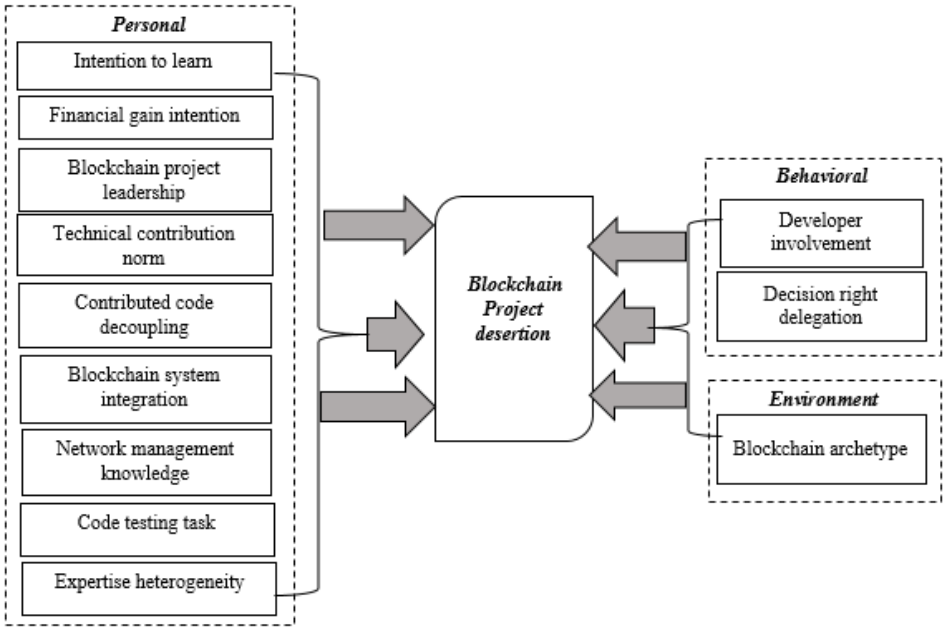

Figure 3. Proposed conceptual framework

Environment/Technical Characteristics

A critical review of literature on OSS and Blockchain discloses that technological contexts of innovation are emphasized in most studies (Damiani et al., 2015). Furthermore, based on an analysis of the literature, technical (environmental characteristics) are generally treated as vital determining factors (Carillo, 2010). As a result, evaluating the impact of technical challenges predictors is critical (Bosu et al., 2019). Technically, an individual developer who is experienced and enjoys programming activity is likely to be involved in the project. However, researchers have found that the skills and technical complexity of the technology deter individuals from participating (Gharehyazie et al., 2015). As a result, many developers abandon Blockchain projects because of the technological complexity, which is the primary source of challenges (Bosu et al., 2019). Based on the preceding findings and the characteristics of Blockchain technology, the Blockchain archetype, and Project desertion will be the environmental predictors studied in this study (see Table 4 for the definitions).

Table 4. Definition of environmental/technical predictors

Predictors	Description	References
Blockchain archetype	Implies some form of classification of various Blockchain decentralization degrees	Bian et al., 2018; Walsh et al., 2016
Blockchain project desertion	The degree of ceasing a developer's patch code contribution to a Blockchain project	Tiwana, 2015

Behavioral Characteristics

According to Wei et al. (2017), developer coding-related contribution behaviors can facilitate and inhibit contribution participation. In the Blockchain context, the characteristics of the developer exert a significant role in the sustenance contributions decision. Behavioral characteristics refer to the action and traits of individuals (Bird, 2011; Rastogi & Nagappan, 2016; Wei et al., 2014). Several behavioral characteristics that may impact project desertion were determined based on a literature review. These characteristics include all the features of the individual developer comprising the number of

individual contributions, socialization with other community members, degree of psychological beliefs, and personal decision for making design and coding efforts. Given the above characteristics and results, the behavioral predictors included in this study are developer involvement and decision right delegation (see Table 5 for the definitions).

Table 5. Definition of behavioral predictors

Predictors	Description	References
Developer involvement	The degree of psychological belief in the project in which he/she was participating as personally relevant.	Barki & Hartwick, 1994; Xu et al., 2009
Decision right delegation	The degree to which the authority for making specific design, development, and contribution decisions resides with the Blockchain developer	Tiwana, 2015

Personal Characteristics

Any cognitive, personality, or demographic characteristics that define an individual are considered personal factors. Individuals choose how they interact with new technology as it evolves. Individual cognitive characteristics are another force that drives developers to abandon OSS projects. The literature reveals that the process of how potential developers perceive OSS projects is one of the main determinants of developer engagement in many developer participation models (Alyahya & Alamer, 2019; Bosu et al., 2019; Reboucas et al., 2017; Xu et al., 2009). The open nature of Blockchain allows a developer an inclusive decision-right to contribute to the projects that directly influence the decision processes of implementing new ideas (Islam et al., 2019; Lindman, 2021; Yi et al., 2021). A Blockchain developer refers to an individual who voluntarily contributes to Blockchain projects. In the context of Bitcoin projects, in which project leaders typically have little formal authority to govern the behaviors of the developer, the developer's cognitive personality is a significant key predictor of the developer's discontinued contribution to a Blockchain project (Islam et al., 2019). In the development context, developers generally play a significant role in maintaining Blockchain software (Bosu et al., 2019; Dirose & Mansouri, 2018; Islam et al., 2019). Furthermore, several studies on OSS, including Blockchain, have advocated that the role of the developers is fundamental to the projects as their decisions affect both present and future activities of the project evolution. Therefore, based on the SLR and experts' verification, nine constructs under the personal characteristics were examined in this study; intention to learn, financial gain intention, Blockchain project leadership, technical contribution norms, contributed code decoupling, code testing task, system integration, network management knowledge, and expertise heterogeneity (see Table 6 for the definitions).

Table 6. Definition of personal predictors

Predictors	Description	References
Intention to learn	The degree of individual intention to learn from a Blockchain project that may help the developer's future work opportunities.	Xu et al., 2009
Financial gain intention	The degree of individual intention to obtain future financial gains by participating in a Blockchain project.	Hars & Ou, 2002

Predictors	Description	References
Blockchain project leadership	The extent of a project leadership style that is capable of leading a successful Blockchain project.	Bian et al., 2018; Rosete & Ciarrochi, 2005; Xu et al., 2009
Technical contribution norm	A set of agreements informing member behavior against splitting a project into two or more.	Stewart & Gosain, 2006
Contributed code decoupling	The degree to which changes within the source code will not affect the Blockchain project interoperability.	Tiwana, 2015
Code testing task	The degree of a developer's knowledge of factual and technical proficiency in the software testing domain.	Mclean, 2014; Amabile, 1997
System integration	Defined as the costs of integrating modular components into a cohesive Blockchain system.	Tiwana, 2015
Network management knowledge	The degree of a developer's knowledge of the technical proficiency and special talents in the cryptography and network security management areas.	Amabile, 1997; Rampone, 2018
Expertise heterogeneity	The diversity in the expertise possessed by the members of a project team.	Mclean, 2014)

CONCEPTUAL FRAMEWORK CONSTRUCTION

A conceptual framework identifies and defines related concepts and relationships (Risius & Spohrer, 2017). This paper proposed a methodological structure to ease understanding of an OSS or a Project desertion. The conceptual design thus describes the factors that affect the IS project desertion, such as technology/environmental, personal, and behavioral, which reflect on why developers leave or stop patch creation and contribution to Blockchain project implementation. The contribution of the proposed conceptual structure is to explore the factors that might be critical in understanding the project-level insights relating to the project desertion in Blockchain. This complements the understanding of developer turnover issues, as mentioned in recent studies. The insights denote the ability of IS artifacts to sustain success by determining appropriate design choices. This analysis integrated the Social Cognitive Theory (SCT) personal–behavioral-environment framework (Carillo, 2010).

This framework demonstrates the influences of the nine personal predictors (Intention to learn, Financial gain intention, Blockchain project leadership, Expertise heterogeneity, Network management knowledge, Technical contribution norm, System integration, Code testing task, and Contributed code decoupling); two behavioral predictors (Decision right delegation, Developer involvement); and two environmental predictors (Blockchain archetype, Blockchain project desertion). To describe the project desertion outcomes in a Blockchain project, these variables can be integrated and classified into the framework of SCT for Blockchain projects, which are OSS. However, for the organizing predictors, the frameworks represent taxonomies rather than a reflection of having all constituent parts of a theoretical framework or a well-developed theory. The variables can vary from a different context, and thus for enrichment, certain other variables can be integrated into it. Thus, this justified the

use of SCT for project desertion in Blockchain implementation as the theoretical foundation of this paper.

The proposed explanatory structure in Figure 3 is made up of three predictor variables; personal, behavioral, and technological/environmental characteristics. This framework aims to establish a conceptual model of project desertion in Blockchain with a straightforward interpretation of the key constructs. The framework was built based on SCT, a widely used theory in IS research. It is important to note that, according to SCT, environmental factors are twofold. First are social norms, such as agreements informing the members that shape the community or individual behavior; and second, are technological-based predictors. This paper defends the view that using the SCT framework will shed some new light on the technological environment issue in IS research. However, the full potential of SCT has still not been revealed due to a lack of consideration of the complete SCT constructs. The literature has indicated that the behavioral, personal, and environmental factors of SCT constantly influence each other (C. P. Lin, 2010). However, most studies used individual behavior as the dependent variable (Anwar et al., 2019; Bosu et al., 2019; Carillo, 2010).

In contrast, many studies adopted personal construct as the dependent variable (Daniel et al., 2020; Lee & Park, 2019). Based on the triadic reciprocity, several interactions in the SCT triangle have not been explored and deserve future research efforts. For instance, although SCT indicates that an individual's behavior shapes the environment, only a few IS studies were found to have used the construct as the dependent variable. The use of SCT in IS study indicates the recognition of the triadic reciprocity concept, which signifies the integration of personal and behavioral-based variables to predict an environment. In other words, SCT encourages IS researchers to incorporate both factors to understand the technological environment effectively. Such considerations raise issues in considering studies that focus solely on the technical aspects when striving to comprehend Blockchain projects. As a result, IS scholars have emphasized the importance of merging and integrating all of the components to improve the final model's prediction strength and overcome some of its specific flaws.

To validate network actors, blockchain projects like Bitcoin and Ethereum have been identified as IS projects that rely on the number and quality of their developer ecosystems (Bosu et al., 2019). However, there are also characteristic differences between Blockchain and traditional OSS projects (Lindman, 2021; Risius & Spohrer, 2017). For example, Blockchain may have e-marketplaces that provide services similar to the conventional OSS. Nevertheless, Blockchain marketplaces tend to be completely decentralized (Arrunada & Garicano, 2018). Furthermore, OSS development depends on the decisions of a project owner (Lindman, 2021). For instance, Apple Mozilla, Linux, MySQL, and Chrome are representative examples of sustainable and successful OSS projects. Many Blockchain projects are operated as distributed systems without centralized infrastructures and are often developed as OSS projects (Islam et al., 2019).

Moreover, with the distributed nature of Blockchain and the absence of a central decision-maker, the changes to the Blockchain protocol software can only become effective if all the developers accept them. This leads to a phenomenon that is often based on a fundamental subject or phenomenon, such as an IT artifact, from a broad perspective of IS research. (Morisse, 2015; Oshodin et al., 2016). This actual artifact may be the development and management of crypto-currency protocol, which is rich in phenomena based on the intertwining of technological artifacts and the social environment, as seen in the Blockchain project (Bosu et al., 2019). Otherwise, a running Blockchain may experience a fork, resulting in two Blockchains sharing a common history of transactions but diverging at a certain point in time, and allowing users who previously held one Bitcoin to spend it twice, i.e., once on each resulting Blockchain (Lajoie-Mazenc et al., 2017). However, despite prior literature efforts, the consequences of such hard forks that may allow double spending on Blockchain are not yet clear (Islam et al., 2019).

Thus, to address this gap, the IS framework for understanding why developers cease creating and contributing patch code for the project's success has been developed.

THEORETICAL IMPLICATIONS

The theoretical framework for understanding project desertion is intended to provide an accurate description of potential determinants and a precise prediction of why developers cease creating and contributing patch code for the success of the Blockchain project. Furthermore, it may affect the decisions of investors, cyber-security administrators, and projects. Since various interactions in the SCT triangle have not been studied and deserve further study efforts, the suggested framework would significantly contribute to ongoing SCT advancement (Carillo, 2010). Several developed models and theories have been offered for the OSS development community at the individual and project levels. This is one of the first theoretical models that incorporate psychological and behavioral constructs at the individual level and SCT frameworks for Blockchain implementation at the project level. In the literature, all contexts have been extensively discussed and independently researched. Still, limited researchers have dwelled on the value of developer desertion to understand the success of Blockchain technology at the project level.

In addition, this conceptual model and theoretical framework will contribute to the body of knowledge in the developer's contribution to the field of Blockchain projects. Even so, it will also open new research horizons. The new conceptual model may be generalized or refined to produce new theories or models.

PRACTICAL IMPLICATIONS

A systematic literature analysis of selected research from industry practitioners and scholarly publications is the foundation of the present article. Next, a list of the possible determinants is presented in the results. In different circumstances of each project, determinants were used for the motivation to participate in Blockchain or traditional OSS. However, the same determinants could lose their meaning in other IS project scenarios. Therefore, the collection of determinants according to the type of IS project is necessary for producing a better understanding. Furthermore, prior studies indicate that some of the OSS projects disincentivize forks in their projects as forks can split the community and lead to the loss of investment (Islam et al., 2019). For example, unlike forks in traditional OSS software development, Blockchain forks encompass assets and may change the dynamics that affect software developers and their motivation, and sustained involvement than in traditional OSS projects. Hence, this analysis would considerably contribute to the decision-making processes before the investors who want to venture into Blockchain crypto-currency.

Specifically, this research may empower developers and cyber-security analysts who want to start contributing to the Blockchain project to better understand project-level insights into why developers desert a project and may complement prior studies of why they join a project. The insights specifically refer to how an individual's design choices can determine the success and prosperity of IS project. This study will direct Blockchain crypto-currency investors and cyber-security managers to pay attention to the developer's behavior in a non-existence formal owner of decentralized OSS projects to ensure secure investments, especially for crypto-currencies projects.

RESEARCH LIMITATIONS AND FUTURE RESEARCH OPPORTUNITIES

This study, like so many others, has weaknesses. First, the predictors were analyzed from a theoretical perspective due to the nature of the published research. The criteria were based on research in the Blockchain and traditional OSS domains. Various determinants for different IS projects could affect project desertion. Second, the essential purpose of this review and expert verification was to explore the significant determinants that could influence project desertion in Blockchain. The research was based on theoretical findings from previously collected quantitative data. A limited case study shows empirical evidence that the current research results are relevant. Expert developers expect practical

implementation in the industry to expand the present study further. Third, due to human intervention, the textual definitions biases cannot be eliminated, while utmost attempts ensure that the results are more reliable with minimum biases. As a result, the data could represent typical phenomena theoretically. Fourth, few researchers discussed developers leaving Blockchain or OSS projects at the individual level.

Individual-level theories and frameworks, such as SCT, were used to understand why developers stopped contributing or deserted a project, which should be considered and suggested by researchers. As Blockchain represents a decentralized, technologically complex, and hostile environment, SCT could be considered in light of the developers' decision to abandon the project. This will assist the existing Blockchain community in determining the level of developers' involvement and dedication, which serves as a potential tool in identifying those who may be on the verge of leaving or stopping their contribution to the project. Moreover, this may help secure significant investment resources and lead to the success of Blockchain projects. This study investigated the determinants using the most relevant analytical lenses for Blockchain in the OSS research field. In addition, future studies may employ a meta-analysis to increase awareness in this field. Alternative statistical approaches, such as PLS-SEM, should be used to test the framework described in this review and expert verification. This would give a comprehensive picture of the main predictors that lead to project desertion in Blockchain.

Researchers and practitioners can use the findings of this study to understand better and align their efforts to overcome the practical problems of a Blockchain project. Researchers can use this literature review and expert verification for summarizing existing studies and defining new research issues. More specifically, they can use this classification system to analyze the context of the OSS that they are researching.

CONCLUSION

A thorough literature review was conducted to investigate the possible determinants and theories that influence Blockchain project abandonment. This led to the identification and reporting of 21 studies in total. After analyzing the results, a total of 13 predictors were identified and grouped into three contexts, namely technology, personal, and behavior. Sixteen experts provide an important contribution by confirming and verifying factors found in the SLR that could influence project abandonment in the blockchain environment. The review also indicated that the majority of the OSS studies on the current research topic were done for traditional OSS. Therefore, from the perspective of project abandonment, researchers should also pay attention to novel blockchains, such as Bitcoin and Ethereum cryptocurrencies. Finally, more experiments should be conducted on the identified determinants that could affect the success of blockchain projects by applying some other theories or models. It is also noted that the current theoretical structure and conceptual model can be tested using a quantitative, qualitative, or mixed-method approach to develop more refined models in the future.

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