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An Empirical Study on the Adoption Determinants of Permissioned Blockchain as Decentralized Inter-organizational Systems

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Abstract: Permissioned blockchain is a technology relevant for business-to-business transactions among partners with low trust. An extensive literature review indicates an inadequate comprehension of the adoption determinants of permissioned blockchain as the next generation of decentralized inter-organizational systems. To address this gap, this study builds the theoretical model by extending the technology–organization–environment framework to the permissioned blockchain context and incorporating inter-organizational factors. A mixed methodology is adopted to identify and investigate the determinants, including interviews with 10 senior information technology (IT) executives and a questionnaire survey of IT managers with blockchain experience from 212 organizations. A total of 11 factors is identified through literature review and interviews. The empirical results indicate that top management support is the most significant determinant, followed by perceived benefits, technology maturity, trading partner readiness, and perceived advantages of the blockchain industry consortium. Besides, competition intensity is identified as a weak determinant. The implications for theoretical development and professional practice are examined. Longitudinal and latitudinal studies are recommended for future research.

Keywords: decentralized inter-organizational systems, permissioned blockchain, innovation adoption, TOE framework, business-to-business

1. Introduction

Blockchain was first introduced in 2008 as a disruptive technology that leverages cryptographic algorithms to store and synchronize data immutably [1, 2]. This decentralized nature has made blockchain widely adopted for ensuring the security and verifiability of transaction records across multiple parties with low trust [3–5]. Investment in blockchain development has rapidly increased, significantly impacting global markets [6].

Blockchain networks are generally classified into two main types: *permissionless* and *permissioned blockchains*. Permissionless blockchain is open to anyone, maintaining user anonymity and commonly used in business-to-consumer (B2C) and consumer-to-consumer (C2C) transactions, such as virtual gaming economies [7]. In contrast, permissioned blockchain restricts access to approved participants and is widely adopted in business-to-business (B2B) settings [8], such as improving supply chain transparency [9, 10], facilitating digital collaboration [11], and ensuring data integrity [12, 13]. This study focuses on permissioned blockchain as a decentralized inter-organizational system (IOS), redistributing control from a central authority.

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As a decentralized IOS, permissioned blockchain facilitates B2B transactions across organizational boundaries while offering greater efficiency and security compared to traditional IOS [8, 14]. Participants are allowed to directly share transaction data while maintaining control over access rights, consensus mechanisms, and network code modifications [15]. Furthermore, the consensus mechanism enhances trust between trading partners, even in low-trust environments [7, 16], distinguishing it from conventional IOS, which typically operates among well-established trading partners. Moreover, the ways in which permissioned blockchain is adopted as a decentralized IOS solution are varied – some organizations implement it individually, while others adopt it collectively through industry consortia, a novel form of inter-organizational collaboration absent in traditional IOS [17].

Despite the growing interest in permissioned blockchain as a decentralized IOS for B2B transactions, there is a lack of theoretical frameworks to systematically analyze its adoption. Existing studies on innovation adoption and IOS often generalize "blockchain" without distinguishing between permissioned and permissionless models. However, these two blockchain types serve fundamentally different markets. Existing innovation adoption and IOS literature are inadequate for understanding decentralized IOS. Most academic studies on blockchain adoption have examined it from an end-user perspective rather than a corporate decision-making perspective [18, 19]. As a result, organizations seeking guidance on adopting permissioned blockchain as a decentralized IOS lack relevant research insights [20].

Given the strategic importance of permissioned blockchain as a decentralized IOS, it is essential to bridge these gaps by applying innovation adoption and IOS theories to develop a comprehensive understanding of its adoption determinants. This study aims to fill this gap by identifying key factors influencing the adoption of permissioned blockchain as a decentralized IOS and analyzing their impact. The key research questions of this study are: (1) What are the potential factors influencing the adoption of permissioned blockchain as a decentralized IOS? (2) What is the relationship between these factors and permissioned blockchain adoption?

To address these research questions, this study first identifies potential adoption determinants through a comprehensive review of the innovation adoption and IOS literature. The technology–organization–environment (TOE) framework is selected as the theoretical foundation, as it specifically focuses on corporate innovation adoption rather than individual end-users, making it well-suited for this study. In addition, to emphasize the importance of inter-organizational factors to permissioned blockchain as a decentralized IOS, this study extends the TOE framework by incorporating a separate inter-organizational context and identifies 11 potential influencing factors. These 11 factors include perceived benefits, technology maturity, existence of permissioned blockchain characteristics, organization size, scope of business, top management support, existence of the inter-organizational business model, trading partner readiness, perceived advantages of the blockchain industry consortium, competition intensity, and technology policies and regulations. These factors were subsequently validated by conducting interviews with ten senior information technology (IT) executives, all of whom had substantial experience in blockchain-related decision-making. Finally, to empirically test the relationships between these factors and the adoption of permissioned blockchain as a decentralized IOS, a questionnaire survey was administered to IT managers responsible for corporate IT decision-making. By targeting IT managers as respondents, this study provides valuable insights into the corporate decision-making process, shedding light on the factors that drive the adoption of permissioned blockchain as a decentralized IOS.

2. Literature Review and Theoretical Background

2.1. Innovation adoption

A wide range of theories have been developed to account for the process of innovation adoption, including the technology adoption model (TAM), the unified theory of acceptance and use of technology (UTAUT), and the diffusion of innovation (DOI), some of which have been applied to blockchain adoption research. For instance, Kamble et al. [21] adopted TAM to analyze blockchain adoption in India's supply chain based on perceived usefulness and ease of use; Woodside et al. [22] utilized DOI to categorize blockchain adopters, while Queiroz et al. [18] and Wong et al. [19] applied UTAUT to explore users' intention to adopt blockchain. These studies identified various adoption factors, such as trust [18], trading partner pressure [23], and technology readiness [19]. However, these factors primarily reflect the perspectives of individual end-users, whereas permissioned blockchain serves as a decentralized IOS for B2B transactions, requiring an enterprise-level rather than an individual-level decision-making approach. Consequently, these traditional theories and adoption determinants are insufficient for the context of this study.

Beyond these individual-focused models, the TOE framework has been widely used to investigate innovation adoption, particularly at the organizational level [24]. Unlike TAM, UTAUT, and DOI, the TOE framework considers three key dimensions – technological, organizational, and environmental factors – which makes it well-suited for studying the adoption of permissioned blockchain in enterprise settings. Although prior research has applied the TOE framework to blockchain adoption [19, 25, 26], these studies generally do not differentiate between permissioned and permissionless blockchains, nor do they focus on decentralized IOS for B2B transactions. Moreover, existing TOE-based blockchain research often lacks explicit consideration of inter-organizational factors, which are critical in IOS adoption. By introducing an inter-organizational dimension, this study advances the TOE framework to provide deeper insights into the adoption of permissioned blockchain as a decentralized IOS and bridges this gap.

2.2. Inter-organizational systems

IOSs are network-based information systems that facilitate data sharing, business process coordination, and transaction execution among multiple organizations [27–30]. The primary value of IOS adoption lies in its ability to enhance joint performance among business partners while serving as a strategic tool for strengthening business integration [27, 28]. Given their collaborative nature, inter-organizational factors serve a vital function in IOS adoption [30]. Traditional IOSs are typically centrally managed by organizations and their trading partners, with a central authority responsible for processing transactions and maintaining ledger records. In contrast, decentralized IOS, powered by permissioned blockchain, eliminates the reliance on a central authority by distributing transaction validation across multiple pre-approved participants.

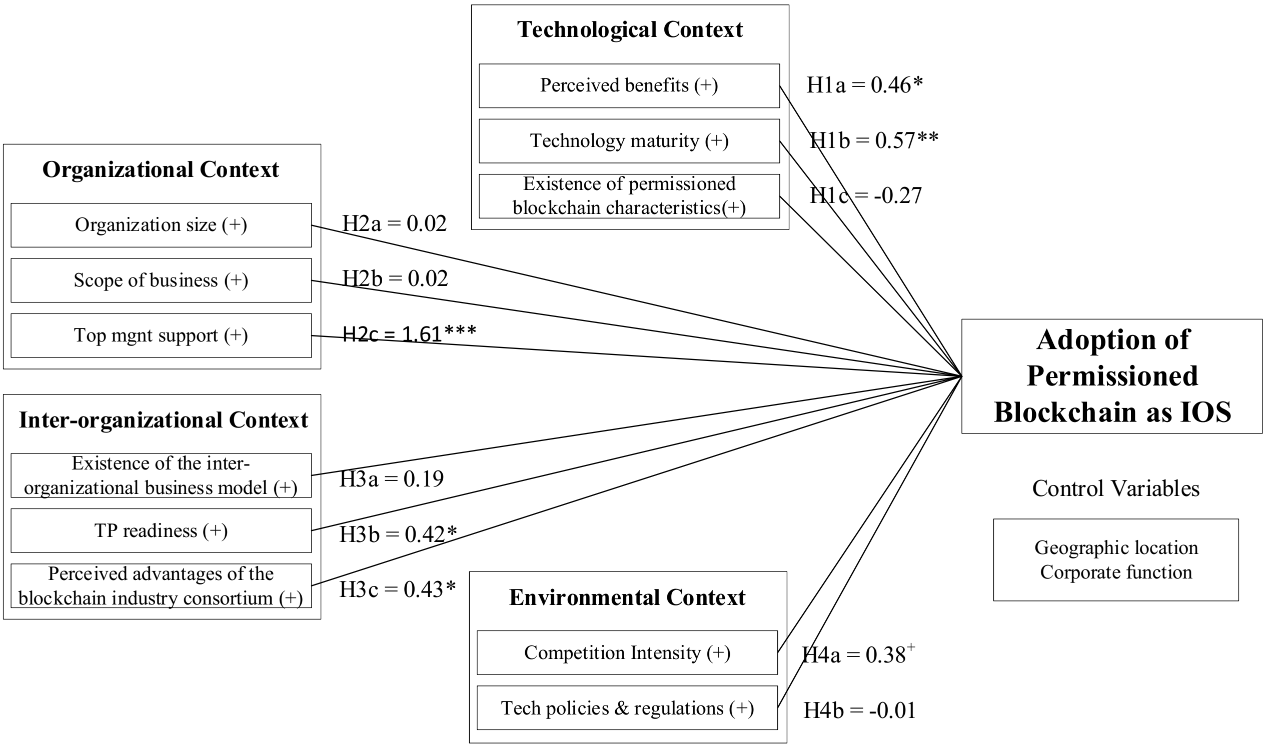
Prior IOS adoption research has categorized determinants into external and internal factors, with inter-organizational factors often classified under the external environment [31, 32]. However, some scholars argue that inter-organizational factors should be treated as a distinct category rather than being grouped with external environmental factors [33, 34]. Furthermore, while some studies explore how blockchain enhances inter-organizational collaboration by reducing dependence on a centralized trust entity [9, 14, 35], few have specifically examined what drives the adoption of permissioned blockchain as a decentralized IOS. Given its unique decentralization characteristics, this study endeavors to bridge this gap in existing research.

2.3. Extended TOE framework and identified determinants

The TOE framework has served as a foundational model in analyzing how various inter-organizational technologies are adopted, including electronic data interchange (EDI), e-business applications, and e-supply chain systems [36–38]. Considering the cross-organizational nature of permissioned blockchain as a decentralized IOS and the significance of inter-organizational factors in its adoption, this study extends the TOE framework by introducing an inter-organizational context as a separate dimension.

To identify relevant adoption determinants, 60 scholarly articles were systematically reviewed, including 22 studies applying the TOE framework [39, 40], 8 IOS studies examining key determinants in IOS adoption [34, 41], and 30 blockchain adoption studies [19, 42], of which 12 applied innovation adoption theories, including TOE. This comprehensive review indicated that no prior studies have specifically applied the TOE framework to permissioned blockchain

Figure 1
Research model with results



as a decentralized IOS. Moreover, through this review, 67 potential determinants were identified (listed in Supplementary A). After further analysis, 11 key determinants were shortlisted (as bolded) based on their significance, relevance to permissioned blockchain adoption, and uniqueness compared to existing determinants. To validate these determinants, 10 senior IT executives with direct experience in permissioned blockchain adoption decisions were consulted. These experts provided insights that confirmed the importance of inter-organizational factors in the adoption process and the highest-relevance factors influencing adoption. Further details regarding the determinant selection process are presented in Section 4.1.

3. Model and Hypotheses Development

Building upon this theoretical foundation, we extend the TOE framework by incorporating an inter-organizational context to develop a research model linking 11 identified factors to the adoption of permissioned blockchain as a decentralized IOS. The model depicts the four contexts of the extended TOE framework, namely, technological, organizational, inter-organizational, and environmental, and the 11 hypothesized paths to adoption. These factors were categorized into appropriate contexts based on their characteristics and prior literature. The conceptual model, along with the proposed hypotheses on the adoption of permissioned blockchain as a decentralized IOS, is illustrated in Figure 1.

3.1. Antecedents of permissioned blockchain adoption as a decentralized IOS in the technological context

Perceived benefits refer to the advantages an organization expects from adoption [43], including perceived direct benefits (e.g., cost reduction or revenue increase) and indirect benefits (e.g., improved customer relationships or enhanced corporate image) [37, 44, 45]. Organizations base their adoption decisions on expected benefits, as the actual value of the technology only materializes post-adoption. Prior studies applying the TOE framework have confirmed the role of perceived benefits in organizational innovation adoption [25, 46]. Given that permissioned blockchain functions as a decentralized IOS, it is essential to investigate its perceived benefits in driving adoption. Therefore, we propose:

H1a.*Perceived benefits are positively related to the adoption of permissioned blockchain as a decentralized IOS.*

Technology maturity describes how extensively a technology's functionality has been proven by its adopters, with known faults or limitations addressed over time [47]. Organizations often look to early adopters as reference points before making adoption decisions [48]. Technology maturity increases the likelihood of successful implementation while mitigating risks associated with premature adoption. Given that permissioned blockchain operates as a decentralized IOS and its adoption affects not only the adopting organization but also its stakeholders, ensuring technology maturity is critical to minimizing adoption risks. Thus, we propose:

H1b.*Technology maturity is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

Permissioned blockchain characteristics in this study refer to core features such as distributed trust, immutability, traceability, and data security [25, 49]. These attributes have been widely recognized in the literature for their role in enhancing the reliability and security of transaction data [50, 51]. By ensuring data integrity and verifiability, these characteristics enable blockchain to address business challenges related to inter-organizational transactions [25]. Given their potential to enhance an organization's competitive performance in data transactions [14], these characteristics are highlighted as a significant determinant of permissioned blockchain adoption. Therefore, we propose:

H1c.*Existence of permissioned blockchain characteristics is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

3.2. Antecedents of permissioned blockchain adoption as a decentralized IOS in the organizational context

Organization size pertains to the scale of an organization, commonly measured by revenue, number of employees, or other relevant parameters [52]. It is widely recognized as a key predictor of innovation adoption [53]. Multiple studies have demonstrated a positive association between organization size and innovation adoption [53, 54]. Within the TOE framework, organization size has also been identified as a determinant of technological adoption [25, 46]. Larger organizations often find it easier to justify investments in innovation due to their broader user base and greater capacity to absorb associated costs. Given this, it is important to assess whether organization size influences the adoption of permissioned blockchain as a decentralized IOS. Therefore, we propose:

H2a.*Organization size is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

Scope of business refers to the breadth of an organization's operations, whether in terms of functional diversity [55] or geographic reach [38]. Organizations with a wider operational scope typically incur higher transaction costs compared to those with a narrower scope [38, 56]. Consequently, they have stronger incentives to adopt digital transformation technologies that can streamline operations and reduce costs. Additionally, a broader scope allows organizations to replicate successful implementations across different areas of operation, maximizing the benefits of adoption. The scope of business and organization size are different. An organization may be large in size but narrow in business scope such as energy companies. Conversely, there are organizations with a wide scope of business but not necessarily large in scale such as trading companies. Investigating these two determinants provides insights into if it is the scale or the scope is a more important determinant. As such, this study aims to examine the role of business scope in the adoption of permissioned blockchain as a decentralized IOS. We propose:

H2b.*Scope of business is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

Top management support reflects the level of commitment organizational leaders demonstrate toward adopting an innovation [25]. This commitment is reflected in the allocation of resources, the willingness to assume risks, and the active involvement in championing the adoption process [57]. Strong top management support ensures that innovation is integrated into business processes by emphasizing its potential to enhance efficiency and drive transformation [36]. Moreover, top management support is pivotal in facilitating business model and process transformation, particularly in uncertain and risk-laden environments [25]. Based on these considerations, we propose:

H2c.*Top management support is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

3.3. Antecedents of permissioned blockchain adoption as a decentralized IOS in the inter-organizational context

An inter-organizational business model defines how an organization conducts business transactions with its trading partners to achieve strategic objectives [58]. Attaran [59] emphasized that inter-organizational collaboration, underpinned by business models and process reengineering, is fundamental to the adoption of IOS. The transformative potential of blockchain, as a distributed ledger technology, has been widely recognized [60]. The added business value from adopting permissioned blockchain as IOS comes primarily from these process transformations [20]. Given the crucial role of business model transformation in blockchain adoption, we propose:

H3a. *Existence of the inter-organizational business model is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

The concept of trading partner readiness reflects the extent to which key stakeholders – such as suppliers and buyers – are equipped to adopt a new innovation [43]. The adoption of permissioned blockchain as a decentralized IOS does not depend solely on a single organization's preparedness but also on the collective preparedness of its trading partners. Unlike traditional centralized IOS models, a decentralized IOS requires trading partners to assume new roles and responsibilities, such as supporting the mutual consensus mechanism for validating transactions [43]. Given the essential role of trading partner readiness in achieving successful adoption, we propose:

H3b.*Trading partner readiness is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

Perceived advantages of the blockchain industry consortium refer to the expected benefits that organizations anticipate when collaboratively adopting permissioned blockchain as a decentralized IOS [61]. In the case of permissioned blockchain, industry consortia have emerged as a preferred model for adoption [14], as they offer key advantages such as a lower adoption cost, reduced risk, improved efficiency, and faster attainment of critical mass [62]. Members of a blockchain industry consortium collectively share responsibilities related to the decentralized IOS business model, including governance and maintenance of the distributed ledger [63]. As such, it is essential to investigate the role of perceived advantages of the blockchain industry consortium in adopting permissioned blockchain as a decentralized IOS. Therefore, we propose:

H3c. *Perceived advantages of the blockchain industry consortium are positively related to the adoption of permissioned blockchain as a decentralized IOS.*

3.4. Antecedents of permissioned blockchain adoption as a decentralized IOS in the environmental context

Competition intensity denotes the level of rivalry within an industry in which an organization operates [40, 62]. Organizations in highly competitive environments often seek innovation to differentiate themselves and enhance their competitive advantages [64]. Greater competition has been linked to increased investment in innovation, as firms strive to maintain or improve their market position [65]. Additionally, organizations may feel compelled to adopt technologies that their competitors have implemented to maintain parity in capabilities [66]. Given these dynamics, competition intensity is frequently identified as a key driver of innovation adoption [19, 46]. We believe this also applies in the context of permissioned blockchain as a decentralized IOS. This suggests the following:

H4a. *Competition intensity is positively related to the adoption of permissioned blockchain as a decentralized IOS.*

Technology policies and regulations encompass the governance, support, and guidelines that official authorities establish regarding technology usage [67]. These can influence innovation adoption through financial incentives, regulatory requirements, or penalties for noncompliance [44, 49, 67]. In light of blockchain's emerging status within the B2B landscape, government policies and regulations – beyond just financial support or penalties – can strongly shape how organizations decide to adopt the technology. Clear regulatory frameworks, industry guidelines, and government-backed initiatives can provide organizations with the confidence and direction needed to integrate blockchain into their operations. Based on this perspective, we propose:

H4b. *Technology policies and regulations are positively related to the adoption of permissioned blockchain as a decentralized IOS.*

4. Methodology

4.1. Research approach

To explore the key determinants underlying the adoption of permissioned blockchain as a decentralized IOS, this study applies a three-phase exploratory sequential design [68], which includes qualitative data collection and analysis, identification of key features for testing, and subsequent quantitative testing. Quantitative research is the dominant approach, supported by qualitative insights [69].

For the qualitative research, 10 senior IT executives from Hong Kong with expertise in permissioned blockchain were interviewed. Selection criteria included executives who had encountered opportunities to adopt permissioned blockchain in the 12 months prior to the interview, regardless of adoption decisions. Seven were adopters, and three were non-adopters. Structured interviews were guided by a question list, with participants discussing the importance of various factors and suggesting additional determinants (see Supplementary B). The interview results, detailed in Supplementary C, were used to develop the survey questionnaire for the next phase. The quantitative phase involved an online survey targeting IT managers or higher in Hong Kong, who are responsible for corporate decision-making and view adoption from an organizational perspective. An analysis of the collected data was conducted to assess the validity of the study's hypotheses.

4.2. Measurement development

The dependent variable (i.e., adoption of permissioned blockchain as a decentralized IOS) is a dichotomous variable: 1 represents an adopter (i.e., adopted or in the process of adoption), while 0 represents a non-adopter (i.e., intend to adopt, exploring adoption, or no plan to adopt). Intend to adopt is classified as a non-adopter because of the nonexistence of resource allocation to adopt. The measurement items were adapted from the literature on innovation adoption, blockchain adoption, and IOS research, resulting in 43 items across 11 determinants. These were assessed using a seven-point Likert scale for greater response sensitivity [70]. A pilot test with five IT managers refined the items further to reduce measurement error and ensure internal validity (see Supplementary D for scale items).

The perceived benefits of adopting permissioned blockchain as a decentralized IOS were assessed using six items, adapted from Teo et al. [37] for direct benefits and Kuan and Chau [44] for indirect benefits, capturing the anticipated advantages for organizations [46]. Technology maturity was assessed by three items adapted from Lee et al. [47] to capture whether the technology can be implemented successfully with irregularities resolved. Existence of permissioned blockchain characteristics was assessed by four items adapted from Clohessy and Acton [25], including distributed trust, immutability, traceability, and data security.

Organization size was assessed by three items: total revenue, number of employees, and number of IT staff [37, 46], capturing the organization's scale. Scope of business was assessed by three items adapted from Zhu et al. [38] to capture the organization's geographic and market presence. Top management support was measured by five items, including strategic importance, engagement, and risk tolerance from Gangwar et al. [71] and willingness to invest and encouragement for adoption from Wang et al. [46].

Trading partner readiness includes four items adapted from Chittipaka et al. [4] to assess the readiness of trading partners for adoption, including their knowledge and technical expertise on permissioned blockchains. There are four items of existence of the inter-organizational business model adapted from Clauss [72], assessing its role in developing capabilities, extending offerings, integrating partners, and improving internal processes. Perceived advantages of the blockchain industry consortium were assessed with five items, including three items from Zavolokina et al. [17] and two items from Naidoo [64], focusing on process efficiency, data access control, innovation, cost reduction, and adoption mass-building.

Competition intensity was assessed by three items adapted from Premkumar and Roberts [73], including the risk of losing customers, the need for adoption to be competitive, and whether competitors have adopted. Three items adapted from Zhu et al. [38] were used to assess technology policies and regulations, capturing government incentives, policies, and regulations supporting adoption.

Control variables such as geographic location and corporate function were included to rule out alternative explanations and were used as screening criteria in the survey.

4.3. Data collection procedure

The survey targeted mid-level or above IT managers in Hong Kong, aiming for a sample size of 220, approximately 3% of the 7,000–8,000 IT managers in the region, which meets the required sample size standards [74, 75]. The finalized questionnaire was deployed on an online survey platform.

Respondents were recruited through information system (IS)-related professional organizations, including the HK Computer Society and the Internet Society of Hong Kong, as well as direct solicitation via LinkedIn. A total of 4,041 invitations were sent, resulting in 831 opens. Of these, 344 responded, yielding a response rate of 8.5%. After excluding incomplete or careless responses, 212 valid responses remained, resulting in a valid response rate of 61.6%. 86.3% of the respondents were decision-makers or part of the decision-making team for technology adoption, with 50 (23.6%) adopters and 162 (76.4%) non-adopters. The demographic characteristics are summarized in Table 1.

To evaluate potential non-response bias, early and late respondents were compared based on global employee numbers and industry sector distribution. The Chi-square p-values are 0.13 for employee count and 0.09 for industry sector, both above the 0.05 threshold, indicating no significant bias [76, 77].

5. Analysis and Results

5.1. Reliability and construct validity

To ensure the reliability and validity of the survey data, we undertake the following procedures. We began by performing a factor analysis. The initial analysis showed good convergent and discriminant validity for most items, except for six items related to organization size (OS1, OS2, OS3) and scope of business (SB1,

Table 1
Demographic information of survey respondents

Demographics	Non-adopters(N = 162)		Adopters(N = 50)		Total (N = 212)	Chi-Square
	Frequency	%	Frequency	%		
Seniority						
Senior Management	97	45.75	32	15.09	129	value=0.27
Middle Management	65	30.66	18	8.49	83	df=1 P=0.602
Company Size Globally						
1-50 employees	36	16.98	14	6.60	50	Value=4.06
51-250 employees	19	8.96	4	1.89	23	df=6
251-500 employees	8	3.77	3	1.42	11	P=0.668
501-2000 employees	25	11.79	4	1.89	29	
2,001-10,000 employees	31	14.62	8	3.77	39	
Over 10,000 employees	42	19.81	17	8.02	59	
Don't know	1	0.47	0	0	1	
Industry Sectors						
Information Technology	41	19.34	16	7.55	57	value=7.55
Banking, Finance, Security & Insurance	26	12.26	15	7.08	41	df=4
Transportation & Logistics	19	8.96	4	1.89	23	P=0.110
Wholesale & Retail	17	8.02	3	1.42	20	
Manufacturing, Telecommunications & Others (combined in reporting)	59	27.83	12	5.66	71	
Role in Technology Adoption Decision						
Sole Decision Maker	23	10.85	14	6.60	37	value=7.16
Part of Decision-Making Team	119	56.13	27	12.74	146	df=2
Not Part of Decision-Making Team	20	9.43	9	4.25	29	P=0.028
Adoption Status						
Adopted			28	13.21	28	
In the process of adoption			22	10.38	22	
Intend to adopt	21	9.91			21	
Exploring adoption	75	35.38			75	
No plan to adopt	66	31.13			66	

SB2, SB3), which appeared to converge into a single factor. Further analysis removed OS1, which cross-loaded between organization size and scope of business with similar coefficients (0.58 and 0.57), but the remaining items still converged. Consequently, we combined these six items into one construct, considering their formative nature for organization size.

Next, convergent and discriminant validity were examined through factor analysis employing varimax rotation (see Supplementary E). The 10 factors exhibited high convergent validity after combining organization size and scope of business. All 43 items had significant factor loadings (ranging from 0.54 to 0.91), all exceeding 0.5, with eigenvalues ranging from 2.33 to 4.19, all greater than 1. Additionally, each item exhibited a stronger loading on its intended construct than on any other, supporting both convergent and discriminant validity.

Finally, the Cronbach's α values for all factors ranged from 0.80 to 0.94, well above the 0.7 benchmark, indicating reliable constructs. Construct reliability was further supported by average variance extracted values ranging from 0.60 to 0.85, all exceeding the 0.5 threshold, confirming adequate reliability [76].

5.2. Common methods bias

To test for common methods bias, we applied Herman's one-factor test [77]. The first factor had an eigenvalue of 13.13, explaining 30.5% of the variance, which is below the 50% threshold, indicating that common methods bias is not a concern. Additionally, the first 10 factors explained 76.09% of the total variance, and each factor's eigenvalue, extracted using principal component analysis with varimax rotation (see Supplementary E), exceeded one, confirming that each factor is distinct.

5.3. Hypothesis testing

For hypothesis testing, logistic regression was used, as the dependent variable is dichotomous. Following factor analysis, the

Table 2
Results of logistic regression analysis

	DV = Adoption of permissioned blockchain	
Model	1	2 (Robustness Check)
Variable		
Independent variables		
Perceived benefits	0.46*	0.76**
Technology maturity	0.57**	0.77***
Existence of permissioned blockchain characteristics	–0.27	–0.03
Organization size/scope of business	0.02	–0.12
Top management support	1.61***	1.66***
Existence of the inter-organizational business model	0.19	0.46*
Trading partner readiness	0.42*	0.22
Perceived advantages of the blockchain industry consortium	0.43*	0.43*
Competition intensity	0.38+	0.61**
Technology policies and regulations	–0.01	0.01
R^2	0.27	0.35

Note: $N = 212$. R^2 = overall variance explained in the dependent variable by the variables in the model. $^{+}p < 0.10$; $^{*}p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$.

items for organization size and scope of business, which converged into a single factor, were combined as one construct. The results of the logistic regression analysis are presented in Table 2.

As shown in Model 1, the adoption of permissioned blockchain as a decentralized IOS is sufficiently explained, with $R^2 = 0.27$. In the technological context, perceived benefits and technology maturity are both positively related to adoption (β = 0.46, $p < 0.05$; β = 0.57, $p < 0.01$), supporting H1a and H1b. However, the existence of permissioned blockchain characteristics has a negative but insignificant coefficient (β = −0.27, $p > 0.10$), so H1c is unsupported. In the organizational context, the combined variable of organization size and scope of business shows no significant effect on adoption (β = 0.02, $p > 0.10$), meaning H2a and H2b are unsupported. In contrast, top management support is strongly positively related to adoption (β = 1.61, $p < 0.001$), supporting H2c.

For the inter-organizational context, the existence of the inter-organizational business model is positively related to adoption, but the effect is insignificant (β=0.19, p>0.10), indicating H3a is unsupported. However, trading partner readiness and perceived advantages of the blockchain industry consortium are both significantly positively related to adoption (β = 0.42, $p < 0.05$; β = 0.43, $p < 0.05$), supporting H3b and H3c. In the environmental context, competition intensity has a weak positive relationship with adoption (β = 0.38, $p < 0.1$), offering partial support for H4a. However, technology policies and regulations show no significant impact (β =−0.01, $p > 0.10$), meaning H4b is unsupported.

Overall, top management support emerged as the most significant predictor of adoption, followed by perceived benefits, technology maturity, trading partner readiness, and perceived advantages of the blockchain industry consortium. Competition intensity shows a weak effect. In contrast, the existence of permissioned blockchain characteristics, organization size/scope of business, the existence of an inter-organizational business model, and technology policies and regulations do not significantly impact adoption.

Further, a robustness check, where adopters were defined to include those intending to adopt, yielded results consistent with the original analysis (see Model 2 in Table 2), confirming the robustness of our findings.

6. Discussion

6.1. Discussion of key findings

Although the adoption of permissioned blockchain as a decentralized IOS is crucial, limited research has comprehensively explored its antecedents. This study contributes to the literature by investigating the determinants within an extended TOE framework. The empirical findings provide support for six out of the eleven proposed hypotheses (see Table 3 and Figure 1).

Key findings from the questionnaire survey and executive interviews reveal several important insights. It is important to note that the permissioned blockchain as a decentralized IOS adoption remains in its early stages, as indicated by the small percentage of adopters, a finding consistent with current research [78, 79]. Additionally, technological advancements and the unique characteristics of this study's sample should be taken into account when interpreting the insignificant results.

First and foremost, *top management support* is confirmed as a critical determinant of adoption. While its importance in innovation adoption is well-documented [37], this study highlights its particularly strong influence in the early stages of permissioned blockchain adoption, where uncertainties about benefits and risks prevail [14]. Top management support is essential in ensuring the availability of resources and fostering organizational readiness.

Second, this study confirms that the *perceived benefit* is an important, though not the most crucial, determinant of adoption. Perceived benefit provides the rationale for adopting permissioned blockchain as a decentralized IOS, particularly from a business perspective, which aligns with previous research on innovation adoption [36, 70]. However, assessing and weighing these benefits is challenging during the early adoption phase [78]. Additionally, some adopters may be motivated by factors other than immediate

Table 3
Results summary

Hypotheses	Expectation	Result
H1a	Perceived benefits positively relate to the adoption of permissioned blockchain as a decentralized IOS	Supported
H1b	Technology maturity positively relates to the adoption of permissioned blockchain as a decentralized IOS	Supported
H1c	Existence of permissioned blockchain characteristics positively relates to the adoption of permissioned blockchain as a decentralized IOS	Not Supported
H2a	Organization size positively relates to the adoption of permissioned blockchain as a decentralized IOS	Not Supported
H2b	Scope of business positively relates to the adoption of permissioned blockchain as a decentralized IOS	Not Supported
H2c	Top management support positively relates to the adoption of permissioned blockchain as a decentralized IOS	Supported
H3a	Existence of the inter-organizational business model positively relates to the adoption of permissioned blockchain as a decentralized IOS	Not Supported
H3b	Trading partner readiness positively relates to the adoption of permissioned blockchain as a decentralized IOS	Supported
H3c	Perceived advantages of the blockchain industry consortium positively relate to the adoption of permissioned blockchain as a decentralized IOS	Supported
H4a	Competition intensity positively relates to the adoption of permissioned blockchain as a decentralized IOS	Supported
H4b	Technology policies and regulations positively relate to the adoption of permissioned blockchain as a decentralized IOS	Not Supported

benefits, such as the desire to innovate [48], explaining why perceived benefit, while important, is not the primary determinant of adoption.

Third, technology maturity, often overlooked in innovation adoption studies, emerges as a significant factor. Prior studies on blockchain adoption have predominantly emphasized end-user adoption and technology readiness rather than the maturity of technology for inter-organizational adoption [18]. Besides, previous studies on IOS adoption also have a few mentions of technology maturity [33]. This study confirms that technology maturity is a key determinant for corporate adoption of permissioned blockchain as a decentralized IOS.

Fourth, perceived advantages of the blockchain industry consortium also play a significant role in adoption. Beyond its technical role in blockchain network operations, joining a consortium offers benefits like economies of scale, risk mitigation, and sharing best practices [62]. Despite limited previous studies on consortia in innovation adoption, this study highlights its importance, especially in the early stages of permissioned blockchain adoption.

Furthermore, trading partner readiness exerts a moderately positive influence on adoption, whereas the effect of competition intensity is only weakly supported. The limited impact of competition intensity can be attributed to the early stage of decentralized IOS adoption. Together with the insignificant effect of technology policies and regulations, these findings suggest that external stakeholders have less influence during the initial adoption phase, where decisions are more internally driven [80]. Existence of permissioned blockchain characteristics' insignificance reflects that new innovations' essential attributes are outweighed by organizational factors such as top management support, which serves as a key determinant, particularly during the early stage of adoption.

6.2. Theoretical contributions

This study advanced theory by offering several notable contributions. Primarily, it contributes to the literature on both innovation adoption and blockchain adoption literature [19, 25, 26] by offering empirical evidence on the adoption of permissioned blockchain as a decentralized IOS, with the recognition of its differences versus permissionless blockchain, which is not an IOS. The existing literature on blockchain adoption has often treated these as a single category [22, 49], leading to confusion for researchers focused on permissioned blockchain specifically. Furthermore, this study emphasizes the importance of viewing permissioned blockchain adoption from a corporate decision-making perspective, rather than an individual end-user perspective, which has dominated previous research [18, 19]. A comprehensive understanding of corporate-level adoption decisions regarding decentralized IOS requires careful consideration of the key factors influencing the process, such as top management support [25].

Second, this study contributes to the TOE framework [24] and enriches related research [19, 46] in two ways. On the one hand, apart from traditional TOE factors (e.g., perceived benefits or organization size), it introduces blockchain-specific factors, such as technology maturity and the perceived advantages of blockchain industry consortium, which were found to have a positive impact on adoption. On the other hand, it extends the TOE framework by examining the role of inter-organizational factors in the adoption of permissioned blockchain. This aligns with Lin's [33] and Premkumar and Ramamurthy's [34] calls for a separate inter-organizational context in technology adoption studies and responds to Baker's [81] call to apply the TOE framework to new technologies. The three inter-organizational factors examined in this study highlight the pivotal role of immediate business partners in the adoption process, as opposed to the influence of more distal environmental factors.

By exploring permissioned blockchain as a decentralized IOS, this study enriches the body of literature on IOSs. Previous IOS studies have primarily focused on centralized technologies, such as EDI, financial EDI, and B2B electronic commerce [33, 44, 65]. Our study expands this body of knowledge by introducing permissioned blockchain as a decentralized IOS, which retains traditional IOS characteristics, such as collaboration with trading partners [33, 65], while also incorporating the unique decentralized model [15]. This study bridges the gap between existing IOS models and decentralized technologies, offering a fresh perspective that will inform future studies on IOS and blockchain.

6.3. Practical implications

The study offers three main practical implications. First, it provides adopters of permissioned blockchain as a decentralized IOS with a clearer understanding of the key adoption determinants, enabling them to assess the factors influencing their decision. With this knowledge, organizations can more effectively evaluate whether permissioned blockchain aligns with their strategic IT infrastructure [82]. For instance, highlighting the importance of securing top management support can help facilitate the adoption of permissioned blockchain as a decentralized IOS.

Second, for non-adopters, this study outlines essential adoption determinants, offering a valuable starting point for evaluating whether permissioned blockchain fits their business needs. This enables organizations to develop targeted adoption strategies and make informed decisions. For those consulting external advisors, this study's findings can complement the return on investment (ROI) models and project selection criteria provided by consultants, enriching the decision-making process.

Third, this study offers insights for governments aiming to promote the adoption of permissioned blockchain as a decentralized IOS. Given that top management support is a critical determinant of adoption, governments can facilitate adoption by educating business leaders on the strategic value of permissioned blockchain within their business ecosystems. Additionally, governments can collaborate with companies to identify regulatory and other forms of support that can help develop consortia and advance the diffusion of permissioned blockchain across organizational contexts.

6.4. Limitations and further research

This study acknowledges three primary limitations that provide avenues for future research. First, the discriminating power of the logistic regression used to identify adopters is moderate due to the limited number of adopters in the sample, and some valid responses may be outliers. However, the consistency of logistic coefficients in the robustness check confirms the reliability of the findings. Subsequent research could enhance the sample size to include more adopters or focus on industries with a higher adoption rate to improve statistical significance.

Second, while the measurement items were adapted from prior research to fit the specific context of permissioned blockchain adoption as a decentralized IOS, their operationalization has not been extensively validated in previous research. Despite demonstrating reliability, convergent validity, and discriminant validity in this study, future research could refine these measurement items by applying established methodologies for developing adoption determinant scales [83].

Third, the empirical focus on Hong Kong may limit the extent to which the findings can be generalized to different regional contexts [46]. Subsequent research could employ longitudinal studies to examine whether the same determinants hold across different adoption stages as permissioned blockchain evolves [84]. Additionally, cross-regional (latitudinal) studies could test the model in diverse geographic locations to explore potential variations in adoption determinants.

7. Conclusion

This study delineates and empirically examines eleven critical factors shaping the adoption of permissioned blockchain as a decentralized IOS. The findings indicate that adoption is still in its early stages, with only 23.6% of survey respondents being adopters, while 45.3% of non-adopters are either considering or exploring adoption. This underscores the importance of understanding adoption determinants, as favorable conditions may encourage wider adoption. This study achieves its objective by confirming that top management support represents a pivotal factor, while technology maturity, perceived benefits, perceived advantages of the blockchain industry consortium, and trading partner readiness are significant determinants. Competition intensity is also found to be a weak but present influence. These findings suggest that adoption determinants may evolve as the technology matures. Moreover, this study highlights the need to consider the maturity stage of permissioned blockchain when applying the TOE framework. Understanding how adoption factors change over time will provide deeper insights into this promising and increasingly relevant technology.

Recommendations

The findings underscore the significance of top management support in facilitating the adoption of permissioned blockchain as IOS. This is due to the cross-organizational resources required in conjunction with the risks associated with adoption. Therefore, it is recommended that support from top management in organizations should be obtained first when an organization is considering adopting permissioned blockchain as an IOS.

As permissioned blockchain as an IOS is still in its nascent phase of adoption, longitudinal studies are recommended to be conducted to identify if there are changes in the importance of the adoption determinants when the maturity of the technology is improved. It is also recommended to consider this research framework for other distributed IOS technologies when they arise.

Ethical Statement

This study did not require formal ethical approval because Southern University of Science and Technology/China does not have an Institutional Review Board or ethics committee requirement for this type of non-medical social science research.

Despite the exemption, the study was conducted in accordance with accepted ethical standards. Participation was voluntary, informed consent was obtained prior to data collection, and no personally identifiable information was collected or disclosed.

Conflicts of Interest

The authors declare that they have no conflicts of interest to this work.

Data Availability Statement

Data are available from the corresponding author upon reasonable request.

Author Contribution Statement

Leo Yeung: Conceptualization, Methodology, Formal analysis, Investigation, Writing – original draft, Writing – review & editing. **Yulin Fang:** Writing – review & editing, Supervision. **Ting Xu:** Writing – original draft, Writing – review & editing.

Supplementary Material

The supplementary material for this article can be found at https://doi.org/10.47852/bonviewFSI62027046.

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