Exploring Trust in Blockchain Technology: A Critical Review of the Theoretical Acceptance Models

Betül Aydogdu[1], Irina Rychkova[1][a]
[1] *University Paris 1, Panthèon-Sorbonne, Paris, France*
{*Betul.Aydogdu,Irina.Rychkova*}*@univ-paris1.fr*

Keywords: Trust, technology acceptance model, blockchain

Abstract: Although Blockchain Technology (BCT) is widely acknowledged for its disruptive potential in reshaping industries through decentralization and enhanced security, its adoption has been slower than anticipated. To address this gap, this secondary study examines 21 recently published surveys on BCT acceptance. While existing literature confirms the critical role of trust in BCT acceptance, our study examines its effect in detail, focusing on the role it plays in the theoretical acceptance models — whether as a predictor, mediator, or moderator. This research contributes to a deeper understanding of the BCT adoption process, which is essential for effective policy-making and defining and implementing digital transformation strategies within organizations.

1 Introduction

The rise of Blockchain technology (BCT) marked a new digital era by eliminating the need for centralized authorities, creating a trustless environment for transactions. Instead of placing their faith in an intermediary, users could trust the blockchain. Historically, trust has been crucial for the adoption of new technologies. For instance, distrust in security hindered online shopping adoption in the 90s [Hoffman et al., 1999]. Despite enhanced transparency, reduced costs, and improved traceability, BCT adoption remains limited[1]. According to PwC[2], in 2020, "45 % of companies investing in blockchain technology believe that lack of trust among users will be a significant obstacle in blockchain adoption".

Technology adoption, defined as the act of beginning to use a new technology, is closely related to, but distinct from, technology acceptance. While technology acceptance encompasses a more subjective behavioral intention to support or embrace the technology, it serves as a precursor to actual use (i.e., adoption). Research community uses various theoretical models to explain the BCT acceptance mechanism and to define its factors [AlShamsi et al., 2022, Al-Ashmori et al., 2022, Norbu et al., 2024]. One of the recurring factors of BCT acceptance is trust.

Three forms of trust are widely recognized in the literature: social trust, digital trust, and trust in technology. Social (or interpersonal) trust is defined as the subjective probability that an entity - a trustee - has the required capacity and willingness to perform an action that is beneficial or at least not detrimental to another entity - a trustor - in a specific context [Gambetta et al., 2000]. Compared to social trust, digital trust defines relationships between entities in the digital world. It is the measure of confidence that a trustor has in the trustee's ability to protect data and privacy of individuals [Pietrzak and Takala, 2021]. Trust in technology is another form of trust that reflects trustor's beliefs that a specific technology has the attributes necessary to perform as expected in a situation where negative consequences are possible [Mcknight et al., 2011, Meeßen et al., 2019]. These forms of trust are intrinsic to organizations and have important implications in organizational decision-making and technology adoption [Mcknight et al., 2011, De Filippi et al., 2020]. They need to be explicitly addressed both in policy making, digital transformation strategies and solution design.

While the research studies confirm that trust is an important factor in BCT acceptance, the conceptual-

[a] https://orcid.org/0000-0002-1100-0116

[1] Deloitte, 2021 Global Blockchain Survey, available at: https://www.deloitte.com/global/en/our-thinking/insights/topics/emerging-technologies/understanding-blockchain-potential.html

[2] PwC, "Time for Trust: How Blockchain Will Transform Business and the Economy," available at: https://www.pwc.com/gx/en/issues/blockchain/blockchain-in-business.html

ization of trust and its specific role are not discussed in detail. In this critical review, we intend to contribute into a deeper understanding of this role. We examine the impact of trust on BCT acceptance, focusing on the role it plays in the defined theoretical models — whether as a predictor, mediator, or moderator. We explore the conceptualization of trust within the defined BCT acceptance models. By analyzing how trust is defined and measured, we aim to determine whether the researchers refer to social trust, digital trust, or trust in technology in their theoretical frameworks.

The remainder of this article is organized as follows: In section 2, we go through the definition of key terms and discuss the related works. Our research methodology is described in section 3. In section 4, we report the results of the analysis of 21 selected studies, answering to our research questions. In section 5, we discuss our results and their potential implications and present our conclusions in section 6.

2 Background and Related Works

2.1 Theoretical Models for Technology Acceptance

While adoption is focused on consistent use of technology in daily activities, it is often associated with technology acceptance. Technology acceptance refers to the willingness and readiness of individuals or organizations to adopt and use new technology. Technology acceptance is closely related to and often predicts technology adoption [Davis, 1989, Venkatesh et al., 2003].

Theoretical models such as the Technology Acceptance Model (TAM) are often applied within the context of information systems to understand predictors of human behavior toward potential acceptance or rejection of the technology [Marangunić and Granić, 2015]. The theoretical models specify a set of constructs and the relationships between them that explain a phenomenon of interest. The theoretical BCT acceptance models, for example, explain the effect of specified independent variables on Behavioral Intention (BI) to use BCT - the dependent variable.

The constructs defined by the theoretical models can play a role of predictors, mediators or moderators (Fig. 1) for the examined phenomena. Predictors are independent variables that directly influence the dependent variable. Mediators are variables that explain the mechanism through which predictors influence the dependent variable. They act as intermediaries in the causal chain, helping to clarify how or why a certain effect occurs. Moderators are variables that affect the strength or direction of the relationship between predictors and the dependent variable. They provide insights into when or under what conditions certain effects occur. Some variables function both as predictors and mediators, depending on the specific relationships being examined.

Trust in blockchain technology (BCT) can be measured either directly, through survey items like ”Do you find BCT trustworthy?”, or indirectly by capturing data on trust antecedents or related indicators. Direct questions pose a challenge as they leave ”trustworthiness” open to individual interpretation. Indicators are the observable variables that reflect the presence or extent of trust. They depend on the trust conceptualization chosen for the study (see Table 1).

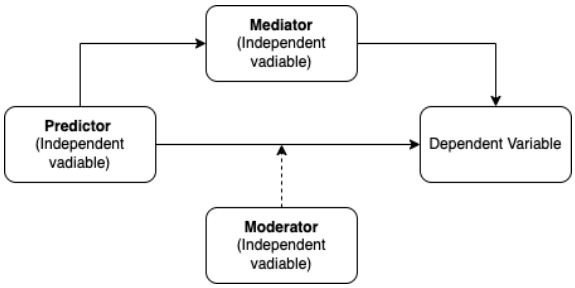

Figure 1: Overview of the variables and their relations in theoretical acceptance models

Understanding acceptance factors and relationships between them is crucial for technology adoption. Knowing the predictors allows for the design of targeted interventions. Understanding mediators provides insights into the adoption process (i.e., how or why a certain effect occurs). For example, trust might mediate the relationship between system quality and user acceptance. Understanding moderators allows for the development of context-specific strategies. For instance, age, gender, or cultural background might moderate technology adoption, necessitating tailored communication and support strategies for different groups.

Several theoretical acceptance models are widely acknowledged in the literature. The Technology Acceptance Model (TAM) developed by Fred Davis in 1989 is a theoretical framework used to understand and predict user acceptance of information technology [Davis, 1989]. This model defines two primary predictors of user acceptance: Perceived usefulness is the degree to which a person believes that using a particular system would enhance his or her job performance. Perceived ease of use is the degree to which a person believes that using a particular system would be free of effort. TAM2 [Venkatesh and

Davis, 2000] extends the original model by introducing the concepts of social influence processes (subjective norm, voluntariness, and image) and cognitive instrumental processes (job relevance, output quality, result demonstrability, and perceived ease of use) as key drivers of user acceptance.

The Unified Theory of Acceptance and Use of Technology (UTAUT) was created in 2003 [Venkatesh et al., 2003]. Built upon TAM, it identifies the four predictors of acceptance: performance expectancy, effort expectancy, social influence and facilitating conditions. Those four factors are influenced by four moderators: age, gender, experience, and voluntariness of use, which result in possible gaps between the intentions to use a technology and the actual use of the technology.

The Task-to-Performance Fit (TTF) model [Goodhue and Thompson, 1995] is a theoretical framework that examines how well technology matches the tasks it is intended to support, and how this fit impacts performance and technology adoption.

The Technology-Organization-Environment (TOE) [Baker, 2012] framework defines the factors that influence the organization's decision to adopt new technology divided into three contexts: technological, organizational, and environmental.

Acceptance predictors from these theoretical models show the importance of combining technical factors and social factors, related to user's personality and the context of use.

2.2 Trust

Trust is a social construct that emerges from interactions between individuals or groups and can be described by a situation where a subject (trustor) is willing to rely on a chosen actions of an object of trust (trustee) [Rousseau et al., 1998, Gambetta et al., 2000, Mayer et al., 1995]. Mayer, Davis and Schoorman define trust as a function of the trustee's perceived ability, benevolence, and integrity and of the trustor's propensity to trust [Mayer et al., 1995]. Here *ability* defines a group of skills, competencies, and characteristics that enable a trustee to have influence within some specific domain; *benevolence* defines the extent to which a trustee is believed to want to do good to the trustor, aside from an egocentric profit motive; *integrity* refers to trustee's moral quality of being sincere, honest, and her capacity and willingness to adhere to some rules/principles.

Advances in technology introduce the new models of social and business interactions, where IT artifacts can take the role of a trustee [Söllner et al., 2012]. Trust in technology reflects trustor's beliefs that a specific technology has the attributes necessary to perform as expected in a given situation where negative consequences are possible [Mcknight et al., 2011] [Meeßen et al., 2019]. According to [Söllner et al., 2012], the antecedents of social trust (i.e., ability, benevolence and integrity [Mayer et al., 1995]) are poorly suited for studying trust relationships between users and IT artifacts, since they are defined to fit the human character traits and human decision making. The authors of [Mcknight et al., 2011] provide a framework for understanding how trust in technology is formed and its effects on technology usage. They put forward performance, functionality and reliability as the factors of trust in specific technology.

Digital trust defines relationships between entities in the digital world. It is the measure of confidence that a trustor has in the trustee's ability to protect data and privacy of individuals [Pietrzak and Takala, 2021]. Digital trust and Trust in Technology are closely related to specific properties of a technology or solution (e.g., security, reliability, availability etc.), with digital trust focused on data security and privacy. Whereas these properties are considered objective measures of technology trustworthiness in the literature [Murtin et al., 2018, Jacovi et al., 2021, Garry and Harwood, 2019, Rychkova and Ghriba, 2023, Gharib et al., 2020], they are not always good predictors of technology acceptance: users (social actors) do not always have the technical expertise to objectively evaluate the complex technical properties and ground their decisions on their subjective beliefs. This work examines the complex nature of trust in blockchain and its effect on the BCT adoption. Table 1 provides an overview of the trust conceptualizations and factors.

2.3 Trust and Blockchain Adoption

Blockchain technology has emerged as a potential solution to cope with mistrust in traditional (centralized) institutions and online intermediaries in general [De Filippi et al., 2020]. Blockchain can be defined as a distributed database that allows its users to transact in a public and pseudonymous setup without the reliance on an intermediary or central authority [Glaser, 2017]. Despite its popularity and efficiency, blockchain technology experiences challenges of user adoption. Depending on the industry sector and the use case, privacy, security, scalability, interoperability, performance are considered the main challenges [Konstantinidis et al., 2018, Casino et al., 2019, Belotti et al., 2019, Marengo and Pagano, 2023].

Theoretical models of acceptance are used by researchers to reason about the factors of blockchain

Table 1: The types of Trust and their factors

	Ref. theory	Factors
Social trust	[Mayer et al., 1995]	Ability, benevolence, integrity, propensity to trust, perceived risk
Trust in technology	[Mcknight et al., 2011]	Performance, functionality, reliability, propensity to trust, institution-based trust
Digital trust	[Pietrzak and Takala, 2021]	Data privacy, data security, confidentiality

adoption in a structured way. The study by Shin [Shin, 2019] shows the impact of Trust, Security and Privacy factors on the blockchain-based-solution acceptance (behavioral intention to use). Following this work, the studies in [Jena, 2022, Kumar et al., 2022, Alazab et al., 2021] extend the TAM/UTAUT models with Trust, Perceived Security and Perceived Privacy. The authors of [AlShamsi et al., 2022] are examining the technology acceptance models, theories and influential factors in BC adoption. Among the 11 factors identified, trust is the most common factor affecting the BCT adoption. The authors of [Taufiq et al., 2018] study the influence factors of BCT adoption taking the example of the payments system in Indonesia banking industry. They highlight the importance of non-technical factors, such as attitude, subjective norm, cognitive style of the user. In [Al-Ashmori et al., 2022], the authors identify the 18 factors of BCT adoption. These factors are consistent with TAM / UTAUT theoretical frameworks and include trust. The systematic literature review [Taherdoost, 2022] confirms that trust is an important factor of BCT adoption, in particular for supply chain industry. The authors of [Marengo and Pagano, 2023] conduct a systematic literature review to examine the factors of adoption of BCT across different countries and industries and identify trust as a recurring factor for supply chain, real estate, and banking. The study presented in [Norbu et al., 2024] focuses on trust as a primary driver for BCT adoption in digital payment systems.

While existing literature confirms that trust is an important factor in BCT acceptance, the nature of trust and its specific role are not discussed in detail. In this work, we investigate the role of trust within the proposed theoretical models (i.e., as a predictor, mediator, or moderator). We also analyze the conceptualization of trust used in these models. By analyzing how trust is defined and measured, we aim to determine whether the researchers refer to social trust, digital trust, or trust in technology in their theoretical frameworks.

Understanding the nature of trust and its impact on BCT acceptance is crucial for addressing the adoption process. We use trust conceptualization from social sciences [Gambetta et al., 2000, Mayer et al., 1995] and from technology [Mcknight et al., 2011, Pietrzak and Takala, 2021], addressing this concept from the broader perspective.

3 Methodology

In this study, we present a critical review of theoretical models predicting BCT acceptance. Unlike a systematic literature review, our approach offers a more reflective analysis, emphasizing judgment and argument over exhaustiveness. We particularly focus on the interpretation and critical evaluation of theoretical acceptance models supported by empirical data, aiming to uncover trends, patterns, and conflicts in the literature. Although formal guidelines for critical reviews are not universally established, we adapted the systematic literature review principles by Kitchenham and Charter [Kitchenham et al., 1995], following these steps: defining research questions, identifying relevant studies, extracting data, conducting critical analysis and evaluation, and reporting the results.

3.1 Research questions

We formulate the following research questions for our review:
RQ1 : What are the most commonly used theoretical models to explain blockchain acceptance?
RQ2: How is the Trust construct addressed in the studies?
RQ2.1 How is Trust defined in these studies?
RQ2.2 What trust indicators are used?
RQ3: What types of Trust are associated with BCT acceptance?
RQ4: How does Trust influence BCT acceptance?

3.2 Study selection

For our critical review, we selected the studies that explicitly integrate trust in their proposed theoretical models of BCT acceptance. The flow diagram adopted from PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) presents an overview of the source selection process in Fig. 2. A literature search was conducted using the Scopus database (scopus.com). We used the following keywords for our search: blockchain, trust, acceptance OR adoption, model OR framework. To improve relevance, these terms have to appear in the title, abstract or key words of the retrieved studies.

According to dimensions.ai, the interest in BCT adoption reflected by the number of publications on this topic increases exponentially since 2019. Therefore, for our study, we chose articles published from January 2019 on. We limit the publication year by 2023 to obtain a consistent set of publications that will not be affected by more recent apparitions. The resulting query is illustrated in Fig. 2. 218 sources have been automatically identified in the Scopus database. After removing non-primary sources we kept 175 records for screening.

We proceeded by screening the metadata of identified records and eliminated irrelevant studies based on the following exclusion criteria:

EC1: The study does not formalize a theoretical acceptance model.

EC2: The study does not provide an empirical validation of the proposed model.

EC3: The study does not consider trust among the factors of acceptance or adoption.

We kept 57 records for the full text assessment. We proceeded with the full text reading and kept 18 relevant studies for the analysis. We conducted backward and forward citation analysis of the eligible publications from the previous step (a so-called "snowballing" technique) and identified 14 records which were re-injected into the process. Three studies have been eventually added to our data set. The final set of 21 studies was used for the analysis.

3.3 Data Extraction

We examined each selected study, extracting data on:

- The theoretical BCT acceptance model proposed by the study: the reference acceptance model (e.g., TAM); the factors affecting BCT acceptance according to the model;
- Conceptualization and measurement of trust in the study: the reference definition from the literature; the indicators (i.e., the questions on trust) defined by the study;
- The role attributed to trust within the proposed acceptance model: the hypothesis related to trust; the results of empirical validation of these hypothesis.

The critical analysis of the extracted data is presented in the next section.

4 Results

Through the analysis of the extracted data, we addressed our research questions and obtained the following results:

4.1 What are the most commonly used theoretical models to explain blockchain acceptance?

The examined studies adapted and extended various theoretical acceptance models to reason about BCT. TAM [Davis, 1989] is the most commonly used theoretical model that was extended in 14 studies out of 21. Six studies use UTAUT [Venkatesh et al., 2003] as their ground model. Other models used include Technology-Organization-Environment (TOE) and Theory of Planned Behavior (TPB). While most of the studies use a single theoretical model, studies in [Alazab et al., 2021, Kamble et al., 2019, Ullah et al., 2021] are grounded on several theoretical models. Table 2 provides the summary.

4.2 How is the Trust construct addressed in the studies?

4.2.1 How is Trust defined in the studies?

To address this research question, we analyze the explicit definitions of trust presented in the text as well as the indicators used in the studies to measure Trust as an independent variable.

10 studies out of 21 provide the explicit definitions in the text. Seven studies define trust as a social construct grounded on willingness of an individual to take risk or to be vulnerable to the actions of another party [Queiroz et al., 2021, Jena, 2022, Khazaei, 2020, Hannoun et al., 2021], or on confidence in the ability and integrity of the other party [Yu et al., 2021, Gil-Cordero et al., 2020, Albayati et al., 2020], which is aligned with the definition from [Gambetta

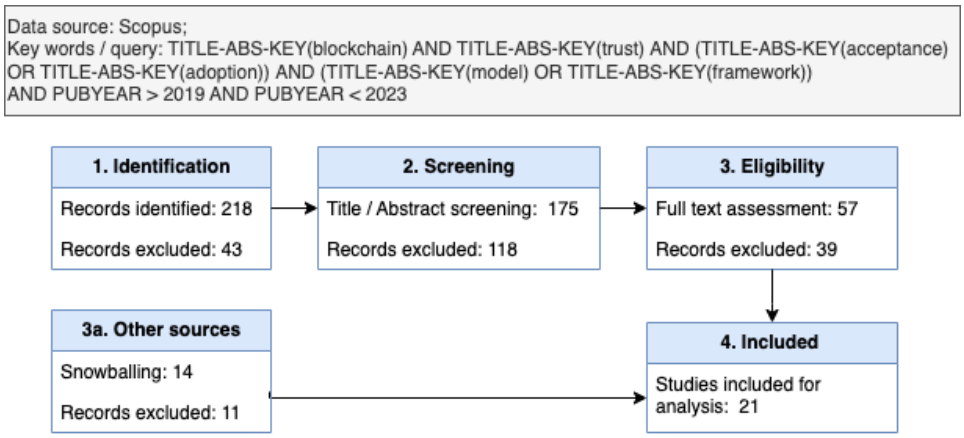

Figure 2: The PRISMA flowchart summarizing the literature selection process

Table 2: Theoretical models adapted for BCT acceptance

Model	Studies	Ref
TAM	14	[Kumar et al., 2022, Saputra and Darma, 2022, Sciarelli et al., 2021, Gao and Li, 2021, Rijanto, 2021, Palos-Sanchez et al., 2021, Yu et al., 2021, Liu and Ye, 2021, Gil-Cordero et al., 2020, Albayati et al., 2020, Dirsehan, 2020, Kamble et al., 2019, Ullah et al., 2021, Shrestha et al., 2021]
UTAUT	6	[Chang et al., 2022, Jena, 2022, Queiroz et al., 2021, Khazaei, 2020, Alazab et al., 2021, Hannoun et al., 2021]
Other	4	[Kamble et al., 2019, Ullah et al., 2021, Chittipaka et al., 2022, Alazab et al., 2021]

et al., 2000]. Study in [Chang et al., 2022] defines trust in association with transparency as 'the degree to which one believes that data provided with blockchain technology and services is error-free, safe, and transacted transparently.' Calculation-based trust grounded in rational evaluation and the expectation of benefits or costs is used in two studies [Chittipaka et al., 2022, Liu and Ye, 2021]. Other studies do not provide an explicit definition of trust.

4.2.2 What trust indicators are used in the studies?

Trust construct is a latent variable that cannot be directly observed. It is measured in the studies via trust antecedents and trust-related indicators used in a survey or questionnaire. These indicators and antecedents are defined by the conceptualization of trust (e.g., social trust, trust in technology or digital trust) as presented in the Table 1.

The nine studies use trustworthiness as a direct indicator of trust: [Queiroz et al., 2021, Kumar et al., 2022, Yu et al., 2021, Gil-Cordero et al., 2020, Saputra and Darma, 2022, Albayati et al., 2020, Dirsehan, 2020, Liu and Ye, 2021, Chang et al., 2022]. In these surveys, the perception of blockchain trustworthiness is assessed through affirmative statements such as "I believe that blockchain is trustworthy" [Queiroz et al., 2021] and "BCT is trustworthy" [Yu et al., 2021, Chang et al., 2022]. Respondents express their agreement with these statements using the Likert scale, relying on their own interpretation of "trustworthiness."

Studies in [Kumar et al., 2022, Saputra and Darma, 2022, Albayati et al., 2020] focus on promise and commitment of BCT. This indicator evaluates whether users believe that the technology prioritizes their best interests. Studies in [Queiroz et al., 2021, Gil-Cordero et al., 2020] include questions on trust in the legal structures surrounding blockchain and cryptocurrencies referred to as institutional trust in [Mcknight et al., 2011]. "I am confident that the legal and technological structures protect me from problems with cryptocurrencies" [Gil-Cordero et al., 2020] underscore the importance of the institutional trust. Studies in [Liu and Ye, 2021, Kamble et al., 2019] emphasize trust built upon experiences, their questions suggest that familiarity and previous interactions with the system or service play a crucial role in forming trust. Trust is measured via safety

and security in [Palos-Sanchez et al., 2021, Yu et al., 2021,Chang et al., 2022,Chittipaka et al., 2022,Dirsehan, 2020]. Other indicators mentioned include: reliability, transparency, integrity, honesty, fairness, confidence, capability, skills.

We analyze the indicators implying user's trust in other model constructs. For example, in [Palos-Sanchez et al., 2021], the respondents are requested to express their belief in BCT security as its 'ability to act in the user's interest'. The survey items related to this indicator include: IT Devices using blockchain technology would be safe from external threats, such as hacking; IT Devices using blockchain technology would be safe from the risk of data forgery and alteration; IT Devices using blockchain technology would secure personal information. This is consistent with the definition of trust in technology [Mcknight et al., 2011]. In [Gil-Cordero et al., 2020], the following trust indicator is used: 'I have confidence in the system'. Similarly, the indicators of privacy and information quality are formulated using an implicit notion of trust in [Gil-Cordero et al., 2020, Ullah et al., 2021,Liu and Ye, 2021,Palos-Sanchez et al., 2021].

4.3 What types of Trust are associated with BCT acceptance?

By analyzing the definitions of trust presented in the text, along with the trust indicators and indicators implying user trust in other model constructs, we classified the Trust constructs used in the studies into Social trust, Trust in technology, and Digital trust. Table 3 provides a summary of this classification.

Social trust conceptualization is used in the nine studies. These studies either use explicit trust definition consistent with [Gambetta et al., 2000, Mayer et al., 1995] or they define their trust indicators using the factors of social trust from Table 1. For example, in [Kumar et al., 2022], respondents are asked about their perception of BCT's commitment to their best interests: 'It gives an impression of promise and commitment; It keeps my interest in consideration' - property consistent with the predictors of social trust. The factors of Trust in technology are found in the nine studies, and the factors of digital trust - in the seven studies. For example, the indicator 'My firm's data in the cloud might be utilized by an outsider without our consent' is used in [Chittipaka et al., 2022], the indicator 'Data in blockchain technology would be saved securely.' is used in [Chang et al., 2022] to measure trust. These indicators associate trust with reliability and security of data on the blockchain.

Several studies define trust indicators based on multiple conceptualizations. For example, in [Kumar et al., 2022], the definition of trust provided in the text is implicit, co-notated with privacy and security (consistent with digital trust), whereas the trust indicators are defined using the notion of commitment and 'consideration of the user's best interests' (aka benevolence), consistent with social trust.

Our analysis shows that social trust plays important role in defining trust in BCT. In several studies, social trust is identified with a relationship built between the users (trustors) and the BCT providers (trustees) - social entities. For example, in [Albayati et al., 2020], the trust indicator 'I believe the service providers (both cryptocurrency and blockchain) keep my best interests in mind.' is used. In the other studies, the technology itself is identified with the qualities intrinsic for a social entity: in [Kumar et al., 2022, Saputra and Darma, 2022], trust indicators include the affirmations 'It [technology] keeps my interest in consideration' and 'The services provided by My T Wallet keep my best interests in mind.'

Trust in technology is a fundamental conceptualization of trust in BCT as well: it provides the user with objective metrics to assess trustworthiness, such as reliability, performance, functionality.

Digital trust conceptualization focuses on more specific technical properties related to data security and privacy in the digital world. In the examined acceptance models, these properties are often integrated into the Perceived Usefulness construct in TAM, or Perceived Security and Perceived Privacy constructs, specifically defined in the models [Jena, 2022, Shrestha et al., 2021, Kumar et al., 2022].

4.4 How does Trust influence BCT acceptance?

We examined the hypotheses made in the studies about the role of trust on BCT acceptance and validation of these hypotheses.

4.4.1 Trust as a Predictor of BCT acceptance:

Predictors are independent variables that directly influence the dependent variable.

$$Trust \rightarrow VAR_X$$

Trust has a direct effect on behavioral intention (BI) to use BCT according to 10 studies. In [Chittipaka et al., 2022], trust is positioned as a predictor of Adoption, which stands for actual use and follows the BI. Trust is defined as a predictor of Attitude towards use in [Kumar et al., 2022, Albayati et al., 2020]. While attitude towards use reflects how positively or negatively an individual feels about using a technology,

Table 3: Trust affecting BCT acceptance

	Study reference
Social trust	[Gil-Cordero et al., 2020] [Jena, 2022] [Alazab et al., 2021] [Queiroz et al., 2021] [Saputra and Darma, 2022] [Kumar et al., 2022] [Dirsehan, 2020] [Hannoun et al., 2021] [Albayati et al., 2020]
Trust in technology	[Gil-Cordero et al., 2020] [Jena, 2022] [Alazab et al., 2021] [Palos-Sanchez et al., 2021] [Yu et al., 2021] [Liu and Ye, 2021] [Ullah et al., 2021] [Dirsehan, 2020] [Queiroz et al., 2021]
Digital trust	[Kumar et al., 2022] [Chittipaka et al., 2022] [Gao and Li, 2021] [Chang et al., 2022] [Liu and Ye, 2021] [Palos-Sanchez et al., 2021] [Kamble et al., 2019]
N/A	[Sciarelli et al., 2021] [Rijanto, 2021] [Shrestha et al., 2021]

behavioral intention reflects the individual's readiness and plan to use that technology. They are often used interchangeably. In some theories, however, the attitude precedes BI. Therefore, we conclude that 13 studies recognize trust as having direct effect on acceptance.

Seven studies show significant effect of trust on other constructs that affect acceptance: Perceived usefulness, Perceived ease of use, Performance expectancy, Perceived privacy. Table 4 provides a summary of our results.

4.4.2 Trust as a Mediator:

Mediators are variables that explain the mechanism through which predictors influence the dependent variable. They act as intermediaries in the causal chain, helping to clarify how or why a certain effect occurs.

$$VAR_X \rightarrow Trust \rightarrow VAR_Y$$

According to [Jena, 2022], Trust acts as a mediator between Facilitating conditions and Performance expectancy and BI (behavioral intention to use BCT). This means that facilitating conditions and performance expectancy enhance users' trust, which in turn affects their intention to use BCT. According to [Gil-Cordero et al., 2020], trust mediates the effect of e-Worm (the electronic word of mouth), web quality, and Perceived risk on BI. Here e-Wom refers to 'any positive or negative statement made by potential, actual or former customers about a product or company, which is made available to a multitude of people and institutions through the Internet'. Similarly, Perceived privacy [Shrestha et al., 2021] has a positive effect on Trust, which in turn affects the intention to use BCT. Trust mediates the effect of Perceived Security [Kumar et al., 2022, Shrestha et al., 2021] and Perceived privacy [Kumar et al., 2022] on Attitude towards use BCT. Table 5 presents the summary of the results.

4.4.3 Trust as a Moderator:

Moderators are variables that affect the strength or direction of the relationship between predictors and dependent variable. They provide insights into when or under what conditions certain effects occur. Some variables function both as predictors and mediators, depending on specific relationships being examined.

$$Trust \rightarrow (VAR_X \times VAR_Y)$$

Trust is defined as enhancing the effects of other variables on BI: Performance expectancy, Effort expectancy, Social influence, Facilitating conditions [Alazab et al., 2021], Subjective knowledge [Dirsehan, 2020]. According to [Gil-Cordero et al., 2020], Trust moderates the effect of e-Worm, web quality and Perceived risk on the user behavior. According to [Shrestha et al., 2021], Trust increases the positive impact of Privacy on the Attitude towards use of BCT. According to [Palos-Sanchez et al., 2021], Trust moderates the effect of the perceived risk on perceived easiness of use. This means that the level of trust a user has can influence how perceived risk impacts their perception of the technology's ease of use. Specifically, higher trust can mitigate the negative effects of perceived risk, making the technology seem easier to use despite potential risks. Conversely, lower trust can amplify the negative impact of perceived risk on perceived ease of use.

5 Discussion

Analyzing the theoretical models of BCT acceptance, we found that social trust is widely used when reasoning about, defining, or measuring trust. Social trust factors appear as indicators in 9 out of 21 studies.

Table 4: Trust as a direct Predictor of the BCT Acceptance: Summary

VAR_X **(dependent)**	**Study**
Behavioral intention (BI)	[Jena, 2022] [Gao and Li, 2021] [Yu et al., 2021] [Hannoun et al., 2021] [Liu and Ye, 2021] [Queiroz et al., 2021] [Khazaei, 2020] [Dirsehan, 2020] [Saputra and Darma, 2022] [Gil-Cordero et al., 2020]
Adoption	[Chittipaka et al., 2022]
Attitude towards use	[Kumar et al., 2022] [Albayati et al., 2020]
Perceived usefulness	[Liu and Ye, 2021] [Dirsehan, 2020]
Perceived ease of use	[Albayati et al., 2020] [Saputra and Darma, 2022] [Palos-Sanchez et al., 2021]
Performance expectancy	[Chang et al., 2022]
Perceived privacy	[Palos-Sanchez et al., 2021]

Table 5: Trust as a Mediator and Moderator of the BCT Acceptance: Summary

Role of Trust	VAR_X **(independent)**	VAR_Y **(dependent)**	**Study**
Mediator	Facilitating conditions, Performance expectancy, eWorm, Web quality, Perceived risk, Privacy	BI	[Jena, 2022] [Gil-Cordero et al., 2020] [Shrestha et al., 2021]
	Perceived Security, Perceived Privacy	Attitude	[Kumar et al., 2022] [Shrestha et al., 2021]
Moderator	Performance expectancy, Effort expectency, Social influence, Facilitating conditions, Subjective Knowledge	BI	[Alazab et al., 2021] [Dirsehan, 2020]
	eWorm, Web quality, Perceived risk	User Behavior	[Gil-Cordero et al., 2020]
	Perceived privacy	Attitude	[Shrestha et al., 2021]
	Perceived risk	Perceived ease of use	[Palos-Sanchez et al., 2021]

Abilities of BCT to eliminate the need for a central authority, to ensure transparency and immutability of transactions also frequently used as trust indicators. While many studies focus on technical properties of blockchain and co-notate the acceptance of BCT with perceived security and privacy [Jena, 2022, Kumar et al., 2022, Alazab et al., 2021], they also highlight the important role of benevolence of the service provider or the technology itself [Kumar et al., 2022, Albayati et al., 2020, Dirsehan, 2020]. Integrity and honesty of BCT is also used as a trust indicator [Kumar et al., 2022, Liu and Ye, 2021, Albayati et al., 2020].

Trust in technology, which focuses on technological properties and excludes the factor of benevolence (as technology is considered not to be able to act or not in users' best interests), is used in nine studies. This form of trust serves as a foundational element. The results suggest that before considering blockchain adoption, users must first establish trust in the technology itself. However, once this basic trust is formed, the focus appears to shift toward the digital functionalities and attributes of blockchain, referred to as Digital Trust.

Digital trust, similar to trust in technology but centered on data privacy, security and confidentiality, is used in seven studies. Some studies incorporate multiple trust conceptualizations.

These findings suggest that trust is a multifaceted concept in BCT acceptance models, with different dimensions of trust (social, technological, and digital) playing distinct roles. Understanding these dimensions can enhance the precision of acceptance models and improve the interventions to boost BCT adoption.

Another outcome of our study is the importance of considering BCT independently from BCT solution providers. While BCT is often referred to as a "trust machine", which excludes human factors and social trust, solution providers and software engineers remain crucial social actors. Therefore, trust building between solution providers and users must be examined and taken into account alongside trust in BCT as a technological entity.

According to 13 studies, trust has a direct impact on the behavioral intention, attitude towards use or adoption of BCT. Several studies highlight the effect of trust on perceived usefulness and perceived ease of use. Mediating effect of trust explaining the effect of other variables on BCT acceptance is found in the four studies, while moderating effect is confirmed in the five studies.

There is no general agreement among the studies about mediating or moderating role of trust. For example, according to [Jena, 2022], trust mediates (or explains) the effect of Performance expectancy on behavioral intention to use BCT. In other terms, expected performance leads to trust, which, in its turn, leads to acceptance. However, according to [Alazab et al., 2021], trust only moderates this effect, meaning that the impact of performance expectancy on acceptance does not depend on trust. Along these lines, in [Kumar et al., 2022], trust mediates the effect of perceived privacy on the attitude towards use of BCT, while in [Shrestha et al., 2021] it is considered as a moderator for this effect.

These findings highlight the critical role of trust in the acceptance of BCT, indicating that it, both directly and indirectly, shapes users' attitudes and intentions.

We suggest the following research questions that can be added to the research agendas:
- What are the most effective communication strategies for BCT solution providers to build trust with their users?
- How can organizations measure the level of trust in BCT among their users accurately?
- What role does trust in technology provider play in enhancing trust in BCT?
- What are the long-term impacts of early trust-building efforts on the sustained adoption of BCT?
- How does trust in BCT compare to trust in traditional centralized systems?
- What lessons can be learned from trust-building in other emerging technologies that can be applied to BCT?
- How do users' previous experiences with technology influence their trust in BCT?

Related to Social trust:
- How do various cultural contexts affect social trust in BCT solutions?
- What actions taken by BCT solution providers are most effective in fostering social trust among users?
- How does social trust develop over time with continued use of BCT?

Related to Trust in technology / Digital trust:
- What are the most critical technological features that affect user trust in BCT?
- What are the best practices for ensuring data privacy and confidentiality in BCT to build digital trust?

While our findings identify gaps and provide directions for future research on technology acceptance, the question *"How can we improve trust in emerging technologies, including BCT?"* remains crucial. To incorporate the concept of trust into technology design, a specific type of requirement—trustworthiness requirements—has been defined in the literature [Amaral et al., 2020, Kambilo et al., 2023]. Other studies propose adapting current design practices by explicitly documenting and tracing user trust concerns and trustworthiness requirements, and by clearly justifying the design assumptions [Haley et al., 2004, Wang et al., 2016] behind technical decisions [Mohammadi, 2019, Rambert and Rychkova, 2024]. We believe that understanding the role of trust in technology acceptance is crucial for developing new methods and approaches that support technology trustworthiness by design.

6 Conclusion

In this paper, we conducted a critical review to analyze the role of trust in the acceptance of blockchain technology (BCT). The concept of technology adoption is often used interchangeably with acceptance, but it is important to distinguish between the two. Adoption refers to the actual use and integration of technology into regular practice, while acceptance refers to the user's willingness and intention to use the technology. In the theoretical models, acceptance is often identified with behavioral intention to use and is closely related to attitudes towards use. This distinction is crucial because a user may accept a technology (intend to use it) without fully adopting it (consistently using it in practice). Conversely, a decision to adopt a technology without full acceptance by the prospective users can lead to important issues such as low utilization rates, resistance, and potential abandonment of the technology. Understanding both concepts helps in designing better strategies for promoting both initial acceptance and sustained use of blockchain technology.

We examined 21 scientific publications that de-

fine theoretical BCT acceptance models, most of which extend the well-known Technology Acceptance Model (TAM) [Davis, 1989]. Our analysis focused on how trust is conceptualized, measured and integrated into the proposed models, identifying the types of trust and the roles trust plays in BCT acceptance.

Our findings provide a nuanced understanding of trust's multifaceted role, guiding future research to incorporate various dimensions of trust and refine survey instruments for more accurate measurement. This advances both theoretical development and practical application in the field of technology acceptance.

REFERENCES

Al-Ashmori, A., Basri, S. B., Dominic, P., Capretz, L. F., Muneer, A., Balogun, A. O., Gilal, A. R., and Ali, R. F. (2022). Classifications of sustainable factors in blockchain adoption: a literature review and bibliometric analysis. *Sustainability*, 14(9):5176.

Alazab, M., Alhyari, S., Awajan, A. W., and Abdallah, A. B. (2021). Blockchain technology in supply chain management: an empirical study of the factors affecting user adoption/acceptance. *Cluster Computing*, 24(1):83–101.

Albayati, H., Kim, S., and Rho, J. J. (2020). Accepting financial transactions using blockchain technology and cryptocurrency: A customer perspective approach. *Technology in Society*, 62:101320.

AlShamsi, M., Al-Emran, M., and Shaalan, K. (2022). A systematic review on blockchain adoption. *Applied Sciences*, 12(9):4245.

Amaral, G., Guizzardi, R., Guizzardi, G., and Mylopoulos, J. (2020). Ontology-based modeling and analysis of trustworthiness requirements: Preliminary results. In *International Conference on Conceptual Modeling*, pages 342–352. Springer.

Baker, J. (2012). The technology–organization–environment framework. *Information Systems Theory: Explaining and Predicting Our Digital Society, Vol. 1*, pages 231–245.

Belotti, M., Božić, N., Pujolle, G., and Secci, S. (2019). A vademecum on blockchain technologies: When, which, and how. *IEEE Communications Surveys & Tutorials*, 21(4):3796–3838.

Casino, F., Dasaklis, T. K., and Patsakis, C. (2019). A systematic literature review of blockchain-based applications: Current status, classification and open issues. *Telematics and informatics*, 36:55–81.

Chang, M., Walimuni, A. C., Kim, M., and Lim, H. (2022). Acceptance of tourism blockchain based on utaut and connectivism theory. *Technology in Society*, 71:102027.

Chittipaka, V., Kumar, S., Sivarajah, U., Bowden, J. L., and Baral, M. M. (2022). Blockchain technology for supply chains operating in emerging markets: an empirical examination of technology-organization-environment (toe) framework. *Annals of Operations Research*.

Davis, F. D. (1989). Perceived usefulness, perceived ease of use, and user acceptance of information technology. *MIS quarterly*, pages 319–340.

De Filippi, P., Mannan, M., and Reijers, W. (2020). Blockchain as a confidence machine: The problem of trust & challenges of governance. *Technology in Society*, 62:101284.

Dirsehan, T. (2020). Analysis of a blockchain-based website using the technology acceptance model: the case of save ideas. *International journal of diplomacy and economy*, 6(1):17.

Gambetta, D. et al. (2000). Can we trust trust. *Trust: Making and breaking cooperative relations*, 13(2000):213–237.

Gao, S. and Li, Y. (2021). An empirical study on the adoption of blockchain-based games from users' perspectives. *The Electronic Library*, 39(4):596–614.

Garry, T. and Harwood, T. (2019). Trust and its predictors within a cyber-physical system context. *Journal of Services Marketing*, 33(4):407–428.

Gharib, M., Giorgini, P., and Mylopoulos, J. (2020). An ontology for privacy requirements via a systematic literature review. *Journal on Data Semantics*, 9:123–149.

Gil-Cordero, E., Cabrera-Sánchez, J., and Arrás-Cortés, M. J. (2020). Cryptocurrencies as a financial tool: Acceptance factors. *Mathematics*, 8(11):1974.

Glaser, F. (2017). Pervasive decentralisation of digital infrastructures: a framework for blockchain enabled system and use case analysis.

Goodhue, D. L. and Thompson, R. L. (1995). Task-technology fit and individual performance. *MIS quarterly*, pages 213–236.

Haley, C. B., Laney, R. C., Moffett, J. D., and Nuseibeh, B. (2004). Picking battles: The impact of trust assumptions on the elaboration of security requirements. In *Trust Management: Second International Conference, iTrust 2004, Oxford, UK, March 29-April 1, 2004. Proceedings 2*, pages 347–354. Springer.

Hannoun, F., Carrino, F., Khaled, O. A., Mugellini, E., and Caon, M. (2021). A study on the acceptance towards blockchain-based access to biobanks' services using utaut2 with itm and perceived risk. In *Lecture notes in networks and systems*, pages 271–279. Springer.

Hoffman, D. L., Novak, T. P., and Peralta, M. (1999). Building consumer trust online. *Communications of the ACM*, 42(4):80–85.

Jacovi, A., Marasović, A., Miller, T., and Goldberg, Y. (2021). Formalizing trust in artificial intelligence: Prerequisites, causes and goals of human trust in ai. In *Proceedings of the 2021 ACM conference on fairness, accountability, and transparency*, pages 624–635.

Jena, R. (2022). Examining the factors affecting the adoption of blockchain technology in the banking sector: An extended utaut model. *International Journal of Financial Studies*, 10(4):90.

Kambilo, E. K., Rychkova, I., Herbaut, N., and Souveyet, C. (2023). Addressing trust issues in supply-

chain management systems through blockchain software patterns. In *International Conference on Research Challenges in Information Science*, pages 275–290. Springer.

Kamble, S. S., Gunasekaran, A., and Arha, H. (2019). Understanding the blockchain technology adoption in supply chains-indian context. *International Journal of Production Research*, 57(7):2009–2033.

Khazaei, H. (2020). Integrating cognitive antecedents to utaut model to explain adoption of blockchain technology among malaysian smes. *JOIV: International Journal on Informatics Visualization*, 4.

Kitchenham, B., Pickard, L., and Pfleeger, S. L. (1995). Case studies for method and tool evaluation. *IEEE Softw.*, 12(4):52–62.

Konstantinidis, I., Siaminos, G., Timplalexis, C., Zervas, P., Peristeras, V., and Decker, S. (2018). Blockchain for business applications: A systematic literature review. In *Business Information Systems: 21st International Conference, BIS 2018, Berlin, Germany, July 18-20, 2018, Proceedings 21*, pages 384–399. Springer.

Kumar, N., Singh, M., Upreti, K., and Mohan, D. (2022). Blockchain adoption intention in higher education: Role of trust, perceived security and privacy in technology adoption model. In *Lecture notes in networks and systems*, volume C1. Springer.

Liu, N. and Ye, Z. (2021). Empirical research on the blockchain adoption – based on tam. *Applied Economics*, 53(37):4263–4275.

Marangunić, N. and Granić, A. (2015). Technology acceptance model: a literature review from 1986 to 2013. *Universal access in the information society*, 14:81–95.

Marengo, A. and Pagano, A. (2023). Investigating the factors influencing the adoption of blockchain technology across different countries and industries: a systematic literature review. *Electronics*, 12(14):3006.

Mayer, R. C., Davis, J. H., and Schoorman, F. D. (1995). An integrative model of organizational trust. *Academy of management review*, 20(3):709–734.

Mcknight, D. H., Carter, M., Thatcher, J. B., and Clay, P. F. (2011). Trust in a specific technology: An investigation of its components and measures. *ACM Transactions on management information systems (TMIS)*, 2(2):1–25.

Meeßen, S. M., Thielsch, M. T., and Hertel, G. (2019). Trust in management information systems (mis). *Zeitschrift für Arbeits-und Organisationspsychologie A&O*.

Mohammadi, N. G. (2019). *Trustworthy cyber-physical systems: A systematic framework towards design and evaluation of trust and trustworthiness*. Springer Vieweg, Wiesbaden, Germany, 1 edition.

Murtin, F., Fleischer, L., Siegerink, V., Aassve, A., Algan, Y., Boarini, R., González, S., Lonti, Z., Grimalda, G., Vallve, R. H., et al. (2018). Trust and its determinants: Evidence from the trustlab experiment.

Norbu, T., Park, J. Y., Wong, K. W., and Cui, H. (2024). Factors affecting trust and acceptance for blockchain adoption in digital payment systems: A systematic review. *Future Internet*, 16(3):106.

Palos-Sanchez, P. R., Saura, J., and Ayestaran, R. (2021). An exploratory approach to the adoption process of bitcoin by business executives. *Mathematics*, 9(4):355.

Pietrzak, P. and Takala, J. (2021). Digital trust - a systematic literature review.

Queiroz, M. M., Wamba, S. F., De Bourmont, M., and Telles, R. (2021). Blockchain adoption in operations and supply chain management: empirical evidence from an emerging economy. *International Journal of Production Research*, 59(20):6087–6103.

Rambert, P. and Rychkova, I. (2024). Implications of trust in cyber-physical systems design: the assa case study. In *Enterprise Design, Operations, and Computing – 28th International Conference, EDOC 2024, Vienna, Austria, September 10 - 13, 2024*, volume 15409. Springer.

Rijanto, A. (2021). Blockchain technology adoption in supply chain finance. *Journal of Theoretical and Applied Electronic Commerce Research*, 16(7):3078–3098.

Rousseau, D. M., Sitkin, S. B., Burt, R. S., and Camerer, C. (1998). Not so different after all: A cross-discipline view of trust. *Academy of management review*, 23(3):393–404.

Rychkova, I. and Ghriba, M. (2023). Trustworthiness requirements in information systems design: Lessons learned from the blockchain community. *Complex Systems Informatics and Modeling Quarterly*, (35):67–91.

Saputra, U. R. and Darma, G. S. (2022). The intention to use blockchain in indonesia using extended approach technology acceptance model (tam). *Commit Journal*, 16(1):27–35.

Sciarelli, M., Prisco, A., Gheith, M., and Muto, V. (2021). Factors affecting the adoption of blockchain technology in innovative italian companies: an extended tam approach. *Journal of Strategy and Management*.

Shin, D.-H. (2019). Blockchain: The emerging technology of trust the role of trust in the acceptance of blockchain. *Telematics and Informatics*, page 101278.

Shrestha, A. K., Vassileva, J., Joshi, S., and Just, J. (2021). Augmenting the technology acceptance model with trust model for the initial adoption of a blockchain-based system. *PeerJ. Computer science*, 7:e502.

Söllner, M., Hoffmann, A., Hoffmann, H., Wacker, A., and Leimeister, J. M. (2012). Understanding the formation of trust in it artifacts.

Taherdoost, H. (2022). A critical review of blockchain acceptance models - blockchain technology adoption frameworks and applications. *Comput.*, 11:24.

Taufiq, R., Hidayanto, A. N., Prabowo, H., et al. (2018). The affecting factors of blockchain technology adoption of payments systems in indonesia banking industry. In *2018 International Conference on Information Management and Technology (ICIMTech)*, pages 506–510. IEEE.

Ullah, N., Al-rahmi, W. M., and Alkhalifah, A. (2021). Predictors for distributed ledger technology adoption: integrating three traditional adoption theories for manu-

facturing and service operations. *Production Manufacturing Research*, 9(1):178–205.

Venkatesh, V. and Davis, F. D. (2000). A theoretical extension of the technology acceptance model: Four longitudinal field studies. *Management science*, 46(2):186–204.

Venkatesh, V., Morris, M. G., Davis, G. B., and Davis, F. D. (2003). User acceptance of information technology: Toward a unified view. *MIS quarterly*, pages 425–478.

Wang, X., Mylopoulos, J., Guizzardi, G., and Guarino, N. (2016). How software changes the world: The role of assumptions. In *2016 IEEE Tenth International Conference on Research Challenges in Information Science (RCIS)*, pages 1–12. IEEE.

Yu, C., Prabhu, M., Goli, M., and Sahu, A. K. (2021). Factors affecting the adoption of blockchain technology in the complex industrial systems: Data modeling. *Complexity*, 2021:1–10.