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Blockchain-Based Accounting Transparency and Audit Quality: The Mediating Role of Transaction Traceability

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ABSTRACT
The blockchain technology is expected to change the way in which the accounting transactions are recorded and verified, however, the transparency of the blockchain alone does not guarantee a better audit. Accordingly, the current study examines the effect of the blockchain-based accounting transparency on the audit quality, and it examines the mediating role of the transaction traceability in this relationship, based on the agency theory. A quantitative, cross-sectional survey design was adopted, and the data were collected from 316 accountants, internal auditors, external auditors, and financial managers in Jordan who have a direct involvement with the blockchain applications. The data were analyzed by using the partial least squares structural equation modelling (PLS-SEM) in SmartPLS 4. The results showed that the measurement model is reliable and valid. Moreover, the blockchain-based accounting transparency has a positive and significant effect on the transaction traceability ($\beta = 0.678$, $p < .001$), and the transaction traceability has a positive and significant effect on the audit quality ($\beta = 0.604$, $p < .001$). Furthermore, the transaction traceability mediates the relationship between the blockchain-based accounting transparency and the audit quality (indirect effect = 0.409, 95% CI 0.346, 0.472). The model explains 45.9% of the variance in the transaction traceability and 36.5% of the variance in the audit quality, and the model has a predictive relevance for the both constructs. Based on these results, the benefit of the blockchain for the audit depends on the ability of the auditors to trace the transactions, and therefore the audit firms, the organizations that adopt the blockchain, and the regulators in Jordan should give a special attention to the traceability features of the blockchain systems.

JEL Classification: M15; M41; O33; C83

1. Introduction

The blockchain technology is a distributed ledger in which the transactions are recorded in blocks that are time-stamped, linked cryptographically, and shared among the participants of the network. Accordingly, the accounting researchers argued that the blockchain may change the way in which the transactions are recorded and verified, and it may also change the way in which the financial information is assured by the

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auditors (Dai & Vasarhelyi, 2017; Coyne & McMickle, 2017). In addition, it was suggested that the shared and tamper-evident ledger may reduce the ability of the managers to manipulate the records after the fact, and this is considered an important issue for the corporate governance and the external stakeholders (Yermack, 2017). Moreover, the main promise of the blockchain for the accounting is the transparency, where the accounting information becomes more accessible, more clear, and more verifiable for the authorized users. However, it should be noted that the transparency alone does not guarantee a better audit. The auditor needs to follow the transaction from its source to its final recording, and the auditor needs to verify the history of the changes in the record, before the auditor can rely on the record as an audit evidence (Rozario & Thomas, 2019; Schmitz & Leoni, 2019). In other words, the value of the blockchain transparency for the audit depends on the transaction traceability, which is the ability to trace the origin, the path, and the recording history of each transaction. On the other hand, some researchers warned from the assumption that the blockchain can solve the accounting problems by itself, because the events that occur outside the chain still require a professional judgment (Coyne & McMickle, 2017).

Regarding the empirical evidence, the previous studies on the blockchain in the accounting and the auditing are dominated by the conceptual papers, the case studies, and the literature reviews (Casino et al., 2019; Schmitz & Leoni, 2019; Han et al., 2023). Therefore, there is a limited number of researches that test the relationship between the blockchain transparency and the audit quality by using the data from the professionals who actually work with the blockchain applications. Furthermore, the previous studies usually examine the direct relationship between the technology and the outcome, and they give a limited attention to the mechanism through which the technology affects the audit quality. In addition, the evidence is concentrated in the developed countries, and the developing markets such as Jordan received less attention, although these markets face a different condition regarding the digital infrastructure, the regulation, and the professional skills. Based on the above, the current study aims to examine the relationship between the blockchain-based accounting transparency and the audit quality, and to examine the mediating role of the transaction traceability in this relationship. Accordingly, the study seeks to answer the following questions: (1) Does the blockchain-based accounting transparency affect the transaction traceability? (2) Does the transaction traceability affect the audit quality? (3) Does the transaction traceability mediate the relationship between the blockchain-based accounting transparency and the audit quality?

This study contributes to the literature in several ways. First, the study provides an empirical evidence from 316 professionals in Jordan who have a direct involvement with blockchain applications, and this responds to the calls for more empirical researches in this area (Schmitz & Leoni, 2019; Han et al., 2023). Second, the study specifies the transaction traceability as the mechanism that links the blockchain transparency with the audit quality, and this helps to explain how the benefit of the technology is transferred to the audit. Third, the study provides a practical guidance for the audit firms, the internal audit functions, and the regulators regarding the features of the blockchain systems that are most related with the audit quality. The remainder of the paper is organized as follows. Section 2 reviews the literature and develops the hypotheses. Section 3 describes the methodology. Section 4 presents the results of the analysis. Section 5 discusses the findings, and Section 6 presents the implications. Finally, Section 7 presents the limitations and the directions for future research, and Section 8 concludes the study.

2. Literature Review and Hypotheses Development

2.1 Theoretical background

The current study is based on the agency theory, which explains that the separation between the ownership and the management creates an information asymmetry between the principals and the agents (Jensen & Meckling, 1976). In this context, the audit is considered a monitoring mechanism that reduces the information asymmetry, and it increases the credibility of the financial information that is provided by the managers. Moreover, the audit quality is commonly defined as the joint probability that the auditor will discover a material misstatement and will report this misstatement (DeAngelo, 1981). Furthermore, Francis (2011) and Knechel et al. (2013) explained that the audit quality depends on the inputs, the processes, and

the outputs of the audit, and the quality of the audit evidence is considered one of the most important inputs of the audit. Accordingly, the blockchain can be viewed as an information infrastructure that affects the information asymmetry between the parties. When the transactions are recorded in a shared and time-stamped ledger, the information becomes more available for the auditors, and the cost of verifying this information is reduced (Dai & Vasarhelyi, 2017; Yermack, 2017). However, the reduction of the information asymmetry depends on whether the auditors can follow and verify the recorded transactions, and this is the role of the transaction traceability in the current model.

2.2 Blockchain-based accounting transparency

The blockchain-based accounting transparency refers to the perceived accessibility, clarity, and verifiability of the accounting information that is supported by the blockchain systems. The previous literature positioned the blockchain in the accounting as a socio-technical capability rather than a stand-alone application (Dai & Vasarhelyi, 2017; Coyne & McMickle, 2017; Kokina et al., 2017; Schmitz & Leoni, 2019; Rozario & Thomas, 2019). In other words, the value of the blockchain depends on the complementary routines, the data governance, and the interpretation of the users, and the adoption alone may produce an activity without a better outcome. Therefore, the transparency in the current study is measured as a capability that is experienced by the professionals, and it is not measured as the presence of the technology only. In addition, the adoption studies showed that the technological capability is accumulated through the organizational readiness, the support of the leadership, the skills, the redesign of the processes, and the institutional pressure (Wang, Han, & Beynon-Davies, 2019; Zhang et al., 2020; Toufaily et al., 2021; Aste et al., 2017). These factors explain why the similar systems generate a different results across the organizations. Moreover, the governance research added an important qualification, where the blockchain may improve the consistency of the records, but it may also create a privacy exposure and an accountability gaps if the governance of the network is weak (Beck et al., 2018; Lumineau et al., 2021; De Filippi & Wright, 2018).

2.3 Transaction traceability

The transaction traceability refers to the ability to follow the transactions and to verify their origins and their recording histories. The concept of the traceability was developed mainly in the supply chain literature, where the blockchain was used to track the products from the producer to the consumer (Tian, 2017; Saberi et al., 2019; Queiroz et al., 2020; Treiblmaier, 2018). Moreover, the information sharing on the blockchain allows the different parties to access the same record of the transaction, and this reduces the need for the reconciliation between the separate records (Nakasumi, 2017; Wang, Han, & Beynon-Davies, 2019). Regarding the accounting, O'Leary (2017) and Wang and Kogan (2018) explained that the blockchain-based transaction processing systems can keep a complete and verifiable history for each transaction, while the confidentiality of the sensitive information is protected. Furthermore, the cryptographic linking of the blocks makes the unauthorized change of a record detectable (Kshetri, 2017; Zheng et al., 2018), and the smart contracts can record the conditions under which a transaction was executed (Gatteschi et al., 2018). Therefore, the transaction traceability can be considered the process through which the technical transparency of the blockchain is converted into a specific information that is useful for the auditor.

2.4 Audit quality in the blockchain environment

The audit quality in the current study is operationalized as the assessment of the respondents for the quality of the audit evidence and the reliability of the audit conclusions. The previous studies suggested that the blockchain can change the nature of the audit evidence, because the auditors can access the transaction data directly and continuously, instead of depending on the samples and the documents that are provided by the management (Rozario & Thomas, 2019; Appelbaum & Nehmer, 2020). In addition, Sheldon (2019) explained that the auditors still need to evaluate the general controls of the information technology in the blockchain environment, such as the access controls and the management of the changes, before relying on the blockchain records. On the other side, the literature also highlighted the challenges of the blockchain for the audit. The blockchain can confirm that a transaction was recorded, but it cannot confirm that the

transaction reflects a real economic event, and this means that the professional judgment of the auditor remains necessary (Coyne & McMickle, 2017; Schmitz & Leoni, 2019). Moreover, the changes in the work of the accountants and the auditors because of the digital technologies require new skills and new audit approaches (Moll & Yigitbasioglu, 2019; Han et al., 2023).

2.5 Hypotheses development

2.5.1 Blockchain-based accounting transparency and transaction traceability

The blockchain records each transaction with a time stamp and a cryptographic link to the previous records, and these records are shared among the authorized participants (Dai & Vasarhelyi, 2017; Risius & Spohrer, 2017). Accordingly, when the accounting information is more accessible, more clear, and more verifiable, the users can follow the transaction more easily from its origin to its final recording. In addition, the supply chain studies showed that the transparency of the shared ledger is the basis for the tracking of the products and the transactions (Saberi et al., 2019; Treiblmaier, 2018; Queiroz et al., 2020). Therefore, it is expected that the higher level of the blockchain-based accounting transparency is associated with a higher level of the transaction traceability. Based on the above, the following hypothesis is proposed:

H1: The blockchain-based accounting transparency has a positive and significant effect on the transaction traceability.

2.5.2 Transaction traceability and audit quality

The audit evidence is considered more reliable when the auditor can verify its source and its history (Francis, 2011; Knechel et al., 2013). In this context, the transaction traceability allows the auditor to follow the transaction through its whole life cycle, and to detect any unauthorized change in the record (Kshetri, 2017; Rozario & Thomas, 2019). Moreover, the traceable records support the continuous audit and the testing of the full population of the transactions instead of the samples (Appelbaum & Nehmer, 2020). Therefore, it is expected that the higher level of the transaction traceability is associated with a higher quality of the audit evidence and more reliable audit conclusions. Accordingly, the following hypothesis is proposed:

H2: The transaction traceability has a positive and significant effect on the audit quality.

2.5.3 The mediating role of transaction traceability

Based on the argument that the transparency does not improve the audit by itself, the current study proposes that the effect of the blockchain-based accounting transparency on the audit quality is transferred through the transaction traceability. In other words, the transparency makes the information available, and the traceability makes this information verifiable for the auditor, and it is the verifiable information that improves the audit evidence (Rozario & Thomas, 2019; Schmitz & Leoni, 2019). Moreover, the previous studies suggested that the digital systems first improve the visibility of the information, and then this visibility enhances the quality of the decisions and the outcomes (Beck et al., 2018; Iansiti & Lakhani, 2017). Therefore, the transaction traceability is proposed as the mechanism that links the blockchain-based accounting transparency with the audit quality. Accordingly, the following hypothesis is proposed:

H3: The transaction traceability mediates the relationship between the blockchain-based accounting transparency and the audit quality.

2.6 Research gap and conceptual model

Although the previous studies examined the blockchain technology, the traceability, and the audit quality, the literature is still fragmented regarding the relationship between these three variables. First, many studies are conceptual or review studies, and there is a limited empirical evidence that is based on the professionals who actually use the blockchain applications (Casino et al., 2019; Han et al., 2023). Second, the previous studies usually model the direct effect of the technology on the outcome, and they provide a limited evidence about the mechanism that is represented by the transaction traceability. Third, the evidence is concentrated in particular countries and sectors, and the developing markets such as Jordan are under-represented, which limits the generalization of the previous findings. Accordingly, the current study integrates the three

variables in one model, and it tests the indirect effect of the blockchain-based accounting transparency on the audit quality through the transaction traceability. The conceptual model of the study is presented in Figure 1.

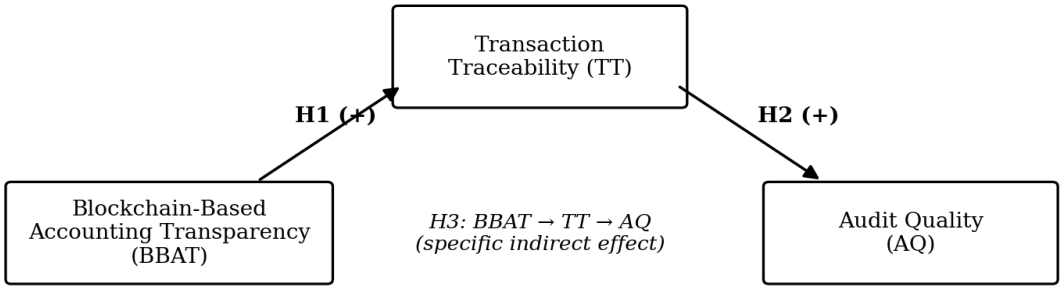


Figure 1. *Conceptual model of the study*

Note. BBAT = blockchain-based accounting transparency; TT = transaction traceability; AQ = audit quality. The solid arrows represent the direct paths that were estimated in the structural model, and H3 refers to the specific indirect effect of BBAT on AQ through TT.

3. Research Methodology

3.1 Research design and setting

The current study adopted a quantitative, cross-sectional survey design in order to examine the relationship between the blockchain-based accounting transparency and the audit quality, with the transaction traceability as a mediating variable. The research setting is Jordan, and the target population consists from the accountants, the internal auditors, the external auditors, and the financial managers who have a practical experience of the blockchain applications in the accounting or the auditing. The individual professional was used as the unit of analysis, and therefore the findings represent the perceptions of the respondents regarding the organizational practices that they assess.

3.2 Sampling and sample size

A purposive sampling technique was used in order to recruit the participants who can provide an informed assessment of the study constructs. The eligibility required at least one year of relevant professional experience and a direct involvement in an operational blockchain application or a pilot project. Screening questions were placed at the beginning of the questionnaire to confirm the eligibility and the relevant experience of the respondents before they complete the substantive part of the questionnaire. The data were collected over a period of three months through the participating organizations and the professional networks.

The recruitment target was set at 300 valid responses, and at the end of the data collection period a total of 316 valid responses were retained for the analysis. The adequacy of the sample was evaluated by an a priori power analysis by using G-Power 3.1 (Faul et al., 2009). By assuming a medium effect size ($f^2 = 0.15$), a significance level of 0.05, a statistical power of 0.80, and a maximum of two predictors for any endogenous construct, the minimum required sample size is 68 respondents. Accordingly, the final sample of 316 respondents exceeds the minimum requirement by a large margin, and it is considered adequate for the PLS-SEM analysis (Hair et al., 2022).

3.3 Measurement of the variables

The questionnaire contains two parts. The first part includes the demographic and the professional questions, and the second part includes 21 measurement items. The blockchain-based accounting transparency was measured by eight items (BBAT1–BBAT8), the transaction traceability was measured by eight items (TT1–TT8), and the audit quality was measured by five items (AQ1–AQ5). All the items were measured on a five-point Likert scale ranging from 1 (strongly disagree) to 5 (strongly agree). The wording

of the items was developed from the relevant literature of the accounting, the auditing, and the blockchain, and the source and the adaptation of each item were documented. The structure of the measurement is summarized in Table 1.

Table 1. Constructs, roles, and measurement items

Construct	Code	Role in the model	Items	Operational definition
Blockchain-based accounting transparency	BBAT	Independent	BBAT1–BBAT8 (8)	Perceived accessibility, clarity, and verifiability of the accounting information supported by blockchain systems
Transaction traceability	TT	Mediator	TT1–TT8 (8)	Ability to follow the transactions and to verify their origins and recording histories
Audit quality	AQ	Dependent	AQ1–AQ5 (5)	Assessment of the quality of the audit evidence and the reliability of the audit conclusions

Note. All three constructs were specified as reflective, and the total number of the indicators is 21.

3.4 Content validity, translation, and pilot study

The questionnaire was reviewed by three specialists in the accounting, the auditing, and the research methods, and they evaluated the relevance, the clarity, and the coverage of the items. Moreover, the questionnaire was prepared in Arabic and English versions by using the translation and back-translation procedure (Brislin, 1970). After that, a pilot study was conducted with 30 eligible professionals in order to assess the comprehension of the items, the time of completion, and the preliminary performance of the measurement. It should be noted that the responses of the pilot study were excluded from the main analysis. Furthermore, the participation was voluntary, the informed consent was obtained from all the participants, and the confidentiality of the responses was assured.

3.5 Data screening and common method bias

Before the estimation of the model, the dataset was examined for the duplicate submissions, the missing responses, the ineligible cases, and the evidence of the inattentive responding. The exclusion rules were specified before the testing of the hypotheses, and the unusual observations were investigated for the recording errors rather than being removed only because they weaken the hypothesized relationships. After the screening, 316 valid responses were retained.

Since the data of the independent, the mediating, and the dependent variables were collected from the same respondents at the same time, the common method bias was considered. Regarding the procedural remedies, the questionnaire used a neutral wording, the anonymity and the confidentiality of the responses were assured, and the constructs were placed in separate sections of the questionnaire (Podsakoff et al., 2003). Regarding the statistical remedies, the full collinearity assessment approach was used (Kock, 2015), and the results are reported in Section 4.2.

3.6 Data analysis technique

The data were analyzed by using the partial least squares structural equation modelling (PLS-SEM) in SmartPLS 4 (Ringle et al., 2024). The PLS-SEM was selected because the study aims to explain and to predict the variance in the endogenous constructs, and because the PLS-SEM does not require the assumption of the multivariate normality (Hair et al., 2019). The analysis was conducted in two stages. In the first stage, the measurement model was assessed through the outer loadings, the Cronbach's alpha, the composite reliability (rho_A and rho_C), and the average variance extracted (AVE). The loadings and the reliability

coefficients of at least 0.70 and the AVE values of at least 0.50 were used as criteria (Hair et al., 2022). Moreover, the discriminant validity was assessed mainly by the heterotrait-monotrait ratio (HTMT) with the conservative threshold of 0.85 (Henseler et al., 2015), and the Fornell–Larcker criterion was used as a supplementary evidence (Fornell & Larcker, 1981).

In the second stage, the structural model was assessed. Consistent with the theoretical argument that the blockchain transparency affects the audit quality through the traceable audit trail, the structural model specified two direct paths (BBAT → TT and TT → AQ), and the effect of BBAT on AQ was modeled as an effect that is transmitted through TT. The collinearity between the predictors was examined by the variance inflation factor (VIF), and the explanatory power was assessed through the standardized path coefficients, the coefficient of determination (R^2), the adjusted R^2, and the effect size (f^2) (Cohen, 1988; Hair et al., 2019). The significance of the path coefficients was tested by the bootstrapping procedure with 10,000 resamples, by using two-tailed tests and a significance level of 5%, and the 95% confidence intervals were computed from the bootstrap standard errors. An effect was considered significant when its confidence interval does not include zero.

The mediating role of the transaction traceability was evaluated through the specific indirect effect of the blockchain-based accounting transparency on the audit quality through the transaction traceability, where the indirect effect was bootstrapped in the same procedure (Preacher & Hayes, 2008; Zhao et al., 2010; Nitzl et al., 2016). Finally, the predictive performance of the model was evaluated by the PLSpredict procedure with ten folds and ten repetitions, where the Q^2predict, the root mean squared error (RMSE), and the mean absolute error (MAE) were reported (Shmueli et al., 2019).

4. Results

This section presents the results of the analysis in two main stages. The first stage presents the assessment of the measurement model, which includes the indicator reliability, the internal consistency reliability, the convergent validity, and the discriminant validity. The second stage presents the assessment of the structural model, which includes the collinearity, the explanatory power, the predictive relevance, the testing of the direct hypotheses, and the testing of the mediation. In addition, the assessment of the common method bias is presented between the two stages.

4.1 Assessment of the measurement model

The measurement model was estimated by the PLS algorithm, and the results of the estimation are presented in Figure 2. The figure shows the outer loadings of the 21 indicators on their constructs, the path coefficients between the constructs, and the R^2 values of the two endogenous constructs.

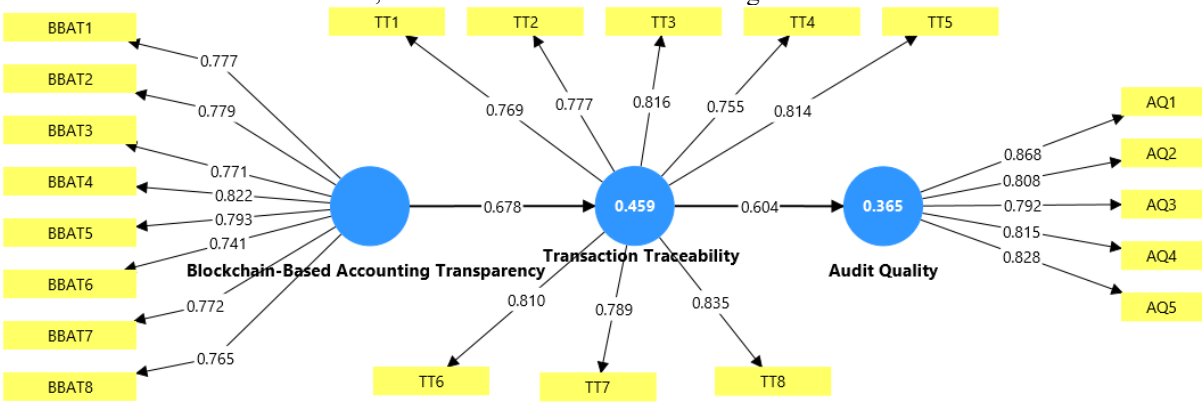


Figure 2. Results of the PLS algorithm for the measurement model

Note. The values on the arrows between the constructs and the indicators are the outer loadings, the values on the arrows between the constructs are the standardized path coefficients, and the values inside the circles are the R^2 values of the endogenous constructs.

4.1.1 Indicator reliability

The indicator reliability was assessed through the outer loadings of the indicators on their constructs. As shown in Table 2, all the outer loadings exceed the recommended threshold of 0.70, and all of them are significant at $p < .001$.

Table 2. Outer loadings and indicator reliability

Construct	Indicator	Loading (λ)	Indicator reliability (λ^2)	p value
BBAT	BBAT1	0.777	0.604	< .001
	BBAT2	0.779	0.607	< .001
	BBAT3	0.771	0.594	< .001
	BBAT4	0.822	0.676	< .001
	BBAT5	0.793	0.629	< .001
	BBAT6	0.741	0.549	< .001
	BBAT7	0.772	0.596	< .001
	BBAT8	0.765	0.585	< .001
TT	TT1	0.769	0.591	< .001
	TT2	0.777	0.604	< .001
	TT3	0.816	0.666	< .001
	TT4	0.755	0.570	< .001
	TT5	0.814	0.663	< .001
	TT6	0.810	0.656	< .001
	TT7	0.789	0.623	< .001
	TT8	0.835	0.697	< .001
AQ	AQ1	0.868	0.753	< .001
	AQ2	0.808	0.653	< .001
	AQ3	0.792	0.627	< .001
	AQ4	0.815	0.664	< .001
	AQ5	0.828	0.686	< .001

Note. BBAT = blockchain-based accounting transparency; TT = transaction traceability; AQ = audit quality. The threshold for the loadings is 0.70 (Hair et al., 2022). The p values were obtained from the bootstrapping procedure.

The results in Table 2 show that the loadings of the blockchain-based accounting transparency range from 0.741 (BBAT6) to 0.822 (BBAT4), the loadings of the transaction traceability range from 0.755 (TT4) to 0.835 (TT8), and the loadings of the audit quality range from 0.792 (AQ3) to 0.868 (AQ1). Accordingly, the indicator reliability (λ^2) of all the items is higher than 0.50, and this means that each construct explains more than half of the variance of each of its indicators. Therefore, all the 21 indicators were retained in the model, and no item was deleted. It is worth mentioning that the highest loading was found for AQ1, and this indicates that the first item of the audit quality is the strongest reflection of the construct in the perception of the respondents.

4.1.2 Internal consistency reliability and convergent validity

The internal consistency reliability was assessed by the Cronbach's alpha and the composite reliability (rho_A and rho_C), while the convergent validity was assessed by the average variance extracted (AVE). The results are presented in Table 3.

Table 3. Internal consistency reliability and convergent validity

Construct	Cronbach's alpha	rho_A	rho_C	AVE	Loading range
Blockchain-based accounting transparency	0.907	0.908	0.925	0.605	0.741–0.822
Transaction traceability	0.917	0.919	0.932	0.633	0.755–0.835
Audit quality	0.880	0.883	0.913	0.676	0.792–0.868

Note. rho_A and rho_C = composite reliability; AVE = average variance extracted. The criteria are alpha, rho_A, and rho_C ≥ 0.70 and AVE ≥ 0.50 (Hair et al., 2022).

As shown in Table 3, the values of the Cronbach's alpha range from 0.880 for the audit quality to 0.917 for the transaction traceability, and the values of the composite reliability (rho_A) range from 0.883 to 0.919. Moreover, the values of the composite reliability (rho_C) range from 0.913 to 0.932. Therefore, all the reliability values exceed the threshold of 0.70, and they are also below the level of 0.95, which means that the items are not redundant (Hair et al., 2019). Regarding the convergent validity, the AVE values are 0.605 for the blockchain-based accounting transparency, 0.633 for the transaction traceability, and 0.676 for the audit quality, and all of these values exceed the threshold of 0.50. In other words, each construct explains between 60.5% and 67.6% of the variance of its indicators. Accordingly, it can be concluded that the measurement model has an adequate internal consistency reliability and an adequate convergent validity.

4.1.3 Discriminant validity

The discriminant validity refers to the degree to which a construct is empirically distinct from the other constructs in the model. In the current study, the discriminant validity was assessed by the Fornell–Larcker criterion and by the HTMT ratio. The results of the Fornell–Larcker criterion are presented in Table 4.

Table 4. Discriminant validity: Fornell–Larcker criterion

Construct	BBAT	TT	AQ
Blockchain-based accounting transparency (BBAT)	0.778		
Transaction traceability (TT)	0.678	0.796	
Audit quality (AQ)	0.553	0.604	0.822

Note. The diagonal values are the square roots of the AVE, and the off-diagonal values are the correlations between the constructs.

According to the Fornell–Larcker criterion, the square root of the AVE for each construct should be higher than its correlations with the other constructs (Fornell & Larcker, 1981). As shown in Table 4, the square root of the AVE for the blockchain-based accounting transparency (0.778) is higher than its correlations with the transaction traceability (0.678) and the audit quality (0.553). Similarly, the square root of the AVE for the transaction traceability (0.796) is higher than its correlations with the blockchain-based accounting transparency (0.678) and the audit quality (0.604), and the square root of the AVE for the audit quality (0.822) is higher than its correlations with the other two constructs. Therefore, the Fornell–Larcker criterion is satisfied. However, since Henseler et al. (2015) showed that the Fornell–Larcker criterion may

fail to detect the lack of the discriminant validity, the HTMT ratio was also examined, and the results are presented in Table 5.

Table 5. Discriminant validity: Heterotrait-monotrait ratio (HTMT)

Construct pair	HTMT	Threshold	Decision
BBAT ↔ TT	0.739	< 0.85	Established
BBAT ↔ AQ	0.617	< 0.85	Established
TT ↔ AQ	0.671	< 0.85	Established

Note. BBAT = blockchain-based accounting transparency; TT = transaction traceability; AQ = audit quality. The conservative threshold of 0.85 was applied (Henseler et al., 2015).

The results in Table 5 show that all the HTMT values are below the conservative threshold of 0.85. The highest HTMT value is 0.739 between the blockchain-based accounting transparency and the transaction traceability, and this relatively higher value is expected, since the two constructs are theoretically related, where the transparency is proposed as the antecedent of the traceability. Nevertheless, this value is still below the threshold, and this means that the respondents distinguished between the transparency of the accounting information and the ability to trace the transactions. Moreover, the HTMT values between the audit quality and the other two constructs are 0.617 and 0.671. Accordingly, the discriminant validity is established for all the constructs, and it can be concluded that the measurement model is reliable and valid, and it is suitable for the assessment of the structural model.

4.2 Common method bias

In order to examine the common method bias statistically, the full collinearity assessment approach was applied (Kock, 2015). In this approach, each latent variable is regressed on all the other latent variables, and a VIF value higher than 3.3 is considered an indication of the pathological collinearity and the possible contamination by the common method bias. The results are presented in Table 6.

Table 6. Full collinearity assessment for common method bias

Construct	Full collinearity VIF	Threshold	Decision
Blockchain-based accounting transparency	1.969	< 3.3	No concern
Transaction traceability	2.152	< 3.3	No concern
Audit quality	1.675	< 3.3	No concern

Note. The full collinearity VIF values were computed from the latent variable correlations reported in Table 4, where each construct was regressed on the other two constructs (Kock, 2015).

As shown in Table 6, the full collinearity VIF values range from 1.675 for the audit quality to 2.152 for the transaction traceability, and all the values are below the threshold of 3.3. In addition, the highest correlation between the constructs is 0.678 (Table 4), which is well below the value of 0.90 that indicates a serious common method bias (Bagozzi et al., 1991). Therefore, together with the procedural remedies that were applied in the design of the questionnaire, the results suggest that the common method bias is not a serious problem in the current study.

4.3 Assessment of the structural model

4.3.1 Collinearity, explanatory power, and effect size

Before the testing of the hypotheses, the structural model was examined for the collinearity between the predictors, and then the explanatory power of the model was assessed by the R^2 and the adjusted R^2, while the contribution of each predictor was assessed by the f^2 effect size. The results are presented in Table 7.

Table 7. Collinearity, coefficient of determination, and effect size

Endogenous construct	Predictor	Inner VIF	R^2	Adjusted R^2	f^2	Effect size
Transaction traceability	BBAT	1.000	0.459	0.458	0.849	Large
Audit quality	TT	1.000	0.365	0.363	0.574	Large

Note. The inner VIF equals 1.000 because each endogenous construct has one predictor in the estimated model. The f^2 thresholds are 0.02 (small), 0.15 (medium), and 0.35 (large) (Cohen, 1988).

Regarding the collinearity, each endogenous construct in the estimated model has one predictor only, and therefore the inner VIF values equal 1.000, which means that there is no collinearity problem in the structural model. Regarding the explanatory power, the results in Table 7 show that the blockchain-based accounting transparency explains 45.9% of the variance in the transaction traceability ($R^2 = 0.459$; adjusted $R^2 = 0.458$), and the transaction traceability explains 36.5% of the variance in the audit quality ($R^2 = 0.365$; adjusted $R^2 = 0.363$). According to Chin (1998), the R^2 values of 0.19, 0.33, and 0.67 are considered weak, moderate, and substantial respectively, and therefore both R^2 values in the current model are considered moderate. It is worth mentioning that the small difference between the R^2 and the adjusted R^2 indicates that the explanatory power of the model is not inflated.

Furthermore, the f^2 effect size of the blockchain-based accounting transparency on the transaction traceability is 0.849, and the f^2 effect size of the transaction traceability on the audit quality is 0.574. According to Cohen (1988), both values exceed the threshold of 0.35, and therefore both effects are considered large. In other words, the removal of any of the two predictors from the model would reduce the explained variance of its endogenous construct in a substantial way. On the other hand, it should be noted that 54.1% of the variance in the transaction traceability and 63.5% of the variance in the audit quality are still unexplained, and this indicates that there are other factors that affect the two constructs, which are not included in the current model.

4.3.2 Predictive relevance

In addition to the in-sample explanatory power, the out-of-sample predictive power of the model was assessed by the PLSpredict procedure (Shmueli et al., 2019). The results are presented in Table 8.

Table 8. Predictive relevance of the model (PLSpredict)

Endogenous construct	Q^2predict	RMSE	MAE	Decision
Transaction traceability	0.455	0.743	0.588	Predictive relevance
Audit quality	0.284	0.850	0.699	Predictive relevance

Note. RMSE = root mean squared error; MAE = mean absolute error. The values are reported at the construct level. A Q^2predict value higher than zero indicates that the model outperforms the naive mean benchmark.

The results in Table 8 show that the Q^2predict value is 0.455 for the transaction traceability and 0.284 for the audit quality. Since both values are higher than zero, the model has a predictive relevance for the two endogenous constructs, and it predicts the values of the constructs better than the mean of the training sample. Moreover, the prediction errors of the transaction traceability (RMSE = 0.743; MAE = 0.588) are

lower than the prediction errors of the audit quality (RMSE = 0.850; MAE = 0.699). This result is consistent with the R^2 values, since the audit quality is more distant from the blockchain-based accounting transparency in the causal chain, and it is also affected by other factors outside the model. Therefore, it can be concluded that the model has a good predictive relevance, and this predictive relevance is stronger for the transaction traceability than for the audit quality.

4.3.3 Testing of the direct hypotheses

The significance of the path coefficients was tested by the bootstrapping procedure, and the results of the bootstrapping are presented in Figure 3 and in Table 9.

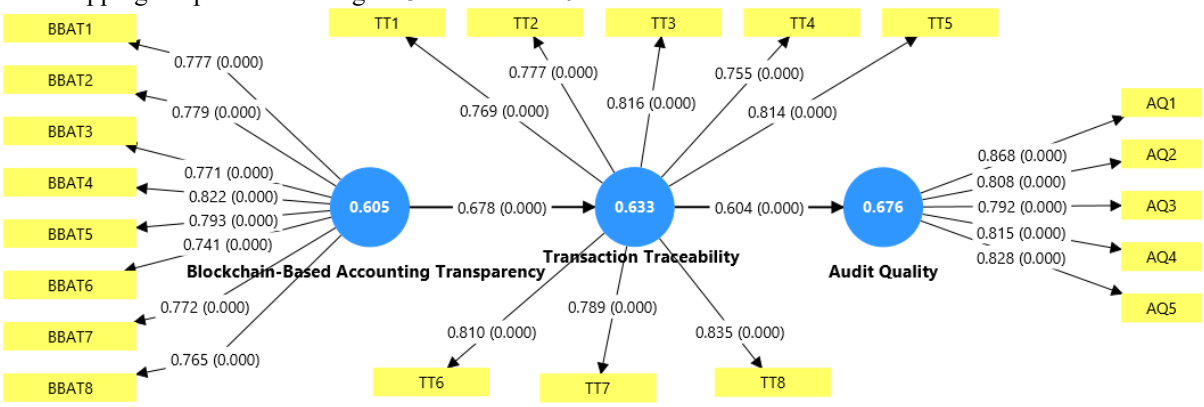


Figure 3. Results of the bootstrapping procedure for the structural model

Note. The values on the arrows are the path coefficients and the outer loadings, with the p values in parentheses. The p values that are shown as 0.000 are reported as $p < .001$ in the text and the tables. The values inside the circles are the AVE values of the constructs.

Table 9. Results of the direct hypotheses testing

Hyp.	Path	β	M	SE	t value	p value	95% CI	Decision
H1	BBAT → TT	0.678	0.679	0.026	25.587	< .001	0.627, 0.729	Supported
H2	TT → AQ	0.604	0.606	0.033	18.308	< .001	0.539, 0.669	Supported

Note. β = standardized path coefficient (original sample); M = bootstrap sample mean; SE = bootstrap standard error; CI = confidence interval, computed as β ± 1.96 × SE. BBAT = blockchain-based accounting transparency; TT = transaction traceability; AQ = audit quality.

The first hypothesis (H1) proposed that the blockchain-based accounting transparency has a positive and significant effect on the transaction traceability. The results in Table 9 show that the path coefficient is positive and significant (β = 0.678, t = 25.587, p < .001), and the 95% confidence interval [0.627, 0.729] does not include zero. Therefore, H1 is supported. This result means that when the respondents perceive that the accounting information in the blockchain system is more accessible, more clear, and more verifiable, they also perceive that the transactions can be traced more easily to their origins and their recording histories. Moreover, the path coefficient of 0.678 is the strongest relationship in the model, and this is consistent with the large f^2 effect size (0.849) that was reported in Table 7. The second hypothesis (H2) proposed that the transaction traceability has a positive and significant effect on the audit quality. As shown in Table 9, the path coefficient is positive and significant (β = 0.604, t = 18.308, p < .001), and the 95% confidence interval [0.539, 0.669] does not include zero. Therefore, H2 is also supported. This result indicates that the ability to follow the transactions and to verify their recording histories is associated with a higher quality of the audit evidence and more reliable audit conclusions, in the view of the respondents. In addition, the small difference

between the original coefficients and the bootstrap means (0.678 versus 0.679, and 0.604 versus 0.606) shows that the estimates are stable across the bootstrap samples.

4.3.4 Testing of the mediating effect

The third hypothesis (H3) proposed that the transaction traceability mediates the relationship between the blockchain-based accounting transparency and the audit quality. In order to test this hypothesis, the specific indirect effect of the blockchain-based accounting transparency on the audit quality through the transaction traceability was estimated by the bootstrapping procedure (Preacher & Hayes, 2008; Nitzl et al., 2016). The results are presented in Table 10.

Table 10. Results of the mediation analysis

Hyp.	Indirect path	β	M	SE	t value	p value	95% CI	Decision
H3	BBAT → TT → AQ	0.409	0.412	0.032	12.875	< .001	[0.346, 0.472]	Supported

Note. β = specific indirect effect (original sample); M = bootstrap sample mean; SE = bootstrap standard error; CI = confidence interval, computed as β ± 1.96 × SE. The indirect effect equals the product of the two direct paths (0.678 × 0.604). Because the direct path BBAT → AQ was not specified in the model, the total effect of BBAT on AQ equals the indirect effect (0.409).

The results in Table 10 show that the specific indirect effect of the blockchain-based accounting transparency on the audit quality through the transaction traceability is positive and significant (β = 0.409, t = 12.875, p < .001), and the 95% confidence interval [0.346, 0.472] does not include zero. According to Zhao et al. (2010), the significance of the indirect effect is the only necessary condition for establishing the mediation. Therefore, H3 is supported, and the transaction traceability acts as a mechanism through which the blockchain-based accounting transparency is associated with the audit quality. In other words, an increase of one standard deviation in the blockchain-based accounting transparency is associated with an increase of 0.409 standard deviation in the audit quality through its effect on the transaction traceability.

However, it should be noted that the direct path from the blockchain-based accounting transparency to the audit quality was not specified in the estimated model, in line with the theoretical argument of the study. Accordingly, the total effect of the blockchain-based accounting transparency on the audit quality in the model equals the indirect effect (0.409), and this equality is a result of the model specification. Therefore, the results confirm the existence of the mediating effect, but they do not allow the classification of the mediation as full or partial, because such classification requires the joint estimation of the direct and the indirect effects (Zhao et al., 2010; Nitzl et al., 2016). This point is discussed further in Section 7. The summary of the results of the hypotheses testing is presented in Table 11.

Table 11. *Summary of the hypotheses testing*

Hyp.	Statement	β	p value	Decision
H1	Blockchain-based accounting transparency has a positive and significant effect on transaction traceability	0.678	< .001	Supported
H2	Transaction traceability has a positive and significant effect on audit quality	0.604	< .001	Supported
H3	Transaction traceability mediates the relationship between blockchain-based accounting transparency and audit quality	0.409	< .001	Supported

As shown in Table 11, all the three hypotheses of the study are supported. The results show that the blockchain-based accounting transparency is positively associated with the transaction traceability, the transaction traceability is positively associated with the audit quality, and the transaction traceability transmits the effect of the blockchain-based accounting transparency to the audit quality.

5. Discussion

The current study examined the relationship between the blockchain-based accounting transparency and the audit quality, and the mediating role of the transaction traceability in this relationship, by using a sample of 316 professionals in Jordan. In general, the results support the proposed model, and they show that the blockchain transparency is associated with the audit quality through the ability to trace the transactions.

5.1 Blockchain-based accounting transparency and transaction traceability

The results showed that the blockchain-based accounting transparency has a strong positive effect on the transaction traceability ($\beta = 0.678$), and it explains 45.9% of the variance in the transaction traceability. This result is consistent with the argument of Dai and Vasarhelyi (2017) and Risius and Spohrer (2017), who explained that the shared and time-stamped ledger creates a complete history for each transaction. Moreover, the result is consistent with the supply chain studies which found that the transparency of the blockchain is the basis of the tracking of the products and the transactions (Saberi et al., 2019; Treiblmaier, 2018; Queiroz et al., 2020). In the accounting context, the result supports the view of O'Leary (2017) and Wang and Kogan (2018) that the blockchain-based transaction processing systems can keep a verifiable record for the whole life of the transaction. A possible explanation for this strong relationship is that the respondents who can access the accounting information clearly on the blockchain are the same respondents who can use this access in order to follow the transactions, and therefore the transparency and the traceability develop together in the practice. Nevertheless, the fact that 54.1% of the variance in the transaction traceability is not explained by the transparency indicates that the traceability also depends on other factors, such as the design of the system, the governance of the network, and the skills of the users (Beck et al., 2018; Toufaily et al., 2021).

5.2 Transaction traceability and audit quality

The results also showed that the transaction traceability has a positive and significant effect on the audit quality ($\beta = 0.604$). This result is in line with the view of Rozario and Thomas (2019) and Appelbaum and Nehmer (2020), who argued that the blockchain allows the auditors to access the full history of the transactions, and this improves the quality of the audit evidence. Furthermore, the result is consistent with the framework of Francis (2011) and Knechel et al. (2013), where the quality of the audit evidence is considered a main input of the audit quality. In the Jordanian context, this result may reflect that the auditors who are able to trace the transactions depend less on the documents that are prepared by the management, and they can verify the records by themselves. However, the transaction traceability explains 36.5% of the variance in the audit quality only, and this is expected, since the audit quality also depends on the competence and the independence of the auditor, and on the judgments that are made about the events outside the chain (Coyne & McMickle, 2017; Schmitz & Leoni, 2019; Sheldon, 2019).

5.3 The mediating role of transaction traceability

Regarding the main question of the study, the results showed that the transaction traceability mediates the relationship between the blockchain-based accounting transparency and the audit quality (indirect effect = 0.409). This finding supports the argument that the transparency of the blockchain does not improve the audit by itself, and it is the conversion of the transparency into a traceable audit trail that makes the information useful for the auditor. In other words, the auditor benefits from the blockchain when the auditor can follow the transaction from its source to its final recording, and not only when the information is visible. This result is consistent with the view that the digital systems first improve the visibility of the information, and then this visibility is converted into better outcomes (Iansiti & Lakhani, 2017; Beck et al., 2018). Moreover, the result gives an empirical support to the conceptual arguments of Schmitz and Leoni (2019)

and Han et al. (2023), who suggested that the value of the blockchain for the audit depends on how the technology is integrated in the audit process.

On the other hand, the correlation between the blockchain-based accounting transparency and the audit quality (0.553, Table 4) is higher than the indirect effect that is implied by the model (0.409). This difference may suggest that part of the association between the transparency and the audit quality is not transmitted through the traceability, and it may operate through other channels, such as the improvement of the communication between the auditor and the client, or the reduction of the time of the audit. Therefore, the result of the current study should be interpreted as an evidence that the transaction traceability is an important channel between the transparency and the audit quality, and it is not necessarily the only channel.

6. Implications of the Study

6.1 Theoretical implications

The current study has several theoretical implications. First, the study extends the agency theory perspective on the audit by showing that the blockchain can reduce the information asymmetry between the parties through the traceability of the transactions, and not only through the availability of the information. Second, the study moves the literature from the conceptual arguments about the blockchain in the auditing (Dai & Vasarhelyi, 2017; Schmitz & Leoni, 2019) to an empirical test that is based on the perceptions of the professionals who work with the blockchain applications. Third, the study separates the transparency and the traceability as two distinct constructs, and the results of the discriminant validity confirm that the respondents distinguish between the two constructs. Accordingly, the future studies are encouraged to model the transparency and the traceability as different constructs, instead of treating the blockchain as one general construct.

6.2 Practical implications

The results of the current study also provide several practical implications. For the audit firms and the internal audit functions, the results suggest that the investment in the blockchain should focus in the features that allow the auditors to trace the transactions, such as the complete recording histories, the time stamps, and the links between the transactions and their source documents. Moreover, the auditors need a training on how to use these features in the collection of the audit evidence, because the traceability is the channel through which the transparency is associated with the audit quality. For the organizations that adopt the blockchain, the results suggest that the design of the accounting systems should consider the needs of the auditors from the beginning, and it should allow the authorized auditors to access the transaction histories. For the regulators and the professional bodies in Jordan, the results suggest the need for the guidance on the audit of the blockchain-based records, including the evaluation of the general controls of the information technology and the treatment of the events that occur outside the chain (Sheldon, 2019).

7. Limitations and Directions for Future Research

Although the current study provides a useful evidence, it has several limitations that should be considered in the interpretation of the results. First, the study used a cross-sectional design, and therefore the relationships between the variables should be interpreted as associations, and the causal conclusions cannot be drawn. Future studies are encouraged to use a longitudinal design or an experimental design in order to examine the causal direction of the relationships.

Second, the structural model specified the effect of the blockchain-based accounting transparency on the audit quality as an effect that is transmitted through the transaction traceability, and the direct path from the transparency to the audit quality was not estimated. Therefore, the study confirms the existence of the mediating effect, but it cannot determine whether the mediation is full or partial. Since the correlation between the transparency and the audit quality is higher than the model-implied indirect effect, future studies are encouraged to estimate the direct and the indirect effects together, and to examine other possible mediators.

Third, the study used a purposive sample of professionals in Jordan who have a direct experience with the blockchain applications, and this limits the generalization of the results to other countries and to the

organizations that do not use the blockchain. In addition, the audit quality was measured by the perceptions of the respondents, and it was not measured by objective indicators such as the audit adjustments or the restatements. Future studies may combine the perceptual measures with the objective measures, and they may compare the results between different countries and different sectors. Fourth, the study did not examine the moderating factors, such as the size of the organization, the type of the blockchain (public or private), or the experience of the auditor, and these factors may change the strength of the relationships. Finally, although the procedural and the statistical remedies suggest that the common method bias is not a serious problem, the collection of the data from the same respondents at the same time remains a limitation.

8. Conclusion

The current study examined the relationship between the blockchain-based accounting transparency and the audit quality, and the mediating role of the transaction traceability in this relationship, by using the data from 316 accountants, auditors, and financial managers in Jordan. The results of the PLS-SEM analysis showed that the measurement model is reliable and valid, and that the structural model has a moderate explanatory power and a good predictive relevance. Moreover, the results showed that the blockchain-based accounting transparency has a positive and significant effect on the transaction traceability, and the transaction traceability has a positive and significant effect on the audit quality. Furthermore, the transaction traceability mediates the relationship between the blockchain-based accounting transparency and the audit quality. Based on the above, it can be concluded that the benefit of the blockchain for the audit depends on the ability to trace the transactions, and therefore the organizations, the auditors, and the regulators should give a special attention to the traceability features of the blockchain systems and to the skills that are needed to use these features.

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