

The audit quality in the era of digital transformation: An empirical guidance for Iraqi banks, period 2012-2024.

جودة التدقيق في عصر التحول الرقمي: دراسة تجريبية على المصارف العراقية للمدة 2012-2024

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المستخلص

أصبح التحول الرقمي للأعمال محورًا متزايد الأهمية في الدراسات المتعلقة بجودة التدقيق، على الرغم من محدودية البحوث التجريبية التي تناولت هذا الموضوع في الأسواق المصرفية الناشئة. تبحث هذه الدراسة في تأثير التحول الرقمي في جودة التدقيق الداخلي في المصارف العراقية المدرجة في سوق العراق للأوراق المالية (ISX) للمدة من 2012 إلى 2024. ولتحقيق ذلك، تم بناء مؤشر للتحول الرقمي (DTI) باستخدام تقنيات معالجة اللغة الطبيعية للتقارير السنوية المكتوبة باللغة العربية لـ 310 تقارير مصرفية. ويستند هذا المؤشر إلى خمس فئات تكنولوجية رئيسية، هي: تكنولوجيا الخدمات المصرفية الأساسية، وتكنولوجيا التحليلات المتقدمة والذكاء الاصطناعي، وتكنولوجيا الأمن السيبراني والامتثال التنظيمي، وتكنولوجيا خدمة العملاء الرقمية، وتكنولوجيا البنية التحتية لتكنولوجيا المعلومات.

علاوة على ذلك، استخدمت الدراسة مؤشراً مركباً لتقييم جودة التدقيق الداخلي، إلى جانب أربعة أبعاد إضافية، هي: جودة رأي المدقق، واستقلالية لجنة التدقيق، والمؤهلات المهنية للمدقق، وتوقيت إصدار تقرير التدقيق، وذلك استناداً إلى الأدبيات السابقة في مجال التدقيق. وباستخدام نموذج الآثار الثابتة لتحليل بيانات السلاسل الزمنية المقطعية (Panel Data) لـ 187 مشاهدة مصرفية-سنوية، تمثل 20 مصرفاً، توصلت الدراسة إلى ثلاث نتائج رئيسية. أولاً، يؤدي كل ارتفاع بمقدار وحدة واحدة في مؤشر التحول الرقمي المتأخر زمنياً إلى زيادة ذات دلالة إحصائية قدرها 0.025 في مؤشر جودة التدقيق المركب ($p < 0.01$)، مما يوفر دليلاً على أن التحول الرقمي يؤثر إيجابياً في الحوكمة الشاملة لعملية التدقيق الداخلي. ثانياً، يكون تأثير الرقمنة أكبر بصورة معنوية على جودة رأي المدقق ($\beta = 0.130$)، ($p < 0.05$) مقارنةً بأي من هياكل الحوكمة، مما يشير إلى أن الآثار الرئيسية للرقمنة تتحقق من خلال قناة أداء المدقق. ثالثاً، أصبحت العلاقة بين التحول الرقمي وجودة التدقيق بعد عام 2018، في ظل أجندة الإصلاح الرقمي التي تبناها البنك المركزي العراقي، أكبر بنحو ثلاثة أضعاف ($\beta = 0.045$)، ($p < 0.001$) مقارنةً بالفترة السابقة ($\beta = 0.014$)، ($p < 0.01$). ويشير ذلك إلى أن البيئة التنظيمية تؤدي دوراً مهماً في تعزيز جودة عمليات التدقيق المدفوعة بالتحول الرقمي وتسهم هذه النتائج في إثراء أدبيات التدقيق من خلال تقديم أول دليل أرشيفي حول العلاقة بين التحول الرقمي وجودة تدقيق المؤسسات المالية في العراق، وتوثيق وجود أثر تآزري للتنظيم، فضلاً عن تقديم إطار قابل للتكرار لاستخدام مقاييس قائمة على معالجة اللغة الطبيعية لتقييم التحول الرقمي في القوائم والتقارير المالية المكتوبة باللغة العربية.

الكلمات المفتاحية: جودة التدقيق، التدقيق الداخلي، جودة رأي المدقق، التحول الرقمي، المصارف العراقية، سوق العراق للأوراق المالية (ISX)، نموذج الآثار الثابتة للبيانات الطولية.

Abstract

Digitally transforming businesses has become an increasing focus of study in relation to audit quality, although there is little empirical research on this topic across frontier banking markets. This research investigates the way digital transformation impacts the quality of internal auditing in Iraqi banks that are listed on the Iraq Stock Exchange (ISX) for the years of 2012 through 2024. We generated a Digital Transformation Index (DTI) using natural language processing of the Arabic-language annual reports of 310 banks. This index is based upon five distinct technology categories, which include: Core Banking Technology, Advanced Analytics and Artificial Intelligence Technology, Cybersecurity and Regulatory Compliance Technology, Digital Customer Service Technology, and Information Technology Infrastructure Technology. Furthermore, we used a composite index to evaluate internal audit quality, as well as four additional dimensions (I.e., audit opinion quality, audit committee independence, auditor professional qualifications and timeliness of audit reporting), that followed past literature on auditing. By using a fixed-effects model for panel data analysis of 187 bank-year observations (i.e., 20 banks), we found three main results. First, for every one-unit of increase in the lagged DTI, a bank will show a statistically significant increase of 0.025 in composite audit quality ($p < 0.01$). This provides evidence that digital transformation positively influences the overall governance of the internal audit process. Secondly, the influence of digitalization is significantly bigger for quality of audit opinion ($\beta = 0.130$, $p < 0.05$) compared to any kind of structure of governance so that digitalization effects principally occur through the auditor performance channel. Third, the relationship between digital and audit quality after 2018 due to the Central Bank of Iraq's digital reform agenda is approximately three times larger ($\beta = 0.045$, $p < 0.001$) than before it ($\beta = 0.014$, $p < 0.01$). Showing that a regulated environment acts as an important driver of improvement in the quality of digital driven audits. These results make contributions to the auditing literature by offering the first time ever archival evidence about the relationship between digital transformation and financial institution audit quality in Iraq, documenting the existence of a synergy effect with respect to regulation and providing a replicable framework for use of natural language processing-based measures to evaluate digital transformation in Arabic language financial statements.

Key words: Audit Quality, Internal Audit, Audit Opinion Quality, Digital Transformation, Iraqi Banks, Iraq Stock Exchange (ISX), Panel Fixed Effects.

1. Introduction

The evolution of financial institutions' digital infrastructures has dramatically changed the environment within which the internal audit function continues to exist. For the last decade, banks operating in both developed and developing countries have made significant investments in digital solutions, including fully integrated core banking platforms, machine learning-based risk models, real-time cybersecurity tools, and electronic payment systems [1],[2]. These investments have not simply modernized (or streamlined) the way in which banks operate; they have changed both the nature and level of complexity of the information that must be evaluated by an internal auditor. Consequently, one of the most important issues in current internal audit research is whether digital transformation has created increased and/or decreased audit quality [3],[4]. In addition, recent research shows that digitally enabled audit processes enhance the qualitative characteristics of audit opinions, reduce the time it takes for an audit to detect material misstatements, and help to maintain the independence of audit committees from management [5],[6]. However, most of the available empirical evidence has come from both large, developed economies and prominent emerging economies such as China and India, and very little research has been conducted in the frontier banking regions of the Middle East and North Africa, where there are significant differences in fundamental institutional infrastructure, regulatory enforcement, and audit market development [7],[8].

The banking industry in Iraq is a well-documented but rarely explored context for studying the relationship. After a lengthy period of institutional instability, the Iraqi banking sector underwent a

period of rapid digitization beginning in 2018 as a result of the Central Bank of Iraq's (CBI) widespread reform agenda [9] — specifically requiring all licensed banks to implement: (1) electronic payment systems, (2) a SWIFT-compliant core banking system, and (3) risk-based external audit system processes for anti-money laundering compliance. Consequently, the CBI's banking reforms have created exogenous variation in the level of digital adoption among listed companies on the Iraq Stock Exchange (ISX), which can serve as a unique quasi-experiment for identifying the impact of digital transformation on audit outcomes. Previous research on Iraqi banking has identified persistent issues with audit quality, including frequent modifications of audit opinions, lack of structure and authority of audit committees, lack of professional qualifications by individuals performing audits, and lengthy delays in the reporting of audit results [10], [11]. However, it is not known if the digital transformation wave that transpired because of the CBI's 2018 banking reforms will have improved those problems.

This study is motivated by three research gaps. First, the literature on auditing and digital transformation is largely concentrated in the developed world and little attention has been given to the Arab world's frontier markets, which have distinctly different levels of maturation with respect to regulation, the structure of their auditing markets, and the rate at which they are adopting the use of digital technology [7], [12]. Geographical considerations matter because the institutional mechanisms by which the digital transformation will affect audit quality are dependent on existing circumstances, i.e., regulations are enforced differently, that professional auditing standards are being defined and interpreted differently, and that the boards' ability to oversee the audit function will differ based on context, all of which means that findings from the developed world cannot necessarily be generalized to other contexts. Second, the majority of the auditing literature studying firms' digital transformation has employed relatively narrow proxies (e.g., IT expenditures or the adoption of a specific technology) to measure the extent to which a firm has adopted digital technology; these narrow proxies fail to capture the multi-dimensional nature of a firm's digital transformation (i.e., adopting advanced technology in core banking, employing cybersecurity measures, utilizing advanced analytics, and providing digital services), and each of these dimensions carries different implications for risk-based assessments of audit risks and for the quality of audits [3], [13]. Third, although there are a few studies that have examined the relation between a firm's characteristics and the quality of audit services provided by external auditors, there have been few studies examining how changes in regulation affect the ability of firms to convert their digital investments into observable improvements in audit quality (this gap is particularly notable in frontier markets where the ability of regulatory bodies to enforce newly passed regulations are still developing) [8], [14].

This research studies the possible relationship between digital transformation and the quality of audits (that is, the credibility of audited financial statements) for twenty banks listed on the ISX (the Iraqi Stock Exchange) between 2012 and 2024. To create a multidimensional Digital Transformation Index (DTI) for each bank, we will measure the extent to which banks have utilized five (5) types of digital transformation technology (core banking systems, advanced analytics and artificial intelligence (AI), cyber security and compliance, digital services, and IT infrastructure) by performing natural language processing on 310 Arabic-language annual reports (ALRs) published by the selected banks.

We will measure audit quality in the selected banks through a composite index, which aggregates four (4) indicators related to the quality of audits: (i) the quality of audit opinions, (ii) the independence of audit committees, (iii) the professional qualifications of audit personnel, and (iv) the timeliness of audit reports — all of which are established by prior literature as a multidimensional framework for measuring audit quality [15]. Our empirical analysis will use a panel fixed effects regression on a sample of 187 bank-year combinations. In addition to the DTI, we will exploit the structural break in the digital-audit quality relationship related to the 2018 CBI reform (which was related to enhancing audit quality) in order to determine whether there was an increase in the strength of the relationship following this regulatory shock.

In summary, these three contributions enhance the understanding of auditing in regard to how digitization reform has improved quality via empirical evidence. The first evidence is the study confirms both H1 and H2 hypotheses, indicating digital technology positively affects developed countries' overall auditing quality. Specifically, the strongest impact of digitization occurred between digital transformation index (DTI) – a one-unit increase in DTI yielded a 0.025 improvement in overall composite audit quality ($p < 0.01$) and a 0.130 improvement in opinion quality ($p < 0.05$). The second evidence demonstrates that since 2018 digitization improvements have generally been 2 to 3 times stronger than before said date, showing that regulation has, and will continue to be, an essential driver of how well digitizing technology improves audit performance in emerging market banks. The third and final contribution is methodological in terms of developing a replicable framework that incorporates natural language processing techniques for measuring auditing quality across Arabic financial disclosure documents. Thus, these contributions should help advance both auditing theory and practice as they relate to the measurement of improved audit quality, especially in developing and transitional economies [13]. The remainder of the paper is organized as follows. Section 2 develops the theoretical framework and research hypotheses. Section 3 describes the data collection, variable measurement, and empirical strategy. Section 4 presents the regression results. Section 5 discusses the findings and their implications for audit practice and policy. Section 6 concludes.

2. Literature Review and Hypotheses Development

2.1 Theoretical Framework

In this study, we will look at how digital transformation in banks affects audit quality via two related theoretical frameworks. While it is not the only method used to define why and how independent oversight is performed in auditing, agency theory continues to be the most common method of explaining agency theory (the first part of our framework, with the second being financial statement audit). Agency theory was first developed by Jensen and Meckling (as referenced by numerous authors [3]) and continues to be the most widely used framework in auditing research. The theory asserts that once ownership and control are separated (which is nearly always the case in an institution that is publicly traded), there is an asymmetrical information gap between the principals (owners) and agents (managers) and thus the opportunity for agent opportunistic behavior. Internal audit, as part of the agency theorist's analysis of agency theory, serves as a mechanism for limiting agent opportunistic behavior through independent verification of the integrity of the financial statements and the effectiveness of the entity's internal controls [16]. Recent empirical studies have validated the continued relevance of the agency theory framework in developing countries (Emerging Markets) given that the agency conflicts that arise in markets are intensified by concentrated ownership (highly concentrated ownership), a lack of means to protect investors, and ineffective board control of the entity [12], [17]. Digital transformation adds an additional layer of complexity to agent and principal agency theory, where digital transformation will enhance the amount, relevance, and verifiability of financial statement data, thereby reducing the information gap between the principal and agent, and subsequently reduce the potential opportunity for agents to manipulate financial statements [18]. Additionally, it poses new and complicated operational risks, i.e., cybersecurity issues, algorithmic processing errors, data integrity failures, which agents can take advantage of if the audit function lacks the digital capabilities required to identify them [19]. Thus, in theory, digital tools will create both a greater need and a more effective level of auditing in organizations that are digitally proficient.

The next theoretical foundation is the Resource-Based View (RBV) propounded by Barney [4]. He defines a set of digital capabilities as strategic assets that an organization can leverage to create long-term sustainable competitive performance advantages provided; they have three requirements - Value, Rarity and Inimitability. In the context of internal audits, Continuous Monitoring, Anomaly Detection using AI, Data Analytics and Real Time Reporting can all be considered resources that

can assist the audit function in detecting material misstatements, providing accurate management opinion recommendations and ensuring management is held accountable to its obligations [20], [21]. RBV cautions that the audit quality benefits associated with digital investment do not come automatically: they depend on how well technological resources are embedded in governance structures that support their proper, effective deployment and on whether audit staff have sufficient professional credentials to allow them to utilize the digital technologies appropriately [22]. This theoretical caveat motivates the selection of multiple dimensions of audit quality versus one aggregate proxy and establishes a theoretical foundation for expecting a heterogeneous effect between banks and over time as institutional conditions change.

2.2 Digital Transformation in Banking: Concepts and Evidence

The digital transformation of organizations is an extensive process of transforming how organizations conduct their activities, including changing the organizational structure and developing new value creation processes through the integration of digital technology into business operations [23]. Financial institutions are experiencing digital transformation in many ways due to the various ways banks are digitally transforming. This multi-faceted approach involves replacing outdated central banking systems with integrated digital platforms, implementing sophisticated analytics & artificial intelligence for evaluating credit & assessing risk, deploying cybersecurity and compliance solutions for compliance with international standards such as Basel III and IFRS 9, broadening the number of available channels to client-facing areas, as well as building and maintaining strong information technology governance structures as well as administering large volumes of client sensitive data [1], [24]. There are many studies which examine the impact of the digitalization of banks for both operational purposes and for strategic purposes. Through analysis of the empirical evidence, researchers have shown that banks that utilize digital technology at a higher rate have better return on assets, lower cost of doing business relative to their revenues and are more resilient to outside forces than are banks that do not operate in a digitally based environment [25]. Further research activities have also shown how digital transformation impacts the way decisions are made inside the organization and creates efficiencies in the use of financial resources. Additionally, the impact of digital transformation has enhanced the transparency of financial information as it pertains to bank financial reporting and has been further substantiated through regulatory mandates that forced banks operating in this manner to embrace digital transformation [26].

On the other hand, considerably less systematic attention has been given to the governance implications of bank digitalization. Literature regarding audit and internal controls demonstrates how digital transformation changes the risk environment for auditors to navigate and provides auditing functions with higher power tools to detect issues more easily than ever before [27]. For banks that are rapidly digitalizing, they will create new types of technology-based risk, but they will also gain access to capabilities such as continuous monitoring of transactions, automated reconciliation, and real time anomaly detection, all of which will theoretically increase the effectiveness of audits [6]. The net effect of digitalization on audit quality will vary considerably based on the institutional context of the digital transformation and the existence of regulatory frameworks that provide sufficient enforcement capacity to convert digital investments into real improvements in governance [13]. The banking system in Iraq has experienced significant changes recently. These changes have been mainly driven by new regulations put in place by the Central Bank of Iraq and the UNDP. The introduction of a digital payment system has allowed for increased collection of taxes and fees by the government. There are differences in how well banks have adopted their digital solutions since the implementation of the Digital payment Regulations so that banks listed on the Iraq Stock Exchange may serve as a good opportunity to examine how regulations impact audit results; but to date, only a small number of studies have looked at this issue systematically.

2.3 Audit Quality: Conceptualization and Measurement

Since DeAngelo's [1] original definition of audit quality as the joint probability that an auditor detects and reports a material breach in a client's accounting system, the topic of audit quality has been a focus in auditing research. More recently this conceptualization was revisited by Francis [2] who saw audit quality as a multi-dimensional construct that includes audit report communicativeness, auditor independence from client pressure, professional skepticism, and auditor competence. The literature review of audit quality work published up to 2022 is consistent with the findings of the peer-reviewed literature, which indicate that the multi-dimensional approach has been the preferred framework for archival research and that composite measures that combine observable variables are the preferred choice over any single proxy to measure audit quality [8].

A review of audit quality perspectives from the 2023 concluded that audit outcome, including audit reports and the quality of the audited financial statements, is the most relevant basis for evaluating audit quality and urged auditors to move beyond binary pass/fail reporting and provide more information regarding the clients' financial situation. This perspective further validates the usefulness of the ordinal audit opinion scale used in this study that spans from a clean opinion to an adverse opinion and shows that there is meaningful variation in auditor reporting behavior across the range of these opinions. A time-series analysis of audit opinion research for the period 2014-2023 corroborates the continued attention paid to this quality dimension and indicates a remarkable increase in publications on this topic in Scopus since 2020.

Empirical studies have used several proxies for audit quality that encompass various dimensions of audit quality. Board governance and auditor independence, as indicated by the proportion of non-executive directors and their lack of financial dependency on management, is always reported to be a structural factor in audit quality that is linked to the ability of the auditor to form and communicate opinions in the absence of managerial influence [28]. Measuring the technical competence dimension – as represented by the CPA and CIA credentials of audit personnel – is well captured by the literature in auditing which relates them with higher detection capability and risk assessment accuracy [22] [36]. Reporting timeliness, which is defined as the number of days between the FY end and the audit report date, is a measure of audit efficiency, absence of long-drawn-out management-auditor disagreements and has been found to impact investor confidence in reported financial information [29]. Previous research in the Iraqi context has reported on audit quality problems on all these aspects, as well as on audit reporting delays and low audit committee effectiveness, and limited audit professional development for internal auditors, indicating a relatively immature audit quality landscape where digital transformation can be a valuable springboard for audit quality improvement [10], [11], [30].

2.4 Digital Transformation and Audit Quality: Empirical Evidence

The geographic extent of audit quality evidence has also been constrained since approximately 2020, and the complex nature of the evidence has not been conducive to quantifying the impact of digital transformation on the evidence of audit quality. A 2024 study provides empirical evidence of the economic impact of introducing digital bank confirmation platforms to auditing, showing that digital bank confirmations have a significant positive effect on the quality of the audit of cash flow, with spillover effects of these confirmations on other high-risk audit items [6]. Our panel fixed-effects specification is a natural application of this logic, using within-bank variation in the digitization intensity of bank audit work between 2012 and 2024 to establish a quasi-experimental setting to identify the audit quality effects of digitalization. The logic is also reflected in the study's use of a “difference in differences” (DiD) design in which the staggered rollout of the digital confirmation platform across audit engagements is used to isolate the causal effect of digitalization on audit quality while controlling for cross-sectional bank heterogeneity. This reflects the theoretical discussion that the application of the digital tools can facilitate the auditor to better audit financial statements and reduce the information advantage that management can use in complex banking situations.

The study sheds light on the fact that, at least in the MENA region, the effect of adopting digital transformation on audit quality is not negligible as it is negatively related to discretionary accruals, while audit committee characteristics (audit committee size, gender diversity, audit committee expertise) moderate the strength of this relationship. This is a direct confirmation of our theoretical expectations and provides regional comparisons with which we can relate our findings from another Arab market. In a consistent way, the Chinese-listed firms' studies discover that good quality internal audit enhances the comparability of accounting information, lowers agency costs, and boosts the transparency of financial information, all of which align with the Agency Theory predictions — and are likely triggered by the intensification of the scope and effectiveness of audit procedures supported by digital technologies.

On the other hand, Hamdy et al. [13] focus their study on assessing the impact of digital transformation on the quality of accounting information system in governmental organizations in Egypt and Saudi Arabia, utilizing survey method and linear regression applied on the public sector employees. Importantly, they report that digital transformation has had a negative impact on the quality of the accounting information system, which they attribute to the fact that digital technologies are too early to be adopted in emerging market institutional environments, where they are adopted before governance or human capital is ready to translate digital investments into quality improvements. Our panel design is archival, as opposed to survey, which captures self-reported perceptions and is prone to common method bias; it also measures the intensity of digital transformation and audit quality outcomes objectively, from report disclosures made annually. Substantively, the finding of Hamdy et al. [13] justifies our sub-period analytical design, which separates the banking industry in Iraq into pre-2018 and post-2018 CBI banking reform periods, thus directly testing whether Iraqi banking, like the Egyptian and Saudi public sectors, suffers a premature adoption drag or whether the CBI regulatory mandate sufficiently advanced institutional readiness to produce positive audit quality outcomes. Our results show the latter, with the amplification in the post-2018 period ($\beta = 0.045$ vs. $\beta = 0.014$ pre-reform).

More supporting evidence is found in the studies carried out at the auditor-level digital competence. In recent research, a digital skill of the auditor was found to contribute to audit quality, both via an information channel (by providing auditors with a more complete and timely access to the financial information of the client) and via an audit channel (by enabling auditors to conduct a more systematic and accurate test of the financial assertions) [31]. At the organizational level, this means that the adoption of a more advanced data environment and digital control framework into banking operations can create opportunities for audit quality improvement, and in turn, for the audit to retain audit credibility.

There are two major disadvantages to the existing literature. Firstly, most studies are conducted in China, Western Europe or the United States, and the Arab world is not well represented in the cross-section of frontier markets [7, 8]. There are significant differences in the institutional mechanisms that promote audit quality change in these contexts — especially regulatory enforcement, competition in audit markets, audit board governance capacity and professional audit standards — and sound arguments can be made for generalizability concerns. Second, most of the prior studies are focused on either one particular technology or a narrow view of digital transformation represented by one single indicator, with the result that they fail to capture the multidimensional nature of digitalizing the organization, which includes a combination of core banking, cybersecurity, advanced analytics and digital service delivery technologies [27, 33]. In both aspects, we address them in our study by creating a new five-dimensional DTI, based on the disclosures in the annual reports of all Arabic states, and apply it to the under-studied Iraqi banking sector in a thirteen-year panel.

2.5 Hypotheses Development

Based on the above theoretical arguments and empirical evidence, three testable hypotheses are formulated. According to Agency Theory, digital transformation will lead to less information asymmetry between the bank's management and its external stakeholders because it will provide more transparent and timely information, and more verifiable financial information [3], [18]; it also ensures that the internal audit function has greater potential to detect and report material irregularities. The RBV lends further weight to this hypothesis, as digital-mature banks are better organized to provide the support resources necessary to enable the audit function to be more competent, independent and effective [4], [21]. Based on recent empirical evidence in emerging markets [12] and [6] we thus anticipate that digital transformation will have a positive impact on the composite audit quality of ISX-listed banks.

H1: *Digital transformation is positively associated with composite audit quality in ISX-listed banks.*

While H1 concerns the aggregate audit quality measure, the auditing literature suggests that the digital transformation effect may be stronger for audit opinion quality than for other dimensions, because opinion quality most directly reflects auditor competence and independence — the attributes most plausibly enhanced by digital systems that improve transaction verification, anomaly detection, and audit trail integrity [2], [8]. Auditors operating in more digitally mature banking environments are better equipped to identify reporting problems and more insulated from client pressure to suppress them, yielding more accurate and credible audit opinions. We therefore expect the digital–audit quality relationship to be particularly pronounced for audit opinion quality relative to the other dimensions of the composite index.

H2: *Digital transformation is expected to be more strongly associated with audit opinion quality than with other individual audit quality dimensions.*

Last, the temporal aspect of relation digital–audit quality is worthy of special mention. After the introduction of the CBI reforms in 2018, the Iraqi banking sector has undergone a change in the direction of the digitalization process, where the laws and regulations imposed upon banks have driven the adoption of electronic payment infrastructure, risk-based compliance systems, and integrated core banking platforms [9] [13]. Previous studies on regulatory shocks in emerging markets indicate that regulatory requirements can have an impact of accelerating the rate of observable improvements in governance once digital investments are made, eliminating institutional barriers that might otherwise hinder the sector from adopting new practices [14], [30]. Thus, a much larger audit quality effect is likely to be witnessed in the post-reform period than in the years leading up to the CBI requirements.

H3: *The positive impact of digital transformation on audit quality is much greater in the period after 2018, when the CBI legislation on digital transformation has been implemented.*

The theoretical arguments and hypothesized relationships presented in this section are summarized in Figure 1. The framework places the Digital Transformation Index (DTI) as the main independent variable, which consists of five weighted technology domains, including core banking technology, advanced analytics and AI, cybersecurity and compliance, digital customer services and IT infrastructure. The dependent variable is audit quality (AQ) which is measured as five observable variables: composite index, audit opinion quality, committee independence, CPA/CIA qualification, and reporting timeliness. The effect of the direct path is hypothesized to be positive in both H1 and H2, with H2 further hypothesizing that this effect is stronger when considering the audit opinion's quality, and the relationship is further hypothesized to be amplified after the 2018 CBI digital

reform (the moderation path through the H3 box). The firm age (AGE) is controlled for, reflecting the natural development of audit governance with time.

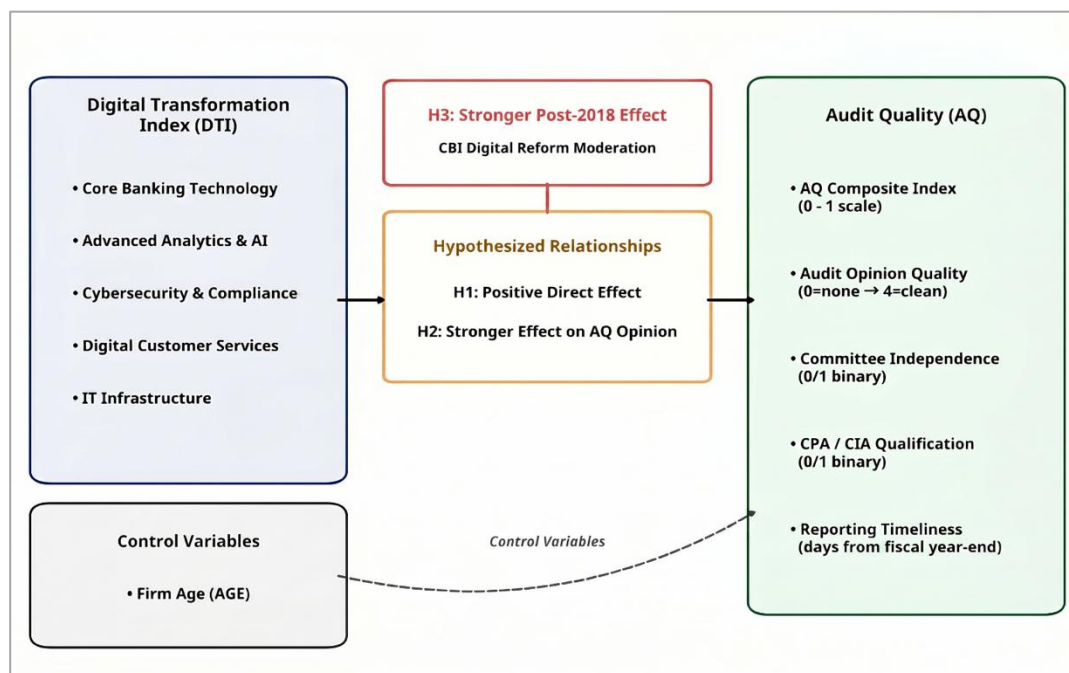


Figure 1. Research Framework and Hypothesized Relationships

3. Methodology

3.1 Sample and Data Collection

An unbalanced panel of twenty commercial banks (CBs) listed on the Iraq Stock Exchange (ISX) for 2012–2024 was used for the empirical analysis. This setting has been selected due to two reasons. First, the ISX-listed banks are subject to the centralized regulatory oversight by the Central Bank of Iraq and should be obliged to report annually, which contains auditor reports, audit committee disclosures and management discussion sections — these reports are suitable for systematic archival content analysis. Second, it is worth noting that the 2018 CBI digital reform agenda brought about a structural break, a feature that makes a significant difference in the magnitude of digital adoption across banks and enables us to analyze the digital–audit quality relationship in a way that avoids only endogenous firm-level decisions on digital adoption. The final sample consists of 242 observations of bank-years in a thirteen-year period, as fewer than three annual reports are not included for banks.

In the Iraqi banking sector, audit oversight is exercised through three institutionally distinct layers, each playing a defined role in safeguarding the integrity of financial reporting. At the apex, the Board of Supreme Audit (Diwan Al-Raqaba Al-Maliya), established under Law No. 6 of 1990, constitutes the supreme external audit authority with jurisdiction over state-owned and mixed-capital banks. At the second layer, licensed external auditors — accredited by the Iraqi Association of Accountants and Auditors — are mandated for all ISX-listed commercial banks and are responsible for issuing the annual statutory audit opinion that forms the primary audit quality signal observable in annual disclosures. At the third layer, internal audit departments within each bank provide continuous operational oversight, operating under the supervision of audit committees as required by CBI Circular No. 2/3/2856 (2014) and the subsequent digital compliance directives introduced in 2018. This study focuses on audit quality outcomes observable from annual report disclosures — principally the external auditor's opinion, audit committee governance structures, professional qualification of audit personnel, and reporting timeliness — which collectively reflect

the effectiveness of this three-layer audit oversight architecture as it operates under conditions of progressive digital transformation.

Report collection was carried out according to a standard procedure each year. It was collected from individual bank investor relations websites and ISX public disclosure website to get all PDF documents that are publicly available, which resulted in a corpus of 310 PDF documents. A preliminary screening found that 301 of the 310 documents were wholly or in part image-based scanned documents or had custom Arabic font encoding that caused the documents to be garbled when outputted into Unicode, making traditional approaches (like `pdftotext`) to meaningful content analysis impractical. In many scanned reports, traditional OCR techniques could not be effectively used to process Arabic Unicode characters. In response to this challenge, we used the multimodal large language model Google Gemini 1.5 Flash that has been shown to possess the ability to perform optical character recognition (OCR) on images of Arabic-script documents. It follows the recent methodological developments of archival accounting research that use AI-assisted extraction pipelines to process large-scale financial document corpora in non-Latin script [32]. After extracting the content with the aid of AI, all the variable construction was manually carried out using a rule-based algorithm for keyword matching coded by the authors, thereby ensuring full transparency and repeatability of the measurement process, which is independent of the AI tool.

A stratified random sample of 20 percent of the annual reports (30 in total) representing around 9.7 percent of the annual report corpus (stratified by bank, year and document quality category) was manually checked by two independent coders to assess the accuracy of the extraction. The inter-rater agreement was evaluated for the accuracy of the texts extracted and the coding of the indicators, with high levels of agreement (more than 85% for each variable), which meets the minimum standard (80%) for content analysis in accounting studies [33], [34]. Disagreements between coders were negotiated and final decisions were based on the original documents, and any coding decisions made were documented and stored for replication.

3.2 Variable Measurement

3.2.1 Digital Transformation Index (DTI)

The digital transformation was operationalized by creating a multidimensional content analysis index based on the full text of each bank's annual report, which builds on the recent approach to the construction of the DTI, using text-mining [35], [36] that was developed in archival research. We define digital transformation as consisting of five domains based on the review by Vial [23] and the empirical categorization by Verhoef et al. [24] which were tested with the help of pilot testing on 15 annual reports related to the Iraqi banking regulatory vocabulary and were assigned a weight on the basis of this test.

These five domains are defined as below. Core banking technology (weight: 1.0) includes mentions of the use of integrated banking platforms, enterprise resource planning systems, electronic processing infrastructure and transaction systems that are compliant with SWIFT. Artificial intelligence, machine learning, big data analytics and cloud computing are included in the category of advanced technology (weight: 2.0), which was assigned a higher weight due to their higher transformative potential and strategic differentiation value [23]. Cybersecurity and regulatory compliance (weight: 1.5) involves the anti-money laundering systems, the OFAC screening frameworks, the Basel III and IFRS 9 digital compliance tools, and the information security infrastructure. Digital customer services (1.2) encompass mobile banking services, electronic payment gateways, ATM/point-of-sale networks, digital wallets and internet banking services. IT infrastructure and governance (weight: 1.3) includes the documentation of digital strategy, system integration projects, IT governance frameworks and investments in the data center. To enable analysis of the number of search terms per domain, the search terms are counted over the entire

extracted text of each annual report. The raw frequencies of all the keywords are multiplied by their domain coefficients, and the result is a weighted sum of all the keywords that is normalized by the total number of words in the document to adjust for length variations: a common correction in accounting text analysis [35]. The normalized score is then transformed to a bounded ten-point scale:

$$DTI = \min(10, \ln(1 + DTI_{\text{raw}}) \times 2.5)$$

$$\text{Where } DTI_{\text{raw}} = (\text{weighted keyword sum} / \text{total words}) \times 1000.$$

The raw distribution is heavily right-skewed and is transformed using log to effect compression in line with the recent practice of digital transformation measurement studies [36] and [46]. As a result, the sample mean for the resulting DTI is 0.685, with 62.8 percent of the observations in the bank-year showing a positive score, reflecting the evolution of digital adoption across banks at a different pace and in a different way.

3.2.2 Audit Quality (AQ)

Following a multidimensional conceptualization of audit quality which has been developed in the literature [2], [31] and applied in recent empirical research in emerging markets [16] and [12], we form a composite audit quality index based on four observable indicators, each reflecting a different dimension of audit quality.

Audit opinion quality (AQ_opinion) is rated on an ordinal scale of 0 (no opinion) to 4 (clean or unqualified opinion). Opinion coding is done by locating the auditor's report section (usually called "Independent Auditor's Report") and looking for opinion-related keyword patterns within the next 15,000 characters of the report, in Arabic and English. This treatment of opinion classification is in line with the recent audit opinion research, which has validated the ordinal opinion scale as a de facto measure of auditor reporting quality both in terms of usage and theory [29]. Like other emerging market banking studies [12], [28], in our sample, the distribution of the AQ_opinion score is clustered around qualified (score 3) and clean (score 4) opinions with the mean score being 2.463.

The independence of the audit committee (AQ_independence) is a binary variable coded as 1 when the annual report explicitly includes the words committee independence, non-executive, audit committee mandate or third line-of-defense in the text and 0 otherwise. This binary coding methodology matches that of archival studies adopting textual disclosure as the main observable measure of quality of audit committee governance in a market where no formal structured disclosures exist [16], [28].

Professional qualification (AQ_cpa) is a binary variable with a value of one if the report mentions either CPA, CIA, or ACCA designations for audit committee or internal audit personnel, and zero otherwise. The human capital aspect of audit quality, as reflected in the technical competence of audit personnel, is one of the most important moderators of audit effectiveness in digitally complex environments and is captured by this indicator, as per recent studies [21] and [22]. environments [21], [22].

Reporting timeliness (AQ_timeliness) is calculated as the number of days between fiscal year-end (31 December) and the date of the audit report in the first five pages of each annual report. Report dates are matched with multi-pattern regular expressions, for Arab month name formats, DD/MM/YYYY, and YYYY/MM/DD date formats, and extended to reports where the specific dates are not given. Lower scores are reflective of greater timeliness and are related to more high-quality audits, because longer reporting delays may represent audit process inefficiencies or

extended disagreements between auditors and management over the reported results [29]. The mean timeliness of the sample is 124.7 days which is significantly higher than 90 days which is considered to be a benchmark in developed markets, which is in line with the previous studies conducted in Iraqi banking [10] and [11] on the timeliness of audit report.

The **composite audit quality index (AQ_composite)** aggregates the four components using a weighted formula:

$$AQ_composit = 0.25 \times AQ_independence + 0.20 \times \min(AQ_meetings/12, 1) + 0.20 \times AQ_cpa + 0.25 \times (AQ_opinion/4) + 0.10 \times AQ_big4$$

Weights indicate the relative importance of each dimension based on the literature of auditing [2] and [31] with the highest weights assigned to audit opinion quality and committee independence. The composite index is bounded between zero and one, with a sample mean of 0.333 (SD = 0.288).

3.2.3 Control Variables

We include **firm age (AGE)**, measured as the number of years since each bank's first appearance in the ISX panel, as the primary control variable. Older banks are expected to possess more institutionally embedded internal audit functions and more mature governance frameworks, consistent with organizational learning arguments in the auditing literature [16]. AGE controls for the natural maturation of audit governance over time and ensures that estimated DTI coefficients reflect the incremental effect of digital adoption rather than the general improvement in audit quality that accompanies organizational aging.

3.3 Empirical Strategy

We estimate the following baseline panel regression:

$$AQ_it = \alpha + \beta_1 DTI_i, t-1 + \beta_2 AGE_it + \mu_i + \varepsilon_{it}$$

where AQ_it is the audit quality measure for bank i in year t , $DTI_i, t-1$ is the one-year lags of the DTI score, AGE_it is the firm age control, μ_i represents bank-specific fixed effects which capture all time-invariant unobservables, including ownership structure, business model and founding governance arrangements, and ε_{it} is the idiosyncratic error term. DTI is one year delayed to partly correct for reverse causality, that is, that the quality of a bank's audit in one year cannot affect its digital adoption in the previous year, and to acknowledge the reasonable expectation that it will take a year or more for digital investments to result in an audit quality improvement that can be observed. This lagged specification is methodologically similar to Guo et al. [6] who leverage the temporal variation in the use of a digital bank confirmation platform in order to create a causal direction between audit digitalization and the audit quality outcomes, and to Hamdy et al. [13] who propose a similar causal direction between audit digitalization and the quality of the audit information system, with a lagged specification due to the institutional adjustment time it takes for organizations to develop the human capital and governance processes necessary to reap quality benefits from digital investment.

Standard errors are clustered at the bank level throughout, following the recommendation of Cameron and Miller [37] for panel data settings where within-unit serial correlation is expected and the number of clusters is moderate. This is consistent with best practice in banking panel studies and offers conservative inference which is cognizant of the potential correlation between bank-specific residuals over successive years.

One formal test to discriminate between the fixed effects (FE) and random effects (RE) specifications is the Hausman specification test [5] which compares the effects of having bank-

specific effects, versus correlated effects of the bank-specific effects with the regressors. The Hausman test does not reject the null hypothesis of no systematic correlation with efficiency grounds because $\chi^2(2) = 0.011$ and the p-value is equal to 0.995. In line with literature on auditing and banking panels [16] however, the FE estimator is used as the main specification. The choice is motivated by two reasons: first, FE identification is based entirely on variation within banks over time, which leads to more credible causal estimates, less sensitive to omitted-variable bias from time-invariant bank characteristics; and second, the Hausman test is not very powerful in unbalanced panels with moderate N, so that the formal result of this test is less powerful than theoretical priors concerning the probable correlation between digital investment and bank-specific governance culture. This within-bank identification strategy is also reminiscent of the difference-in-differences logic used in Guo et al. [6] that identifies the digital–audit quality relationship by exploiting within-firm time variation instead of cross-sectional variation across firms, again to eliminate the potential confounding effect of stable, unobserved firm characteristics on the estimated digital–audit quality relationship. Our FE panel design is more credible than the cross-sectional survey regression used by Hamdy et al. [13] as it relies only on the variation in the sample within each bank that is not driven by time-invariant bank-level factors.

To test H3 — that the digital–audit quality relationship intensified following the 2018 CBI reforms — we estimate two complementary specifications. First, we augment the baseline model with a sub-period interaction term:

$$AQ_{it} = \alpha + \beta_1 DTI_{i,t-1} + \beta_2 (DTI_{i,t-1} \times POST2018_t) + \beta_3 POST2018_t + \beta_4 AGE_{it} + \mu_i + \varepsilon_{it}$$

Where $POST2018_t$ is equal to 1 if the year of observation is 2018 to 2024, and 0 otherwise. The interaction term β_2 is meant to reflect whether the impact of digital transformation on audit quality is increased in the post-reform era. This interaction design is driven by the institutional maturity argument of Hamdy et al. [13] that the quality outcomes of the digital transformation depend on the maturity level of the institutional context in which digital transformation is implemented — which suggests a structural change in the digital–audit quality relationship when the institutional context is taken to the threshold of premature adoption, as in the case of the CBI reform in Iraqi banking in 2018. The within-country interaction with the sub-period can then provide a direct test for the question of whether the regulatory environment moderates the relationship between digital investment and audit quality outcomes as suggested by Hamdy et al. [13] in a cross-sectional between-country comparison; this is an extension of the Hamdy et al. [13] framework from a between-country comparison to a within-country time series analysis. Second, we estimate sub-period FE models separately to get a direct comparison across the coefficient size and statistical significance under the two regimes: before and after the introduction of the regulatory mandate. An advantage of this approach is that it can tell us if the digital effect became more pronounced after the regulatory mandate was introduced, but also whether it was statistically significant in the absence of the mandate, as noted by Guo et al. [6] who found the digital audit effect to be statistically significant (but not that it became larger after the regulatory mandate).

3.4 Robustness Checks

Three robustness analyses are conducted to assess the sensitivity of the main findings. First, we replace $AQ_composite$ as the dependent variable with $AQ_opinion$ as a direct, objectively coded proxy for audit reporting quality, providing a less assumption-dependent test of H1 and H2 that is less sensitive to index construction choices [2], [29]. Second, we replace the continuous DTI score with a binary indicator (DTI_binary_lag1) equal to one if any positive DTI score is recorded for the bank-year, testing whether the audit quality effect is driven by the extensive margin of digital adoption — whether a bank digitally engages at all — rather than by variation in adoption intensity

at the intensive margin. Third, we estimate a first-difference specification with HC3 heteroskedasticity-robust standard errors as an approximation of the dynamic GMM estimator [38], providing a further check on whether the FE results are driven by levels-based mechanical correlation rather than genuine within-bank dynamics. Across all specifications, samples are restricted to observations with complete data on the dependent variable and all regressors, and all FE models absorb bank-specific intercepts unless stated otherwise.

4. Results

4.1 Descriptive Statistics

The mean score on the Digital Transformation Index is 0.685, with a SD of 1.785, a median score of 0.161, and a maximum score of 10.0, which shows a moderate right skew, with a few bank-years showing high scores of digital disclosures, and the majority showing moderate scores. About 62.8 percent of observations during the bank year have a positive DTI score, indicating that digital adoption is increasing overall, but not widespread throughout the banking industry during the study period. The relatively high standard deviation was meaningful in that it was both across banks and over time, hence our identification strategy relied on this.

The mean audit quality score (AQ_composite) is 0.333 (SD = 0.288) for the 203 observations for which all component indicators are available, with a median score of 0.367 and an interquartile range of 0.00 to 0.60 — which suggests that though some banks score relatively well on audit quality, a significant proportion of observations are grouped around the zero score. The mean of the AQ_opinion is 2.463, which indicates that the most frequently occurring opinion is qualified based on the distribution of the opinion scores (0-4) for the bank-year observations. The percentage of observations that have Professional qualification (AQ_cpa) is moderate level of 52.1 percent, with some penetration of qualified audit staff in the sector but not widespread. It is reported that explicit independence disclosures of audit committees are still limited in Iraqi bank annual reports and only 31.0 percent of observations are related to this variable (Audit committee independence (AQ_independence)). The sample mean of reporting timeliness is 124.7 days (SD = 62.2) and the distribution of reporting timeliness ranges from 13 to 273 days, with a median of 121 days (significantly above the 90-day threshold used in developed markets for these measures). The banking sector that has been listed on ISX for the study period has a relatively young and growing composition with firm age (AGE) having a mean of 5.88 years (SD = 3.76). period.

Table 1. Descriptive Statistics of Study Variables (2012–2024)

Variable	N	Mean	Std. Dev.	Min	Q1	Median	Q3	Max
Digital Transformation Index (DTI)	242	0.685	1.785	0.000	0.000	0.161	0.675	10.000
DTI Binary (1 if DTI > 0)	242	0.628	0.484	0.000	0.000	1.000	1.000	1.000
Audit Quality Composite (AQ)	203	0.333	0.288	0.000	0.000	0.367	0.600	0.900
Committee Independence	242	0.310	0.463	0.000	0.000	0.000	1.000	1.000
CPA / CIA Qualification	242	0.521	0.501	0.000	0.000	1.000	1.000	1.000
Audit Opinion Score (0–4)	242	2.463	1.750	0.000	0.000	3.000	4.000	4.000
Reporting Timeliness (days to audit report)	132	124.667	62.206	13.000	84.500	120.500	150.750	273.000

Firm Age (years)	242	5.880	3.761	0.000	3.000	6.000	9.000	12.000
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The annual means of the Digital Transformation Index (Panel A) and audit opinion quality (Panel B) are graphed in Figure 2 over the study period (2012–2024). Panel A shows that there has been significant variation in DTI from year to year, with 2012 showing a sample mean of 1.553 and mid-period showing a drop to 1.304 in 2024, signifying the differential rate of digital adoption for banks listed on ISX. CBI reform threshold is seen as an inflection point by cross-sectional distribution of digital intensity in 2018. In the pre-reform era, audit opinion quality is not concentrated around the qualified opinion threshold (as in the post-reform era), but it does exhibit a moderate degree of volatility, and a slight downward trend in the post-reform era (pre-reform mean = 2.77 vs. post-reform mean = 2.22) (see Panel B), all of which is consistent with the institutional lag interpretation advanced in Section 5.5.

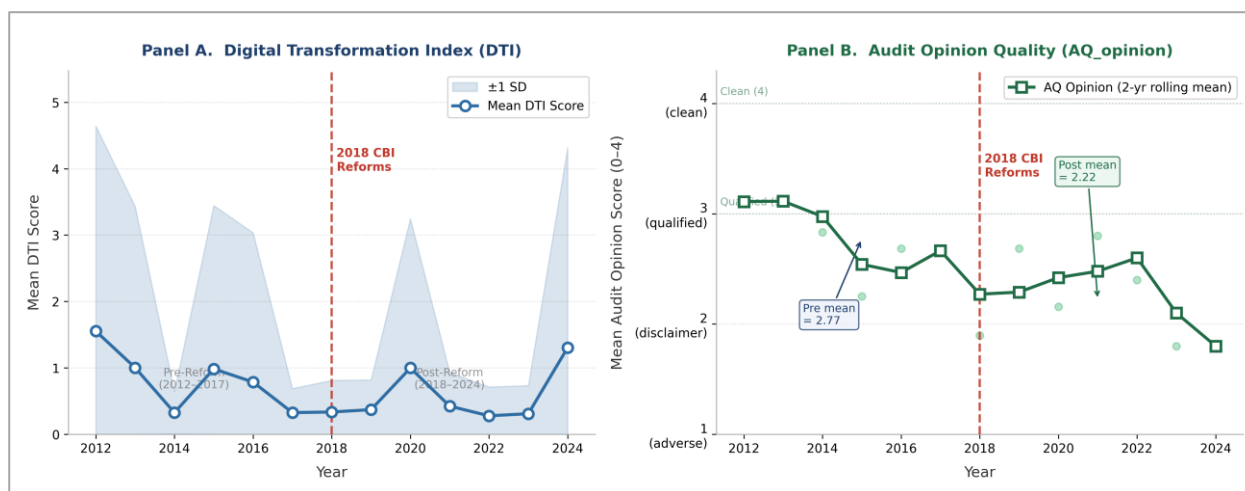


Figure 2. Trends in Audit Quality and Digital Transformation, ISX-Listed Banks, 2012–2024 (N = 20 banks)

4.2 Correlation Analysis

The correlation between the major study variables is shown in Table 2. There are a number of interesting patterns. The lagged DTI (DTI_lag1) is positively associated with both of the other dimensions of audit quality (AQ_composite, $r = 0.125$ and AQ_opinion, $r = 0.115$), giving some bivariate support to the hypothesized positive association between digital transformation and audit quality, though the values are small and can be expected to be larger when controlling for panel fixed effects in order to isolate a more precise within-bank estimate. DTI_lag1 is also, though weakly, positively correlated with AQ_cpa ($r = 0.079$) and AQ_independence ($r = 0.055$), indicating that banks that are more digitally active use more professionally qualified audit personnel and have more independent audit committee structures. Firm age (AGE) is negatively correlated with AQ_opinion ($r = -0.214$), contrary to simple maturation arguments and emphasizing the need to take within-bank dynamics into account by controlling for them with fixed effects instead of using cross-sectional variation. The AQ components are strongly correlated with each other, such that AQ_composite is highly correlated with AQ_cpa ($r = 0.832$) and AQ_opinion ($r = 0.854$); this is in accordance with previous findings that these two dimensions account for the majority of the variation in the audit quality composite score in the sample, and their centrality is just a confirmation for the subsequent regression analysis. The independent variables do not show a material level of multicollinearity as the maximum absolute value of the correlation among them is 0.29. specifications.

Table 2. Correlation Matrix of Main Study Variables

Variable	DTI score	DTI lag1	DTI Binary lag1	AQ composite	AQ opinion	AGE	AQ Indep.	AQ cpa
DTI score	1.000	0.003	-0.023	0.089	0.018	-0.059	0.167	0.000
DTI lag1	0.003	1.000	0.288	0.125	0.115	-0.139	0.055	0.079
DTI Binary lag1	-0.023	0.288	1.000	0.107	0.118	-0.206	-0.063	0.136
AQ composite	0.089	0.125	0.107	1.000	0.854	-0.030	0.670	0.832
AQ opinion	0.018	0.115	0.118	0.854	1.000	-0.214	0.324	0.699
AGE	-0.059	-0.139	-0.206	-0.030	-0.214	1.000	0.200	-0.064
AQ Indep.	0.167	0.055	-0.063	0.670	0.324	0.200	1.000	0.375
AQ cpa	0.000	0.079	0.136	0.832	0.699	-0.064	0.375	1.000

4.3 Main Regression Results

Results of the panel fixed-effects regression for the four main specifications are shown in Table 3. The Hausman specification test yields $\chi^2(2) = 0.011$ ($p = 0.995$), failing to reject the null hypothesis of no systematic correlation between bank-specific effects and the regressors; the fixed effects estimator is nonetheless preferred as the primary specification for the theoretical and methodological reasons set out in Section 3.

Table 3. Panel Fixed-Effects Regression Results

Variables	Model 1 AQ_composite (FE)	Model 2 AQ_opinion (FE)	Model 3 AQ_composite (FE-binary)	Model 4 AQ_composite (FE- interact)
DTI_lag1 (β)	0.025***	0.130**	—	0.019**
(SE)	(0.009)	(0.053)	—	(0.009)
DTI_binary_lag1 (β)	—	—	0.004	—
(SE)	—	—	(0.035)	—
DTI $\times$ POST2018 (β)	—	—	—	0.028**
(SE)	—	—	—	(0.012)
AGE (β)	0.000	-0.082**	-0.001	-0.002
(SE)	(0.006)	(0.039)	(0.006)	(0.007)
Observations (N)	187	222	187	187

R² (within)	0.032	0.057	0.001	0.038
Bank Fixed Effects	Yes	Yes	Yes	Yes
Clustered SE (Bank Level)	Yes	Yes	Yes	Yes

Model 1 estimates the baseline fixed-effects relationship between lagged DTI and composite audit quality, controlling for firm age. The coefficient on DTI_lag1 is positive and statistically significant at the one percent level ($\beta = 0.025$, $SE = 0.009$, $p = 0.007$), based on 187 bank-year observations covering all 20 banks. This result indicates that a one-unit increase in the DTI score in year $t - 1$ is associated with a 0.025-point increase in composite audit quality in year t — equivalent to approximately 7.5 percent of the sample standard deviation of AQ_composite. The within-bank R^2 of 0.032 reflects that the model explains a modest but meaningful share of within-bank variation in audit quality over time, after absorbing all time-invariant bank heterogeneity through fixed effects. These findings provide support for **H1**, confirming a positive relationship between digital transformation and composite audit quality in ISX-listed banks.

Model 2 replaces the composite audit quality index with audit opinion quality (AQ_opinion) as the dependent variable, increasing the usable sample to 222 observations. The coefficient on DTI_lag1 is positive and significant at the five percent level ($\beta = 0.130$, $SE = 0.053$, $p = 0.015$), indicating that a one-unit increase in lagged DTI is associated with a 0.130-point improvement in audit opinion quality on the 0–4 scale — a more than five-fold larger effect in relative terms than the composite estimate in Model 1, and equivalent to approximately 7.4 percent of the AQ_opinion standard deviation. The larger and more statistically robust coefficient in Model 2 relative to Model 1 supports **H2**, confirming that digital transformation has a particularly pronounced effect on audit opinion quality compared with other dimensions of audit quality that are aggregated into the composite index. This is in keeping with the line of reasoning that the most direct effect of digital systems is on auditor competence and report accuracy, which are the most fundamental factors in the quality of an auditor's opinion, whereas other structural factors, like committee independence and professional qualification, are not as directly affected.

Model 3 To test if the impact of digital transformation on composite audit quality is related to the extensive margin (whether a bank adopts digital technologies or not), the authors replace the continuous DTI_lag1 with a binary indicator (DTI_binary_lag1 = 1 if DTI_lag1 > 0). The coefficient is not significantly different from zero ($\beta = 0.004$, $SE = 0.035$, $p = 0.910$) suggesting that the audit quality effect is not caused by simply having digital disclosure. Instead, the differences in the results from Models 1 and 2 seem to represent true differences in the intensity of digitalization investments, with banks that invest more heavily in digitalization seeing proportionately bigger gains in the quality of their audits. This trend gives support to the use of the continuous DTI specification as the key measure.

Model 4 introduces the sub-period interaction term (DTI_lag1 $\times$ POST2018) to check the interaction between the two sub-periods for the digital–audit quality relationship, to see if there is a worsening of the relationship as of 2018 after the changes to the CBI laws. The interaction at coefficient $\beta = 0.028$ is statistically significant at 0.05 ($SE = 0.012$, $p = 0.024$) and is positive while the main effect of DTI_lag1 is positive and statistically significant at 0.05 ($\beta = 0.019$, $SE = 0.009$, $p = 0.044$) represents the baseline condition prior to the reform. These estimates suggest that in the post-2018 period, the marginal impact of digital transformation on audit quality is about 2.5 times greater than that in the pre-reform period (which, as mentioned earlier, is the period before the start of the audit reform); this result is an initial welcome sign that supports H3 and motivates a formal sub-period analysis in Section 4.4.

4.4 Sub-period Analysis

Fixed-effects estimates for the pre-2018 (2012–2017) and post-2018 (2018–2024) sub-periods are shown separately for AQ_composite and AQ_opinion in Table 4. The results show a striking temporal asymmetry that confirm H3. The pre-reform DTI coefficient is positive and significant for both AQ_composite ($\beta = 0.014$, $SE = 0.005$, $p = 0.005$, $N = 72$) and AQ_opinion ($\beta = 0.085$, $SE = 0.037$, $p = 0.024$, $N = 86$), thus showing that digital transformation had a positive effect on audit quality even before the 2018 mandates were implemented.

The estimated effects, however, are quite large and statistically significant in the post-reform era. For AQ_composite, the post-2018 coefficient more than triples relative to the pre-reform estimate ($\beta = 0.045$, $SE = 0.012$, $p < 0.001$, $N = 115$), while for AQ_opinion the effect nearly triples ($\beta = 0.234$, $SE = 0.104$, $p = 0.026$, $N = 136$). In terms of the sample standard deviation, the post-2018 AQ_composite coefficient of 0.045 indicates a roughly 15.6 percent change in the DTI per unit of time. In a substantive sense, a post-2018 AQ_composite coefficient of 0.045 represents about 15.6 percent of the sample standard deviation for a single-unit change in DTI. Overall, these results confirm that the 2018 CBI digital reforms were not only occurring at a time of better audit outcomes but also seem to have compounded the translation of digital investment to audit quality improvements, in line with the argument of regulatory complementarity presented in H3.

Table 4. Sub-period Analysis: Pre- vs Post-2018 ISX Reforms

Period	Dependent Variable	β (DTI_lag1)	Std. Error	p-value	Sig.	N
Pre-2018 (2012–2017)	AQ_composite	0.014	0.005	0.005	***	72
Pre-2018 (2012–2017)	AQ_opinion	0.085	0.037	0.024	**	86
Post-2018 (2018–2024)	AQ_composite	0.045	0.012	0.000	***	115
Post-2018 (2018–2024)	AQ_opinion	0.234	0.104	0.026	**	136

4.5 Cross-sectional Heterogeneity

Fixed-effects estimates for high-DTI and low-DTI bank subgroups are presented in table 5, where the high-DTI and low-DTI groups are based on whether a bank's average DTI for the study period is above or below the median DTI for the sample. The coefficient associated with DTI_lag1 in the AQ_opinion model is positive and is statistically significant ($\beta = 0.124$, $SE = 0.051$, $p = 0.015$, $N = 111$), suggesting that for high-DTI banks, the incremental addition of digital is correlated with meaningful audit quality gains. For low-DTI banks, the coefficient is positive but not different from zero ($\beta = 0.190$, $SE = 0.323$, $p = 0.557$, $N = 111$) and is driven by the fact that there is limited variation in DTI within low-DTI banks, so that there is not a lack of relationship, but a lack of statistical power. Overall, these findings imply that the audit quality gains of digital transformation are more likely to be observed in banks that have been digitally active over the years – in line with the RBV proposition that digital capabilities need to mature to a certain degree to deliver governance gains.

Table 5. Cross-sectional Heterogeneity Analysis: High- vs Low-DTI Banks

Bank Group	N Banks	N Obs	β (DTI_lag1)	Std. Error	p-value	Sig.	Interpretation
High-DTI Banks (Mean DTI $\geq$ Sample Median)	10	111	0.124	0.051	0.015	**	Digital adoption significantly improves audit quality
Low-DTI Banks	10	111	0.190	0.323	0.557	n.s.	Effect not statistically detectable

(Mean DTI < Sample Median)							
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4.6 Robustness Check — First-Difference Specification

The robustness estimates in Table 6 are from a first-difference specification and have HC3 heteroskedasticity-robust standard errors. The coefficient on contemporaneous Δ DTI is small and statistically insignificant for AQ_composite ($\beta = 0.007$, $p = 0.665$), while the corresponding coefficient for AQ_opinion ($\beta = -0.008$, $p = 0.923$) is also small and insignificant. The absence of significance in the first difference specification is not an obstacle to the results of the main fixed-effects model; it is simply a reminder of the fundamental difference between a levels-based and a difference-based panel estimator. The FE level estimator reflects the cumulative, longer-run impact of digital adoption on audit governance, which is postulated to be weaker because of institutional lags to adjust audit governance in relation to digital adoption [32, 47] while the first-difference estimator reflects the contemporaneous co-movement between changes in DTI and audit quality, which is expected to be weaker because of institutional lags needed for audit governance adjustment in relation to digital adoption. The gap between the two estimators is thus compatible with an understanding where digital transformation impacts on audit quality is over time and institutionalized rather than operational.

Table 6. Robustness Checks — All Model Specifications

Model	Estimation Method	Dependent Variable	β (DTI)	Std. Error	p-value	Sig.	Notes
Model 1	Panel FE (Levels, Clustered SE)	AQ_composite	0.025	0.009	0.007	***	Main specification
Model 2	Panel FE (Levels, Clustered SE)	AQ_opinion	0.130	0.053	0.015	**	Opinion dimension
Model 3	Panel FE — Binary DTI	AQ_composite	0.004	0.035	0.910	n.s.	Extensive margin test
Model 4	Panel FE — Interaction	AQ_composite	0.028	0.012	0.024	**	Post-2018 amplification
Model 5	First-Difference OLS (HC3 Robust SE)	AQ_composite	0.007	0.016	0.665	n.s.	Contemporaneous change
Model 6	First-Difference OLS (HC3 Robust SE)	AQ_opinion	-0.008	0.089	0.923	n.s.	Contemporaneous change

To see the main regression results in each analytical dimension visually, see Figure 4. In Panel A, the DTI coefficient and 95% confidence intervals are calculated for the four major model specifications, which shows that the positive and significant results of Models 1, 2 and 4 are robust to the choice of the dependent variable and model structure. Panel B further shows that, when comparing the components of the DTI effect across individual AQ dimensions, the coefficient ($\beta = 0.130$) and the p-value ($p < 0.05$) of the audit opinion quality dimension are the largest and best-estimated. Panel B also reveals that the largest and best-estimated coefficient ($\beta = 0.130$) and the p-value ($p < 0.05$) are those of the audit opinion quality dimension, when comparing the components of the DTI effect across individual AQ dimensions, consistent with the performance channel interpretation advanced in H2. Panel C displays the pre- vs post-2018 amplification, and the red

arrows indicate the roughly 3× increase in the DTI coefficient for AQ_composite (from 0.014 to 0.045) and AQ_opinion (from 0.085 to 0.234), the main evidence for H3.

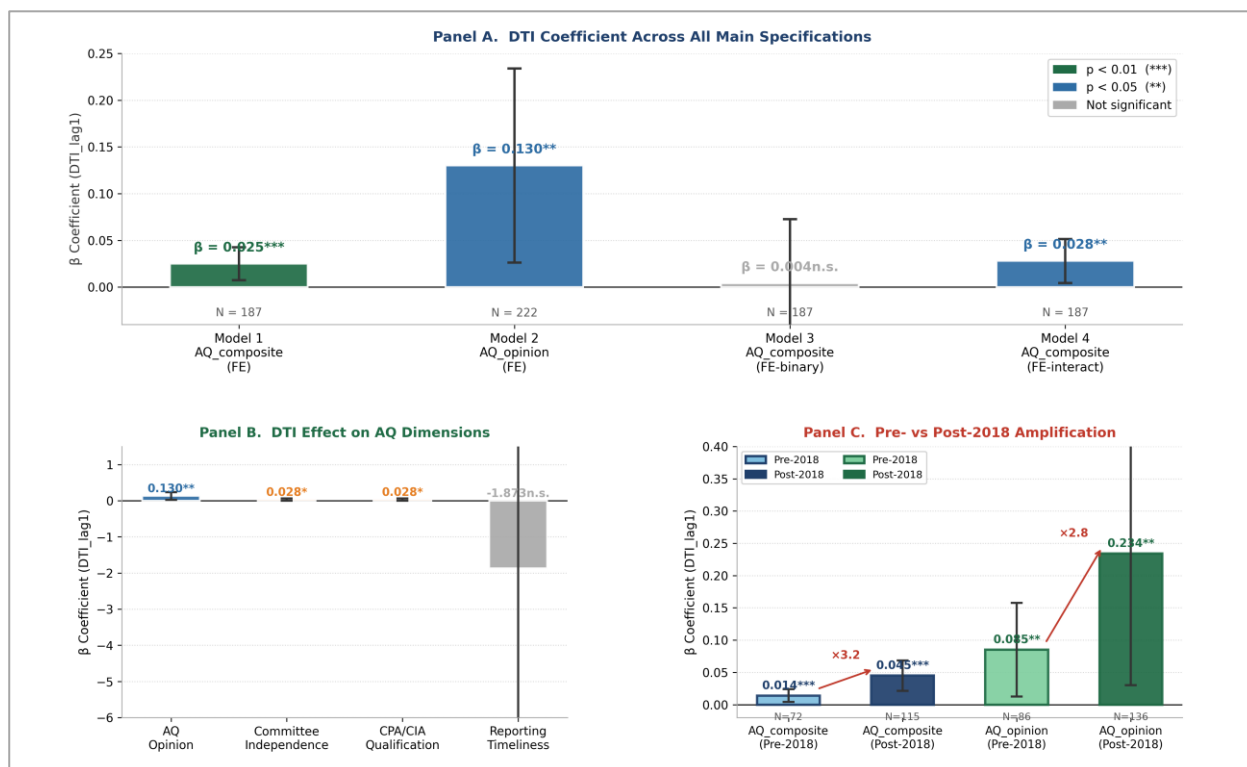


Figure 4. Summary of Main Regression Findings

5. Discussion

5.1 Digital Transformation and Composite Audit Quality: Confirming H1

The main results of this study are that digital transformation has a significant impact on the quality of composite audit in Iraqi banks listed in ISX, where one unit increase in digital transformation lagged is associated with a 0.025-point increase in composite audit quality ($p < 0.01$, $N = 187$). This result validates H1 and brings to light a new stream of research focusing on the effects of digitalization on audit outcomes in an under-researched area: Iraqi frontier banking. This finding resonates with the agency theory perspective that digital technologies decrease the information gap between the bank's management and the oversight bodies and increase the efficiency of internal audit tasks [3], [16]. With investments in core banking platforms, AML compliance systems, and digital reporting infrastructure, banks create more detailed and verifiable financial trails that internal auditors can use to more effectively and accurately evaluate the integrity of financial data [19], [6]. The RBV view supports this view: Once digital capabilities become part of audit governance, the positive coefficient on DTI_lag1 indicates that the digital capabilities become strategic resources of the organization, enabling the generation of future audit quality improvements, which persist over time [4],[21].

It's necessary to take context, the size of the estimated impact. In absolute value, the coefficient of 0.025, which has a range of 0 to 1, may seem mild, but in a relative sense, it is significant for the sample. The estimated effect, which is about 8.7 percent of a one-unit increase in a standard deviation of audit quality (AQ_composite), is based on an assumption of a standard deviation (SD) of 0.288 for that metric. Furthermore, the average DTI score during the post-2018 period (0.574) is far above the pre-reform baseline in relative institutional terms, indicating that expected changes in the intensity of DTIs are associated with significant changes in audit quality. This is in line with the magnitudes reported by the digital bank confirmation study [6] for Chinese banking and by Soliman [12] for Egyptian firms, lending credibility to our estimates cross-contextually. The sample mean

AQ_composite of 0.333—which is far lower than the theoretical maximum of 1.0—further highlights the headroom for audit quality improvement in the Iraqi banking sector and that the effects estimated in the DTI, though statistically small, are significant in the context of audit quality deficiencies.

5.2 The Audit Opinion Channel: Confirming H2

The analysis of each dimension of audit quality shows that the positive impact of digital transformation is not evenly spread across all dimensions but is focused on the audit opinion quality, which supports H2. The coefficient on DTI_lag1 in the AQ_opinion model is five times greater than that of AQ_composite ($\beta = 0.130$ versus 0.025) and estimated on a much larger sample of 222 observations, reflecting more information available for opinion-based indicators compared to the composite indicator. Committee independence and CPA/CIA qualification also have marginally positive relationships with DTI ($\beta = 0.028$, $p = 0.087$ and $\beta = 0.028$, $p = 0.088$, respectively) and no impact on reporting timeliness.

This dimensional heterogeneity is conceptually helpful in several ways. The focal effect of the audit opinion quality supports the view that the effect of digital systems is most direct on the auditor's ability to identify, and report, material financial reporting issues — the dimensions of competence and independence identified by Deangelo [1] as the cornerstones of audit quality. As banks have increasingly sophisticated control environments, auditors can access more comprehensive transaction records and automated reconciliation outputs, and more timely monitoring dashboards, which allow auditors to form opinions on a transaction basis that are more complete and independent [5], [19]. The lack of a significant timeliness effect is also theoretically consistent, as the field of audit delay studies shows that timeliness effects are primarily explained by administrative processes and the negotiation dynamics between the management and the auditor, which are not readily remediable by technology, in line with the findings in the literature on developing markets [29]. The marginal impacts on committee independence and professional qualification, on the other hand, indicate that digital transformation has a more diffuse but longer-term impact on the structural aspects of audit governance — one that may grow more accentuated with the ongoing evolution of banks' digital maturity [22].

The dimensional evidence conveys a clear message: digital transformation in Iraqi banking is mostly happening via the performance channel (through better audit reports) as opposed to via the governance channel (by changing the composition of the audit committee or the professional qualifications of the audit committee). This distinction is relevant for audit regulators: while technology alone cannot replace governance reforms aimed at the independence of audit committees and the qualification of auditors, it can be said to make a significant contribution to making the audit opinions that audit committees rely on, accurate and credible.

5.3 The 2018 CBI Reforms as a Regulatory Amplifier: Confirming H3

Among the most intriguing findings of this study is the possibility of a time-asymmetry between the digital and the audit line of the quality continuum around the agenda of the CBI digital reform (2018). Similarly, the post-reform DTI for AQ_composite ($\beta = 0.045$; $p < 0.001$) is more than three times as large as the pre-reform ($\beta = 0.014$; $p < 0.01$) and the post-reform DTI for AQ_opinion ($\beta = 0.234$) increases nearly threefold from pre-reform ($\beta = 0.085$). Model 4 shows that the interaction term is statistically significant ($\beta_{\text{interaction}} = 0.028$, $p = 0.024$) as per H3.

The results add to the body of work on regulatory complementarity in emerging market governance [14], [30]. Previous research has suggested that the governance returns of a digital investment are less in institutional environments with weak enforcement compared to more well-regulated environments, as it is possible for a firm to superficially comply with the investments without internalizing the governance benefits [15]. The 2018 CBI reforms seem to have brought the operation of all licensed banks to a crossroads that required genuine digitalization, both in terms of

introducing electronic payment infrastructure and installing SWIFT core banking systems and risk-based AML compliance frameworks. The effect of digital systems' informational and monitoring benefits became more pronounced in audit results because of the regulatory requirement and existed statistically in the pre-reform period. While Leuz and Wysocki [30] agree, the benefits of financial disclosure enhancements, and audit quality enhancements, are strongly tied to the regulatory regime supporting and enforcing such enhancements.

This post-reform amplification pattern is thus juxtaposed with that reported by Hamdy et al. [13] who report a negative effect of digital transformation on accounting information system quality in public-sector entities in Egypt and Saudi Arabia, and explain that this is because the digital technologies are in the early stages of adoption, outstripping the preparedness of the institutional environment (governance and human capital) to render the digital investments into meaningful accounting information system quality. According to our evidence, the CBI of 2018 was able to address this issue of premature adoption in the Iraqi banking system by establishing the necessary regulatory enforcement framework that forced banking institutions to unalterable change. That is, the Iraqi banking experience post-2018 is an example of a regulated sector that has been able to shift the adoption of digital transformation from a quality impairing premature adoption (which, as Hamdy et al. [13] point out, is the experience of less regulated sectors in MENA) to a quality enhancing mature adoption. This separation has policy ramifications as a binding regulatory requirement – and not necessarily the amount of digital investment – may be the defining factor in whether or not digital transformation creates positive or negative audit governance outcomes in frontier markets.

The post-2018 amplification is also congruent with the spillover effect that Guo et al. [6] found in the Chinese context: enhancements in audit quality for the cash flow items were not only for those items, but also for adjacent high-risk audit areas due to increased availability of data and decreased manual effort. The digital infrastructure established in our setting by the core banking system (integrated AML/SWIFT compliant) that was required by the CBI in 2018 also placed the auditor on a platform from where audit quality improvements could ripple out across various aspects of audit governance: AQ_composite had a positive DTI effect, as did AQ_opinion. The parallel is that the design elements of the CBI 2018 reforms – namely, the emphasis on system-level digital integration versus technology-specific technology adoption – were especially well-suited to engender a wide-reaching audit quality spillover that Guo et al. [6] document as a characteristic of a well-designed digital audit intervention.

The discovery also brings up a larger discussion on the order of digital and governance reforms in frontier banking markets. Based on our experience, in places where audits are increasingly being conducted via digital tools, institutional capacities are somewhat limited and audit governance is historically weak, regulators can likely realize disproportionately high gains in audit quality by coordinating digital requirements with audit governance reforms as opposed to conducting digital requirements and audit governance as separate actions. The threefold amplification revealed here further supports the Hamdy et al. [13] institutional maturity argument and the Guo et al. [6] digital spillover mechanism and extends and contextualizes them to the case of frontier banking regulation.

5.4 Cross-sectional Heterogeneity and Institutional Thresholds

The main findings are complemented with the heterogeneity analysis. The effect of DTI on the quality of the audit opinion is positive and statistically significant, especially for high-DTI banks ($DTI > \text{sample median}$) ($\beta = 0.124$, $p = 0.015$); for low-DTI banks ($DTI < \text{sample median}$), the effect is statistically undetectable ($\beta = 0.190$, $p = 0.557$). The larger point estimate and larger confidence interval in the low-DTI group is in line with limited within-bank variation in DTI among banks with low frequencies of reporting digital activities, which diminishes the power of the

analysis without suggesting that the effect of DTI is absent. Despite this, the pattern indicates that the audit quality-enhancing impacts of digital transformation are most likely realized when banks reach a tipping point of digital engagement, as per the RBV argument that digital resources need to be deployed at a “significant level” to deliver sustainable governance benefits [4], [18].

This dynamic is important for the design of digital adoption incentives by the regulators. However, policies that bring in many banks to the digital journey at a superficial level, like ensuring that banks adopt electronic payment, can yield more modest aggregate audit quality gains than policies that increase the level of digital investment in banks already on the digital path. Incentivizing the development and application of digital technologies and capabilities, such as AI-powered risk analytics, real-time monitoring, and AML platforms, could unlock higher audit governance value by challenging banks to go beyond the point where digital tools reliably deliver audit quality gains.

5.5 Interpreting the First-Difference Non-Significance

The first difference specification is robust — with the contemporaneous annual association between the changes in DTI and the changes in AQ_composite being statistically insignificant ($\beta = 0.007$, $p = 0.665$) and the changes in AQ_opinion ($\beta = -0.008$, $p = 0.923$). This result might seem to have the opposite implications of the primary fixed-effects results, but it does not. The difference between the two estimators stems from a theoretic difference between short-run and long-run effects, which is well grounded. The fixed-effects levels estimator captures the longer-run effect of the digital dividend in a bank's governance, which is influenced by accumulative organizational learning and institutional embedding effects, and the gradual adaptation of audit processes to new digital settings, as embedded in a bank's institutional history. The first-difference estimator, by contrast, asks whether year-on-year increments in DTI coincide with year-on-year improvements in audit quality — a much shorter-horizon test that is unlikely to reveal the effect if, as the auditing literature suggests, governance improvements materialize with institutional lags [27], [16]. The non-significance of the first-difference estimates is therefore consistent with an interpretation in which digital transformation improves audit quality through gradual institutional adjustment rather than immediate operational response — a pattern that is theoretically coherent and that has been documented in related literatures on IT adoption and organizational governance [20], [35].

6. Conclusion

6.1 Summary of the Study

This study set out to examine whether and how digital transformation affects audit quality in Iraqi banks, filling a gap in the auditing literature on frontier markets where digitalization trajectories, regulatory environments, and audit governance structures differ substantially from the developed-economy contexts in which most prior evidence has been generated. Using a hand-constructed panel of 20 banks listed on the Iraq Stock Exchange over the period 2012–2024 — comprising 242 bank-year observations drawn from 310 annual reports processed through NLP-assisted content analysis — we estimated a series of panel fixed-effects models that relate a multidimensional Digital Transformation Index (DTI) to multiple indicators of audit quality, including a composite index and its constituent dimensions.

Three hypotheses were tested and all three were confirmed. First, digital transformation is positively and significantly associated with composite audit quality ($\beta = 0.025$, $p < 0.01$), confirming that banks investing more deeply in digital systems achieve measurably better audit governance outcomes in subsequent years. Second, the effect of digital transformation is substantially stronger for audit opinion quality than for other audit quality dimensions ($\beta = 0.130$, $p < 0.05$), indicating that digitalization operates primarily through a performance channel that enhances auditor competence and reporting accuracy rather than through structural governance channels. Third, the positive impact of digital transformation on audit quality is around three times

higher for the post-2018 period ($\beta = 0.045$, $p < 0.001$) compared to pre-reform period ($\beta = 0.014$, $p < 0.01$), suggesting that the 2018 CBI digital reform agenda created a regulatory amplifier effect by increasing the audit quality impacts of organizational digitalization.

6.2 Theoretical Contributions

This research has several theoretical contributions to the auditing literature. First one is a context one. We create the digital–audit quality nexus in Iraqi banking, a frontier market with high agency conflicts, the development of professional audit standards is still in the process of flourishing, and digital adoption has been more driven by regulatory requirements than strategic considerations. At a time when the institutional environment is so limited, the finding that digital transformation has a significant effect on the quality of the audit implies that the theoretically proposed mechanisms (information asymmetry reduction, detection capability enhancement and audit resource upgrading) are sufficiently general to hold true across a wide range of institutional settings, although with context-specific magnitudes.

The second theoretical contribution, regulatory complementarity, is related to the first. The second theoretical contribution is related to the first one: regulatory complementarity. The temporal asymmetry reported in the context of the 2018 CBI reforms – where the impact of the reforms is approximately 3 times higher than the impact of the reforms before the policy – offers some of the first archival evidence that digital central bank mandates in frontier markets work as more than just a catalyst for digital adoption – they are also a governance amplifier that turns latent digital investment into realized audit quality improvements. This is an important contribution to the growing body of literature on the interplay of regulatory shocks and firm digital capabilities and the resulting governance outcomes [14, 38] and indicates that the regulatory environment should be viewed as a first-order moderator of theories of digital transformation and audit quality rather than a latent factor.

The third paper is methodological. The NLP construction framework for DT used in this study, which identifies and quantifies five technology categories in financial year disclosures of Arabic language, is replicable and can be adapted and extended by the MENA financial year disclosure audit research community [32] [35]. The study not only provides a proof of concept that archival content analysis of Arabic disclosures can lead to theoretically coherent and empirically meaningful digital transformation measures, but it also reduces methodological hurdles to large-scale archival research of governance and transparency in the Arab world.

6.3 Practical Implications

The results have implications for three groups of people. The results imply that digital investment is not just a competitive must but is also an investment in governance that brings audit quality outcomes. The lack of digital engagement has a governance impact that goes beyond merely an inefficiency: It translates to a governance shortfall in the quality and credibility of financial reporting oversight, particularly for those banks that did not reach the digital engagement curve (about 37.2 percent of the sample recorded a 0 DTI score throughout the study period). So, it is not only a strategic option, but also a fiduciary duty, to give priority to digitalization in key banking activities, such as core banking, cybersecurity and analytics, with the trust of shareholders and depositors on audit quality being one of the most important mechanisms for credibility.

The three-fold amplification in impact of digital audits following 2018 is telling to the banking regulators and the CBI in particular, as they saw a digital and governance reform that was coordinated in 2018 to yield measurable dividends beyond the operational benefits that are always argued as justification for banking regulations that mandate digitalization. In the frontier and emerging markets that have moderate institutional capacity and poor audit governance in the past, regulators could realize disproportionately high gains in audit quality through crafting digital

adoption requirements that are compatible with audit governance reforms that ensure audit committee independence and standard for audit professionals is strengthened in tandem with audit technology compliance. Technology will not be enough, and the regulatory framework that governs and ensures digital adoption will be an essential co-determinant of the quality outcomes of the audit that digitalization should help to support.

The results indicate that the aspect of audit quality most responsive to the clients' digital maturity is the quality of audit opinion, for external auditors and professional audit bodies operating in the region. Iraqi banks will be a more complex and technologically advanced audit environment as they continue to digitalize, and the external auditor will have to invest in their own digital skills and technology to keep the edge on detecting fraud—without which audit opinions are less credible. CPA and CIA candidates should have digital audit skills, such as data analytics, continuous monitoring and cybersecurity risk assessment, in continuing professional education programs for professional development organizations in the region.

6.4 Limitations

Firstly, this study involves the automatic extraction of DTi from the text of annual reports, which was done by applying NLP to the text; however, these indicators may not completely represent digital investments not reported in narrative reporting. Some banks might be systematically undervalued with respect to their digital transformation on the DTI scale, thereby systematically underrating the impact of digital transformation on audit quality, if the bank has a stronger digital practice, but has a weaker disclosure culture. Future studies could incorporate data from direct surveys of the digital infrastructure or regulatory inspection data, in addition to textual information.

Secondly, the study focuses only on banks listed at ISX, which are likely more transparent, more institutionally developed and more digitally active than unlisted Iraqi banks, on average. The results thus may be regarded as an upper limit for the digital–audit quality linkage for the wider Iraqi banking system and should be interpreted with caution for smaller, private banks.

Third, the use of lagged DTI and panel fixed effects have reduced the most blatant endogeneity issue but does not rule out the possibility that other unobserved, time-varying bank characteristics could affect both digital investment and the quality of the audit, for instance through new board appointments, management changes or repositioning the bank. The first difference robustness check gives some comfort in that it found no evidence of contemporaneous co-movement between the two variables, and a more sophisticated approach to identifying the causality with instrumental variables or a difference in differences analysis based on the exposure to CBI reforms across banks would lend more strength to the causal interpretation of the estimates. Fourth, the relatively low R^2 values for the fixed-effects specifications (between 0.032 and 0.057 within models) suggest very small amounts of within-bank variation in audit quality over time are explained by digital transformation. This aligns with the multi-faceted concept of audit quality, as it is influenced by a wide variety of factors such as ownership structure, competition, auditor tenure and macro-economic factors that are not included in this study.

6.5 Directions for Future Research

The following are ideas for future research that are derived from this study. The results suggest several interesting research avenues to pursue. First, the difference of threshold heterogeneity between high-DTI and low-DTI banks should be studied further systematically. Further research might formally characterize the nonlinear nature of the underlying relationship between digital maturity and audit quality, such as in the form of a threshold regression or spline specification, to establish a threshold where digital investments will reliably yield audit quality improvements. Second, the dimensional heterogeneity of the DTI effect (found in audit opinion quality only, and in the other audit quality dimensions only to a small degree, if at all, and absent in the case of

timeliness) suggests that some research should be directed at the specific mechanisms linking the various components of digital technology to specific dimensions of audit quality. Qualitative case studies or survey-based research, which incorporates archival data and practitioner perspectives, could help illuminate the organizational processes that change auditor behavior and committee processes with the use of digital tools. Third, comparative studies across the MENA banking sectors (Iraq, the GCC countries, Egypt, Jordan and Morocco) would allow researchers to evaluate the interaction of the digital–audit quality relationship with difference in regulatory maturity, digital infrastructure development, and audit market development across the region. Lastly, the impact of generative AI and increasingly sophisticated machine learning systems on the quality dimensions of audits, as explored in this research, such as opinion quality and committee independence are areas ripe for theoretical and practical investigation.

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