

Digital Internal Control: A Bibliometric Analysis

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ABSTRACT

Digital internal control has become a growing research domain as organizations integrate digital technologies into governance, risk management, and assurance processes. This study conducts a bibliometric analysis to map the intellectual structure, thematic evolution, collaboration patterns, and most influential works in digital internal control research. Data consisting of 66 documents published between 2002 and 2026 were retrieved from the Scopus database and analyzed using VOSviewer through keyword co-occurrence, overlay, density, co-authorship, institutional, and country collaboration mapping, complemented by citation analysis. The results show that the field is organized around four thematic clusters: digital transformation and internal control effectiveness, internal control systems and information management in the digital economy, ESG performance and decision making, and a separate biomedical cluster in which the term internal control refers to laboratory quality assurance. The overlay visualization indicates a clear shift from engineering and laboratory applications toward corporate governance themes, with ESG performance, digitization, and internal control effectiveness emerging as the most recent topics. Citation analysis reveals that the most influential studies are empirical works from China linking digital transformation to internal control quality and firm productivity. Collaboration networks remain limited and fragmented, with China acting as the dominant hub, indicating substantial room for broader international and cross-institutional cooperation.

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1. INTRODUCTION

Internal control has long been regarded as a fundamental mechanism for safeguarding assets, ensuring the reliability of financial reporting, and promoting compliance with laws and regulations. In recent years, the rapid diffusion of digital technologies such as big data, cloud

computing, artificial intelligence, and integrated information systems has changed the way organizations design, operate, and monitor their internal control systems. Enterprise digital transformation is now viewed as a strategic process that reshapes information flows, control activities, and risk assessment within the firm [1], [2]. At the same time, organizations are required to redesign their internal control frameworks so

that they remain effective in increasingly automated and data-driven environments [3], [4].

A growing body of empirical literature has examined the economic consequences of digitalized internal control. Studies show that digital transformation improves total factor productivity through its positive effect on internal control quality [5], [6], and that the influence of digitalization on internal control effectiveness varies across firm life-cycle stages [7]. Other studies report that internal control serves as a channel through which digital transformation enhances corporate innovation [8], although excessive digitalization may also create a paradox in which control benefits diminish [9]. These findings indicate that internal control is not only affected by digital technologies but also functions as a transmission mechanism between digital strategy and firm outcomes.

The literature has also expanded toward audit, governance, and sector-specific applications. Audit digitalization has been found to reduce internal control weaknesses [10], while digital finance influences audit quality through internal control [11]. Managerial characteristics [12] and auditor IT expertise [13] further shape the success of internal control in the digital age. Sectoral studies cover areas such as digital banking [14], while newer works discuss artificial intelligence as an enabler of internal control systems [15]. Several studies emphasize the continuing relevance of the COSO framework as the basis for evaluating digital internal control [16], and recent research connects digital internal control with ESG performance and corporate social responsibility [17], [18].

Despite this expansion, research on digital internal control remains dispersed across accounting, finance, management, information systems, and even engineering and biomedical sciences, where the phrase “internal control” carries a different technical meaning, such as reference controls in droplet digital PCR assays [19], [20] or internal model control in digital controller design [21]. This terminological overlap makes it difficult to obtain a clear picture of the intellectual

structure of the field. Bibliometric analysis offers a systematic and quantitative approach to identify publication patterns, influential works, collaboration networks, and thematic evolution within a research domain [22]. Therefore, this study aims to map the development of digital internal control research by identifying its main thematic clusters, emerging topics, collaboration structures, and most cited publications.

2. METHODS

This study employed a bibliometric analysis design to examine the scientific literature on digital internal control. Data were collected from the Scopus database because of its broad coverage of peer-reviewed publications and its extensive use in bibliometric studies. The search was conducted using the terms “digital” and “internal control” in the document title, without restriction on subject area, in order to capture the full scope of the topic. The search produced 66 documents published between 2002 and 2026, consisting of 46 journal articles, 15 conference papers, three book chapters, one review, and one book. The bibliographic information exported for each record included titles, authors, affiliations, abstracts, keywords, sources, publication years, and citation counts.

The data were exported in RIS and CSV formats and analyzed using VOSviewer, a software tool for constructing and visualizing bibliometric networks [23]. Keyword co-occurrence analysis was used to identify thematic clusters, while overlay visualization was applied to trace the temporal evolution of topics and density visualization was used to identify the most intensively studied themes. Co-authorship analysis was conducted at the author, institution, and country levels to examine collaboration patterns. In addition, citation analysis was performed to identify the ten most cited documents that have shaped the development of digital internal control research.

3. RESULTS AND DISCUSSION

3.1 Keyword Co-Occurrence Network

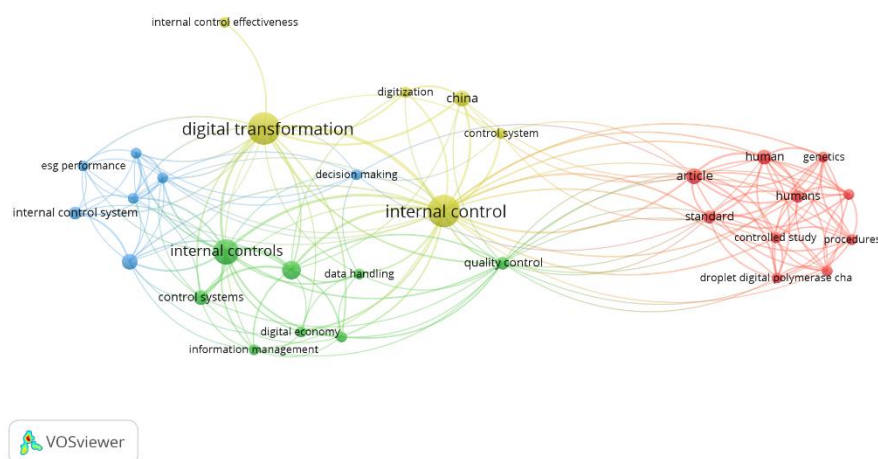


Figure 1. Network Visualization

Source: Data Analysis Result, 2026

Figure 1 presents the keyword co-occurrence network of digital internal control research. The most dominant nodes are “internal control”, “digital transformation”, and “internal controls”, which occupy central positions and have the largest number of links. This structure confirms that the field is built around the relationship between digital transformation and internal control, with most other keywords connected to these core concepts. The network forms four clusters that represent different research streams.

The yellow cluster includes digital transformation, internal control, china, digitization, control system, and internal control effectiveness. This cluster represents the main stream of corporate research that examines how enterprise digitalization affects the quality and effectiveness of internal control, largely using data from Chinese listed

PCR assays [19], [20], [24]. Its position on the far right of the map, with only weak links to the governance clusters, shows that

firms [1], [7]. The green cluster contains internal controls, control systems, data handling, digital economy, information management, and quality control, reflecting studies on the operational and information system aspects of internal control in the digital economy [3]. The blue cluster consists of esg performance, internal control system, and decision making, indicating the connection between digital internal control, sustainability performance, and managerial decisions [17], [18].

The red cluster, which includes article, human, humans, standard, genetics, controlled study, procedures, and droplet digital polymerase chain reaction, is clearly separated from the other clusters. This cluster originates from biomedical studies in which internal control refers to a reference standard used in digital

this stream shares terminology but not substance with accounting-oriented digital internal control research.

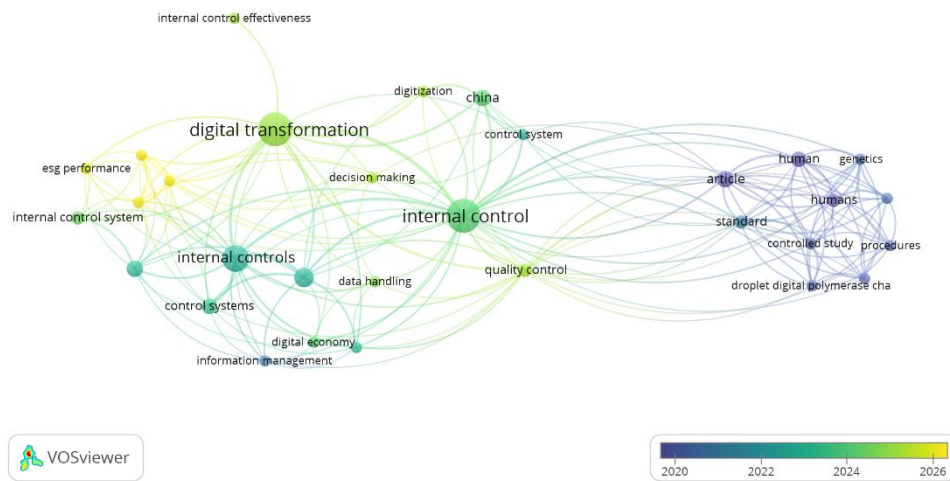


Figure 2. Overlay Visualization

Source: Data Analysis Result, 2026

Figure 2 shows the overlay visualization, in which node colors represent the average publication year of each keyword from 2020 (purple) to 2026 (yellow). Keywords in the red biomedical cluster, such as human, humans, article, genetics, and controlled study, appear in purple and blue, indicating that they belong to the earlier phase of the literature. Information management and standard also appear in darker colors, representing earlier interest in data and control procedures.

Core concepts such as internal controls, control systems, control system, and

internal control are shown in teal to green, indicating that they were central topics around 2023 to 2024, when empirical studies on digital transformation and internal control quality began to grow rapidly [2], [5]. The most recent topics, shown in light green and yellow, include digital transformation, digitization, quality control, decision making, data handling, internal control effectiveness, and especially esg performance. This pattern indicates that the research frontier is moving toward the role of digital internal control in sustainability, governance quality, and intelligent decision support [15], [18].

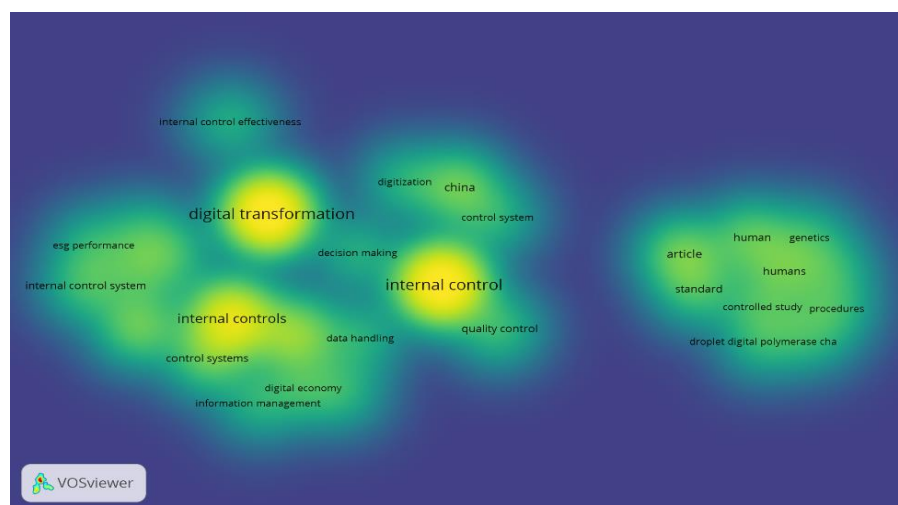


Figure 3. Density Visualization

Source: Data Analysis Result, 2026

Figure 3 presents the density visualization, where brighter yellow areas indicate higher keyword occurrence and stronger concentration of research. The highest density is found around internal control, digital transformation, and internal controls, confirming that these three concepts form the intellectual core of the field. The areas surrounding china, digitization, control system, esg performance, and internal control system show moderate density, indicating established but less intensively studied topics.

The biomedical area on the right side, containing article, human, humans, and

standard, shows moderate density but is isolated from the main governance area. Meanwhile, keywords such as internal control effectiveness, decision making, data handling, digital economy, and information management appear in lower-density zones. These topics represent opportunities for future research, particularly studies that measure internal control effectiveness in digital environments and examine how digital data handling supports managerial decision making [7], [15].

3.2 Citation Analysis

Table 1. Top Cited Documents

Citations	Authors and Year	Title
158	[1]	The stages of enterprise digital transformation and its impact on internal control: Evidence from China
104	[5]	Digital transformation and firms' total factor productivity: The role of internal control quality
93	) [7]	Digital transformation, life cycle and internal control effectiveness: Evidence from China
88	[21]	Demonstration of the internal model principle by digital repetitive control of an educational laboratory plant
75	[19]	Droplet digital polymerase chain reaction (ddPCR) assays integrated with an internal control for quantification of bovine, porcine, chicken and turkey species in food and feed
46	[20]	A robust internal control for high-precision DNA methylation analyses by droplet digital PCR
37	[25]	Frequency stabilization of an internal mirror He-Ne laser by digital control
32	[2]	Research on the Impact of Enterprise Digital Transformation on Internal Control
27	[8]	The impact of digital transformation on corporate innovation: Roles of analyst coverage and internal control
25	[6]	Corporate digital transformation, internal control and total factor productivity

Source: Scopus, 2026

3.3 Co-Authorship Analysis

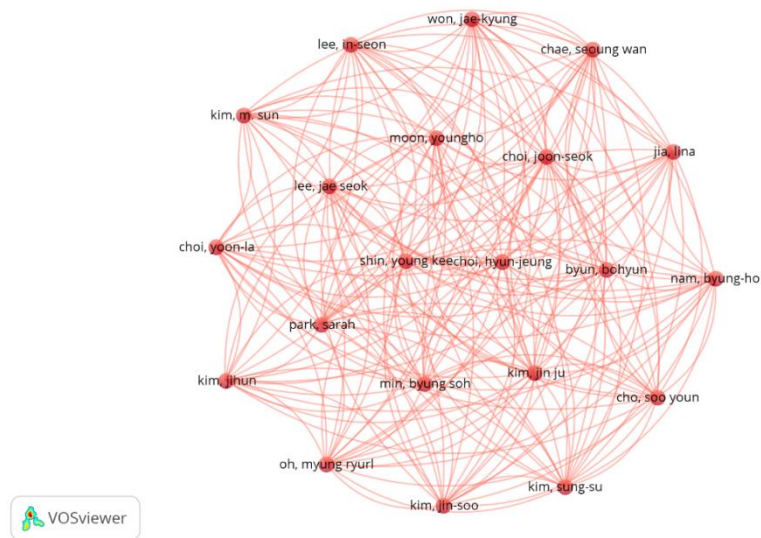


Figure 4. Author Visualization

Source: Data Analysis Result, 2026

Figure 4 shows the co-authorship network among authors in the dataset. The network forms a single, densely connected cluster consisting of Korean researchers such as Kim, Choi, Lee, Shin, Park, Moon, and Min, together with Jia Lina. All authors are linked to each other, which indicates that the network is generated by a multi-author collaborative publication rather than by repeated collaboration across several studies.

This cluster corresponds to the study by Kim et al. [24] on droplet digital PCR-based EGFR mutation detection with an internal quality control index. The pattern shows that authorship collaboration in digital internal control research remains limited, since most studies in the accounting and governance stream are written by small teams that do not form connected networks.

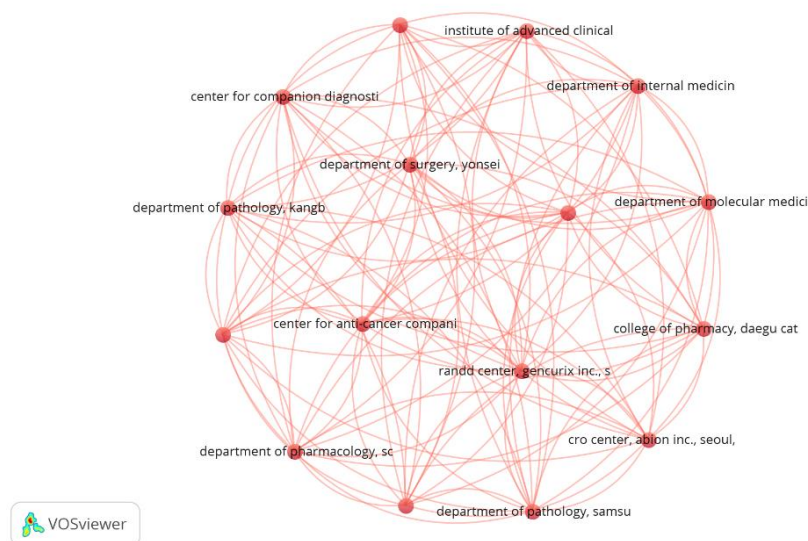


Figure 5. Institution Visualization

Source: Data Analysis Result, 2026

Figure 5 illustrates the institutional collaboration network, which also forms a single cluster of closely connected institutions. These institutions include the Center for Companion Diagnostics, the Center for Anti-Cancer Companion Diagnostics, the Department of Pathology, the Department of Surgery at Yonsei, the Department of Internal Medicine, the Department of Molecular Medicine, the College of Pharmacy at Daegu Catholic, the

R&D Center of Gencurix Inc., and the CRO Center of Abion Inc. in Seoul. The combination of universities, hospitals, and biotechnology companies shows a university-industry partnership model within the biomedical stream [24]. In contrast, institutions contributing to the corporate stream of digital internal control have not yet formed visible collaboration networks, indicating fragmented research activities across universities.

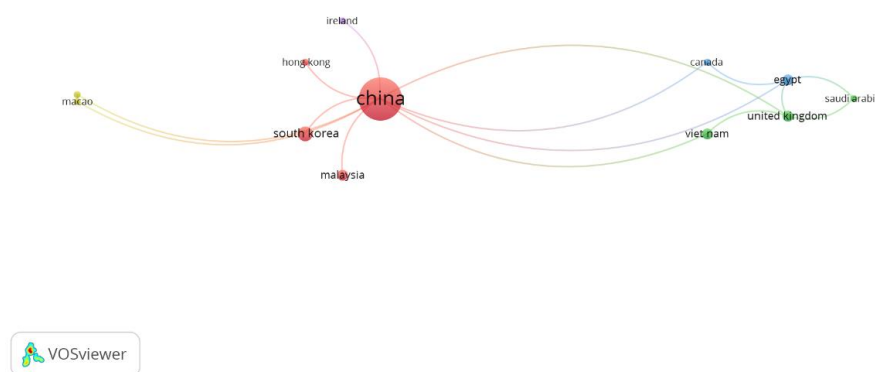


Figure 6. Country Visualization

Source: Data Analysis Result, 2026

Figure 6 shows that China is the most dominant country in digital internal control research, as indicated by its largest node size and central position in the collaboration network. China collaborates with South Korea, Hong Kong, Macao, Malaysia, Ireland, Canada, Egypt, the United Kingdom, and Viet Nam, reflecting its leading role in producing empirical studies on digital transformation and internal control [6], [8], [9], [17]. A second group is formed by Egypt, Saudi Arabia, the United Kingdom, Canada, and Viet Nam, which are connected through studies on auditor IT expertise, managerial characteristics, and laboratory applications [12], [13], [19]. The small number of countries and links indicates that international collaboration in this field is still at an early stage, and that contributions from Southeast

Asian countries, including Indonesia, remain very limited.

4. CONCLUSION

This bibliometric analysis shows that digital internal control research has developed into a growing field centered on the relationship between digital transformation and internal control. The keyword analysis identifies four clusters, namely digital transformation and internal control effectiveness, internal control systems and information management in the digital economy, ESG performance and decision making, and a separate biomedical cluster that uses internal control in a laboratory sense. The overlay and density visualizations indicate a shift from engineering and laboratory applications toward corporate

governance, with ESG performance, digitization, and internal control effectiveness emerging as the newest research frontiers. Citation analysis confirms that recent empirical studies from China are the most influential works in the field. Collaboration at the author and institutional levels remains limited, while China acts as the main hub of

international cooperation. Future research should expand cross-country collaboration, examine digital internal control in emerging economies such as Indonesia, and explore the role of artificial intelligence, ESG integration, and internal control effectiveness in digital environments.

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