Research on Digitalization of Construction Project Audit

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Abstract: Due to the complexity of many aspects of the project, construction project audit has been lacking in the whole life cycle of the project. Based on the classical audit theory, combined with the rapid development of digital technology in the near future, this paper introduces technology into construction project audit, analyzes the audit subject, audit object and audit content of construction project audit under digital technology, establishes the framework of construction project audit under digital technology, summarizes the problems arising from the combination of technology and traditional audit methods, and proposes a method of embedding digital technology into the audit process.

1. Introduction

With the rapid development of the Internet, big data, artificial intelligence and other new generation information technologies, the powerful computing and analysis capabilities of information technology for data have opened up a new development space for the development of various industries. However, due to the complex equipment and various systems of the new technology data center, it is inconvenient for the planning, construction and operation and maintenance management of the project. The emergence of digital twins provides a new direction to solve the above problems. Digital twin is the equivalent mapping of digital model to physical system. The concept of digital twin was proposed by grieves at the University of Michigan in 2011. Since 2017, a large number of relevant research and applications have emerged. On April 7, 2020, the national development and Reform Commission and the central office of cyberspace and information technology released the implementation plan on promoting “cloud application and digital intelligence” to foster new economic development. It pointed out for the first time that digital twin is one of the seven new generation digital technologies, and also proposed the “digital twin innovation plan”. On December 21, 2021, the construction of the digital twin project of Datong gorge was officially launched, which is the first digital twin water conservancy project officially started in the water conservancy industry in China. Through the construction of a smart water conservancy system, the capacity of water regime monitoring and intelligent dispatching is improved with the river basin as the unit.

In the environment of digital innovation, digital technology will change the object and content of construction project audit. Construction project audit should carry out mode innovation and technology innovation on the basis of traditional audit ideas and methods. The use of digital technology, digital twins, intelligence and other technical means to strengthen audit quality and business process reengineering, so as to form a data-driven, flexible and effective audit innovation management mode, which will also be the general trend of the future development of construction project audit.

2. Analysis of Construction Project Characteristics under Digital Technology

In the engineering construction industry, the current application directions of digital twinning include: Twinning a component in the construction of a construction project to solve the problem of visualization of geometry and texture of engineering components; Twin a specific scene in the construction project to solve construction application problems; Twinning a certain kind of problems in construction projects to produce a set of commercial solutions; Twin the construction

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process of the construction project, establish and improve the platform of the whole process, such as the management platform of the whole life cycle and the decision-making assistance platform.

Although BIM Technology has also mentioned “full life cycle” in the past, one difference between BIM Technology and digital twin is that BIM is a static concept, which builds a digital model of real physical entities in computers, but mainly focuses on design and production issues; Digital twin emphasizes the dynamic whole process of the whole construction project and reflects the dynamic changes of real physical entities in real time. [1]Typical applications of digital technology in various stages of the “full life cycle” of construction projects include but are not limited to site analysis, function analysis, space analysis, public facilities analysis and information model analysis in the design and production stage, construction planning, cost control, schedule management and construction simulation in the construction stage, property management, energy monitoring and safety emergency, model maintenance and model interconnection in the operation and maintenance stage.

2.1 Engineering Design Stage

At the design and production stage, there are already some intelligent cloud based engineering management software to provide the general data environment CDE of the project. In 2016, the United Kingdom formally mandated that all public and civil buildings must meet the BIM maturity level 2, of which the use of this common data environment CDE is an important indicator. [2]However, at present, the main function of the software is visualization and multi-party collaboration, so as to manage the project. It does not support the editing and processing of models, and the supported document format is limited, which has not been more reflected in intelligent diagnosis and prediction.

In terms of domestic design standards, the design scheme of Sichuan highway institute includes a powerful cloud based design and production collaboration system CCDs, which digitalizes and standardizes all design information. It can not only guarantee and assist the fine modeling, but also save the time and cost of multi-party collaboration, and ensure the horizontal and vertical delivery quality of information.

2.2 Project Construction Stage

In the construction stage, artificial intelligence technology, such as machine vision, image processing, virtual reality and other means, is also used to solve some problems in the construction stage, including schedule management, construction productivity monitoring, face recognition and so on. In addition, the neural network deep learning model can be used to identify chaotic construction sites, and the laser point cloud technology can be used in process quality control and completion quality acceptance. Although some applications have not been promoted on a large scale at this stage, they have been well verified in many projects.

2.3 Project Trial Operation Stage

In the trial operation stage, in order to understand the status and evolution of the internal performance of the facility structure, various detection instruments, such as concrete radar detectors, can be used to visually present the asset operation and maintenance status through intelligent data collection. Carry out daily inspection for the diseases generated on the route, and associate them with the corresponding components of the BIM model, so as to achieve fine management at the construction level. For specific highway facilities, based on bridge inspection standards, diseases can be effectively collected and processed, and integrated into the geometric model components of the bridge, providing high-quality data support for subsequent intelligent analysis.

3. Theoretical Framework of Construction Project Audit Based on Digital Technology

3.1 Principal Agent Structure of Construction Project Audit

At present, construction projects involve many stakeholders and have complex access to resources, which leads to more information asymmetry among stakeholders of the project and

different types of principal-agent relationships. Based on the current situation in China, the principal-agent relationship of construction project audit is shown in the figure below.

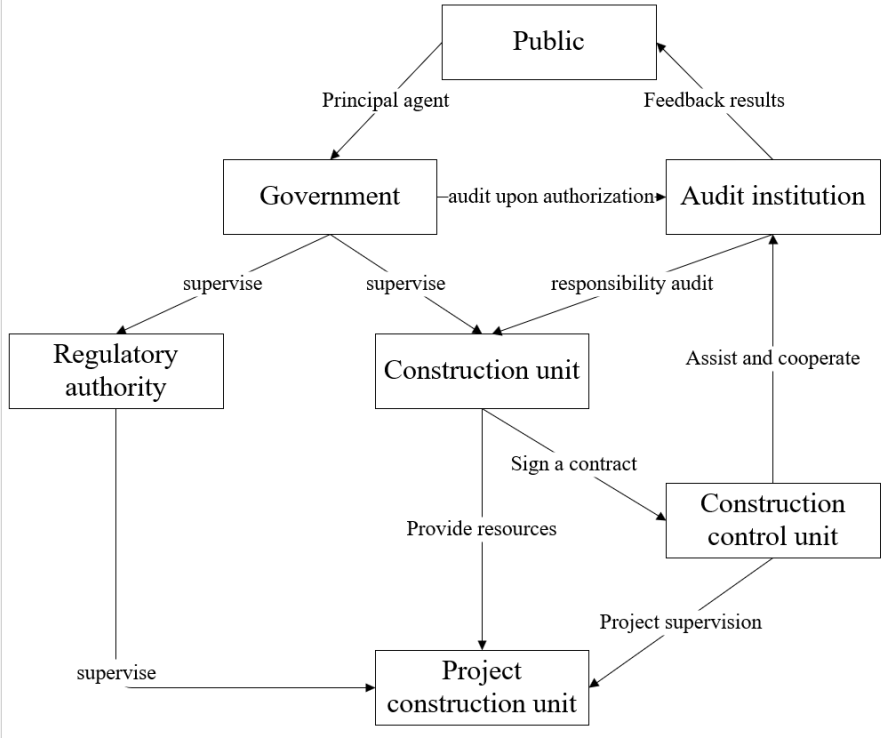

Fig.1 Principal Agent Relationship of Construction Project Audit

Combined with the discussion of audit theory and the situation of construction projects, the principal-agent relationship of construction project audit includes the principal-agent relationship formed by the supply of resources between both parties, the principal-agent relationship formed according to the project contract, and the relationship between the regulatory department and the construction unit formed based on the relevant laws and regulations of the construction project. In the whole process of construction project audit, the government accepts the entrustment of the public, sends audit departments to check the completion of each unit's responsibilities, and then the audit institutions give feedback to the government and the public. [3]Generally speaking, the management responsibility of the agent for the construction project undertaken by the client is composed of financial responsibility and business responsibility. However, due to the incompleteness of the contract, uncertainty of the environment, asymmetric information and other factors, the agent may deviate from the expectations of the client, so that the client needs to audit the performance of the agent's management responsibility for the above projects.

3.2 Audit Subject

According to the regulations of China's government audit, the national audit department is the main body of construction project audit, but due to the complexity and professionalism of construction projects, it is slightly difficult for the national audit department to complete the audit independently, and it needs to cooperate with the project supervision unit. According to the above Discussion on the entrusted agency structure of construction projects, during the audit process, the construction unit can establish a platform through digital technology, The whole process of the project is tracked on the digital twin platform, and the project supervision department also assists and cooperates with the audit work of the audit department. However, it should be noted that the audit body is still the audit institution. The audit institution conducts an overall audit of the use of funds and the performance of responsibilities in the implementation of construction projects. With the assistance of other departments, it makes full use of audit resources and improves audit quality.

3.3 Audit Objects

Although the stakeholders involved in the construction project are complex and the information is asymmetric, according to the above analysis of the principal-agent structure, the audit object is mainly the financial responsibility and business responsibility of the construction unit in the project. The financial responsibility of the construction unit is to effectively use financial resources as required by the government and truthfully report the use of financial resources. The business responsibility of the construction unit is to perform the construction management responsibility. Generally speaking, when the third party provides project construction and related services, the construction management responsibility of the construction unit includes investment decision-making, bidding management, project progress management, project quality management, project investment management, project completion acceptance management, etc. These construction management responsibilities form the business responsibility of the construction unit. Construction project audit needs to do a good job in tracking the whole process of construction projects and promoting the improvement of audit efficiency.

3.4 Audit Contents

After the introduction of digital technology into the construction project, the data of various aspects of the project can be integrated. Construction project audit will be transformed into cost audit and quality audit. Due to the integration of data, the cost audit can be directly based on the financial expenditure at different stages of the construction project, that is, the project budget audit, the construction drawing budget audit, the completion settlement audit and the completion settlement audit in the traditional audit content. Quality audit relies on digital technology for integration in the three traditional dimensions of auditing whether the implementation of projects conforms to relevant laws and regulations, auditing whether the relevant information about project quality is true, judging the performance level of projects, analyzing why there are differences in project quality, auditing whether the relevant systems of project quality are sound and whether they are effectively implemented, The need for professional judgment can be reduced.

4. Challenges of Construction Project Audit in Digital Twin Environment

4.1 Establish Unified Technical Software and Normative Standards

In traditional projects, because the project design drawings are scattered, it is difficult for auditors to directly imagine the real scene of the project in combination with the surrounding environment. This is also the reason why the auditors found that the design results did not meet the expectations in the late stage of construction, but the construction party was unable to modify them. [4]For today's increasingly complex project engineering, it often needs the coordination and cooperation of multiple units in many aspects. Without unified norms and standards, it is difficult to achieve the standardization and unification of resource data, which brings difficulties to the work of auditors. At the same time, China has no mandatory provisions on the popularization of BIM Technology in the industry. At present, many owners do not understand the concept of Bim and will not impose requirements in the project, which leads to the failure of BIM Technology to be popularized in all stages in the follow-up work. In the digital twin environment, BIM data needs to be integrated so that all parties in the project can share digital resources in real time.

4.2 Digital Technology Needs to Form a Complete System

At present, the application of BIM Technology Used in construction project audit involves various specialties, and the software functions differentiated therefrom are also different. For a project, the modeling data may not interact among the design unit, cost unit and construction unit due to the use of different BIM software, and each unit needs to build models for the same project separately. This large amount of repetitive work seriously affects the efficiency of project promotion. At present, BIM Technology is not integrated with the electronic audit system. Although data information and project materials can be uploaded, downloading materials requires process

approval. If a BIM data is uploaded at each stage, it will not only prolong the audit time, but also increase the audit workload of auditors. Digital technology needs to promote the coordinated application of various specialties and improve the overall management ability.

4.3 Integrate Engineering Quantity Calculation and Contract Price with Engineering Data

At present, the training of BIM Technology is mostly carried out by schools, BIM software manufacturers and some work units, and the learning objects are mostly students, designers, cost workers, construction workers, etc. At present, the focus of engineering audit is still on traditional drawings, engineering quantity calculations, contracts, etc. BIM software may only play an auxiliary role for auditors. Moreover, BIM software is difficult to learn and contains many functions, which may be difficult to popularize among auditors. Auditors do not pay enough attention to the study of BIM Technology, resulting in a lack of ability and experience in auditing using BIM Technology. After combining digital technology, we should combine engineering quantity calculation, contract calculation, etc. with engineering data, not only to serve audit, but also to enable all parties to the project to deal with their work more clearly.

5. How to Embed Digital Technology in Construction Project Audit

From the basic data acquisition layer to the top-level application layer, the digital technology system can be divided into four layers: Data assurance layer, modeling and calculation layer, digital twin function layer and immersive experience layer. The realization of each layer is based on the previous layers, which further enriches and expands the functions of the previous layers. At present, the audit work of construction projects needs to be based on the digitalization of the project process, so that the audit link can be embedded in the digitalization of the project. Only in this way can the advantages of the fine collection of audit evidence, the intelligence of information processing, and the timeliness of the application of audit results be realized, which effectively guarantees the needs of construction investment management of engineering projects and realizes the full life cycle audit of construction projects.

5.1 Engineering Design Stage

The audit contents at this stage include the project investment decision-making audit and the project design management audit. Before the implementation of the project investment plan, the auditors confirm the strategic objectives of the project with the management personnel, and audit the economic effect conclusion and measurement process of the project investment.

By importing the basic BIM data of the project into the data support layer of the digital twin platform, auditors can carry out simulation hypothesis analysis and virtual planning, promote the advance deployment of engineering projects, and help avoid unreasonable and unscientific planning and design. Through the three-dimensional information model and visual system, simulation and dynamic evaluation are carried out in quantitative and qualitative ways to ensure the optimization of the comprehensive benefits of the project. [5]Through the establishment of the urban information model platform, more planning data are gathered and various models are constructed to provide decision-making basis for the planning and design of the project. At the same time, it makes use of the recognizable and analyzable characteristics of the data information model to visually analyze the operation data of the project, comprehensively monitor the project from the three levels of environmental monitoring feedback, construction monitoring feedback and operation monitoring feedback, analyze and sort out relevant problems, summarize and constantly optimize the design scheme.

5.2 Project Planning Stage

The audit content at this stage is centered on the project contract and bidding. The auditors take the relevant clauses of the construction project contract as important basis, which are recorded in the project bidding document, to review and evaluate the effect of various contracts and management work in the project construction and the specific implementation of the project

contract audit.

The project designer can use Bim and digital technology to shape the digital entity of the project and its surrounding environment in the modeling and calculation layer, and establish the information data model. The auditor can scientifically verify the relationship between the design scheme and the project environment while the designer is doing interactive design in the visual environment, so that the problems in the contract can be exposed in advance and solved in the design stage. Each discipline should first establish its own three-dimensional data model, and then unify all sub discipline models to form a full discipline model.

5.3 Project Construction Stage

After the project enters the construction stage, the construction project audit mainly focuses on the cost audit and quality audit, and reviews all the project processes one by one according to the preparation order of the national or industrial construction project budget quota or the construction order. Audit the project quality level based on the construction project plan, design documents and technical acceptance specifications. The contents include the evaluation of project quality indicators, various labor and material losses, and whether major liability accidents have occurred.

Under the background of digital twin technology, auditors can use the unique space-time characteristics of digital technology to simulate the project construction scheme at the digital twin functional layer, and comprehensively control the progress, quality and cycle of the project. At this stage, the data model can be used to simulate the lifting scheme of large equipment and to conduct collision detection of pipelines. This stage is the most mature stage in the application of BIM Technology, especially in the electromechanical discipline. Whether it is water supply and drainage, HVAC or electrical, digital technology can form three-dimensional visual models such as pipeline integration, pipeline installation and positioning, and optimize the design scheme.

5.4 Project Trial Operation Stage

Project trial operation audit is an important index to evaluate the quality of the project, mainly by calculating the social, economic and ecological benefits carried by the project. But the traditional audit lacks effective follow-up.

Digital technology is introduced. After the project is delivered, the archived design and construction data will be imported into the immersive experience layer of the digital twin model, and a spatiotemporal database will be built to accurately display the whole picture and details of the building. At the same time, sensors and monitoring equipment are deployed in the internal and external space of the building to collect building environment, equipment operation, component pressure and strain, video monitoring, abnormal alarm and other data, and carry out intelligent analysis and scientific prediction based on the digital twin model. Auditors can evaluate the benefits of the project through the analysis and prediction of big data.

6. The Future Prospect of Construction Project Audit under the Background of Digital Twin

The construction project audit under the digital twin background will further enrich the audit technical means and improve the audit efficiency by using big data analysis and artificial intelligence technology on the basis of the digital technology of traditional construction audit. Digital technology also provides multi-directional innovation in audit methods and technologies for construction project audit, transforming the traditional single “post audit” management mode into a “pre prevention + in process control” management mode, thus greatly reducing audit risks. In the future, on the basis of building process informatization and management resource informatization, we will further study the “remote + on-site” audit mode, further optimize and increase the audit data model, implant “audit probes” in all nodes of the process, and reflect audit early warning information and correction results in real time, further enhance the system's ability to automatically supervise and identify major problems, and improve the efficiency and effect of review, Further enhance the efficiency and support value of system review.

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