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Research on Audit Risks and Countermeasures for Integrated Plant-Network Wastewater Treatment Projects under the Concession Model

-- With the Pricing Mechanism as the Core

Wenchang Xu, Jianning Ma, Manru Wang, Ankang Chen, Dier Yu*

Nanjing Audit University, Nanjing, Jiangsu, 210000, China

*Corresponding Author

Abstract

Audit risks in integrated plant-network wastewater treatment projects under the concession model occur most frequently in the pricing process. Constrained by a dual structure characterized by information asymmetry between government and enterprises, the concealment of sewer-network assets, and the difficulty of quantifying performance, the prevailing cost-plus pricing model can easily lead to inaccurate pricing, such as strategic cost inflation by enterprises and delayed price adjustment. These problems further intensify fiscal fund risks and government-enterprise bargaining. As the central hub maintaining the closed funding loop of the project, the pricing mechanism connects investment and financing, cost authenticity, and performance achievement. Therefore, auditing should shift from routine compliance review to whole-process auditing. The audit threshold should be moved forward to the investment, financing, and construction stages. Technical methods such as geological comparison and geophysical spot checks should be introduced to conduct penetrating verification of the authenticity of equity capital and the cost of hidden works, thereby locking in the cost base. Meanwhile, the integration of business and finance and digital auditing should be promoted. Network performance indicators, including COD collection concentration and structural integrity rate, should be set as preconditions for price adjustment. In this way, a regulatory closed loop of pricing based on true costs and payment based on comprehensive performance can be established. At the institutional level, concession agreements and life-cycle cost benchmarking models should be optimized so as to safeguard fiscal security and improve the effectiveness of water environment governance.

Keywords

Concession Model; Integrated Plant-Network Wastewater Treatment; Pricing Mechanism; Audit Risk; Whole-Process Audit.

1. Introduction

Wastewater treatment is a basic public service for ensuring urban ecological security and public health, and it is also a key support for ecological civilization construction. With the continuous progress of urbanization in China, the scale of urban wastewater discharge has increased year by year, and residents' demand for wastewater treatment has continued to expand. The Water Pollution Prevention and Control Law, as amended in 2017, clearly requires centralized urban wastewater treatment and links facility construction, operation, and maintenance with water-environment quality and public health. At the national level, the 14th Five-Year Plan for urban wastewater treatment and resource utilization, together with policy

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documents on pollution reduction and carbon reduction, repeatedly emphasizes the importance of wastewater treatment for new-type urbanization and optimal allocation of water resources [1]. From the perspective of environmental economics, wastewater treatment addresses the negative externalities caused by pollution, while the pricing mechanism is a crucial tool for coordinating treatment costs and optimizing resource allocation [2].

However, audit risks have become prominent in the practical implementation of concession projects, and the pricing mechanism is the core area in which such risks occur. Most domestic wastewater projects adopt a cost-plus pricing model. Under the constraint of information asymmetry between government and enterprises, problems such as distorted cost accounting, lengthy and delayed price-adjustment procedures, and weak implementation of contractual price-adjustment clauses are common, thereby intensifying price bargaining between government and enterprises [3]. Local audit offices have successively carried out special audits of wastewater projects and identified control loopholes in cost pricing and service-fee payments. Unreasonable pricing of wastewater treatment has caused unnecessary fiscal losses. Against this background, studying audit risks and control countermeasures for integrated plant-network wastewater projects under the concession model from the perspective of the pricing mechanism has both theoretical and practical significance for regulating concession performance, protecting fiscal funds, and improving the effectiveness of wastewater governance.

2. Current Status of the Plant-Network Integration Operation Model for Wastewater Treatment under the Concession Model

To promote ecological civilization construction, support the green and low-carbon transformation of infrastructure, and realize green development, the Regulations on Urban Drainage and Wastewater Treatment issued by the State Council in 2013 explicitly encouraged the use of concession, government purchase of services, and other forms to attract private capital to participate in the investment, construction, and operation of urban drainage and wastewater treatment facilities [4]. Since then, the concession model has been applied to wastewater treatment projects, accelerating the process of integrated water-services development. The Three-Year Action Plan for Improving the Quality and Efficiency of Urban Wastewater Treatment (2019-2021) clearly proposed the plant-network integration operating model, called for improving the long-term management mechanism of drainage systems, and promoted integrated and professional operation and maintenance of wastewater treatment plants, sewer networks, and river-lake water bodies, so as to ensure the systemic integrity and completeness of wastewater collection and treatment facilities [5]. Extending the scope from plants to networks and then to rivers and lakes has expanded the boundary of concession projects, marketized wastewater treatment projects, and further promoted the integration and collaboration between the concession model and wastewater treatment projects.

China's water industry is undergoing a transformation from single-service provision toward an integrated service system. The development path from urban-rural water-supply integration to plant-network integration reflects a trajectory from points to areas and from easier tasks to more difficult ones. In the early stage, urban-rural water-supply integration mainly solved the dual structure of urban and rural water supply through unified pricing and payment. At that stage, pricing primarily addressed cost allocation. Around 2014, in response to the need to improve wastewater treatment efficiency, the plant-network integration model began to develop. Starting with the PPP project for purchasing wastewater treatment and municipal drainage services in the main urban area of Chizhou, the integration of urban water services accelerated. The scope of pricing expanded from a unit price for wastewater treatment to a comprehensive price covering initial project construction, operation and maintenance costs,

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renewal costs, and wastewater treatment fees, while performance assessment was also incorporated into the pricing scope. This promoted the construction of a performance-oriented pricing mechanism. The integration of wastewater treatment assets mainly includes acquisition, concession, and gratuitous government transfer. Among these approaches, the pricing mechanism plays an important role in the concession model. With the support of the pricing mechanism, concession has developed from a financing and construction tool for a single project into a long-term cooperation mechanism that supports the green and low-carbon transformation of an entire urban water system. It provides market-based and investment-financing channels for wastewater treatment projects, converts the government's one-time large sunk cost into predictable long-term operating service fees, and promotes the upgrading of governance models and the integration of the water industry.

3. The Funding Closed Loop of Wastewater Treatment Projects under the Concession Model

The concession model is an institutional arrangement in which the government grants the construction and operation rights of public infrastructure to private capital through open tendering, allowing the private party to recover costs and obtain reasonable returns through user payments. In wastewater treatment projects, local governments may also entrust enterprises with investment and financing, construction, and operation as a whole. Under this model, integrated plant-network projects generally follow the operating process of open tendering, signing of the concession agreement, investment-construction-operation by the project company, performance-based payment, and asset transfer.

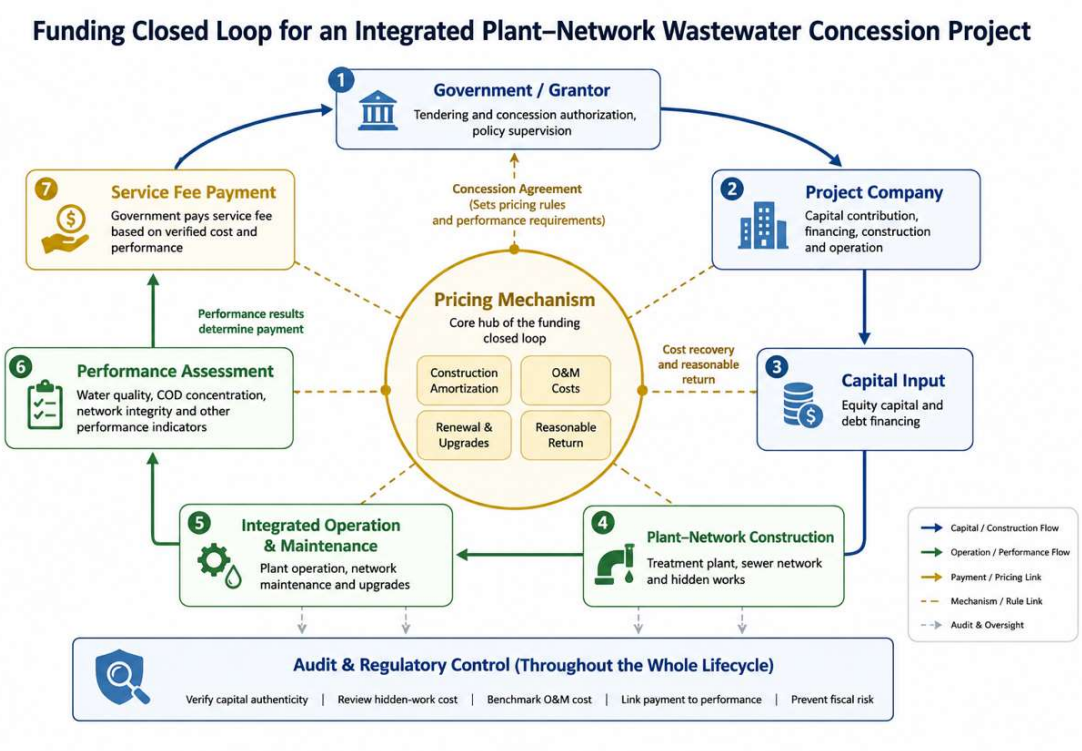

Figure 1. Funding closed loop for an integrated plant-network wastewater concession project

The pricing mechanism is the core hub that maintains the operation of the funding closed loop in integrated plant-network projects. Enterprises first invest equity capital and financing funds to complete plant-network construction. During the operation period, they recover costs and obtain returns through wastewater treatment service fees. At the end of the concession period,

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the assets are transferred to the government free of charge, thereby forming a complete capital cycle. Within this closed loop, pricing plays a bridge role of two-way adjustment and directly determines whether enterprises can cover costs and whether government expenditure is sustainable. Existing studies indicate that wastewater treatment pricing consists of construction amortization, operation and maintenance costs, renewal and renovation costs, and reasonable returns. The accuracy of this calculation directly affects project sustainability [6]. If the price is too low, the enterprise's cash flow will be under substantial pressure. To maintain profits, the enterprise may reduce investment in network operation and maintenance, which can aggravate network leakage, reduce COD collection concentration, and ultimately lead to accelerated asset deterioration and risks of effluent non-compliance [7]. Conversely, if the price is too high, the efficiency of fiscal fund use will decline and a long-term fiscal burden will emerge. Therefore, pricing is not merely the result of financial calculation; it is also a key lever for regulating enterprise operation and maintenance behavior and the scale of government expenditure. A reasonable price should cover true costs and impose binding constraints on network performance, so that the funding closed loop can operate sustainably.

4. Audit Risks and Countermeasures for Wastewater Treatment under Plant-Network Integration

4.1. Audit Risk: Inaccurate Pricing Mechanism

The pricing of wastewater treatment projects involves large upfront sunk costs and the integration of existing assets. In addition, because standardized market-based pricing data are insufficient, it is often difficult for private capital to formulate reasonable service-fee standards. If the fees collected in the later stage cannot cover full life-cycle costs, the willingness of private capital to invest will be greatly weakened. In terms of pricing composition, wastewater treatment service fees need to cover both the direct costs of wastewater treatment and the reasonable profit returns of enterprises [8]. The return for integrated plant-network projects usually takes the form of wastewater treatment service fees. However, the service fees currently collected often cannot cover the expenses required for the normal operation of sewer networks and wastewater treatment facilities; therefore, reasonable fiscal subsidies from the government are still needed.

The effluent quality and quantity of the plant area are relatively easy to measure and assess, while the collection rate, structural health, and leakage level of the sewer network are extremely difficult to quantify and monitor directly. This creates a dual structure in performance assessment and provides an internal incentive for enterprises to strategically classify and inflate costs. Enterprises may have stronger motives to overstate the cost of hidden works, package routine maintenance expenditure as renewal and renovation costs, or allocate non-project expenditures to network operation and maintenance, thereby systematically pushing up the pricing level [9]. If the price is too high, the government may be forced to pay for ineffective services. On the one hand, inflated pricing is often based on overestimated construction investment, imprecise budget estimates, and inflated operating costs, which causes fiscal funds to be locked into sunk costs for a long period and prevents transfer payments from achieving maximum effectiveness. As a result, the efficiency of fund use declines and the government faces long-term fiscal pressure. On the other hand, if the wastewater treatment service fee is set too low and falls below a reasonable market level, private capital may be constrained by insufficient returns to cover costs. This may lead to compression of construction costs at the early stage, untimely project maintenance, and later-stage corner cutting in construction, which can cause secondary pollution and further reduce the quality and utility of wastewater treatment projects. In summary, inaccurate pricing affects not only the profit or loss of a single project, but also the security of public finance and the sustainable development

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of the urban water environment. Therefore, it is urgent to build a pricing audit and regulatory system based on full-cost accounting, dynamic adjustment, and close linkage with performance.

4.2. Audit Countermeasures and Paths

While the concession model improves system efficiency, the natural concealment of sewer-network assets and the difficulty of fully stipulating long-term performance in contracts require auditors to focus on ambiguous areas of government-enterprise rights and responsibilities in concession agreements. These areas include the ownership of network assets, the allocation of renewal and renovation responsibilities, and clauses that may trigger government backstop obligations, so as to prevent implicit fiscal expenditure risks caused by unclear responsibility boundaries [10]. Meanwhile, against the background of a long-term single financing channel and an incomplete risk-sharing mechanism in the water industry, when project capital is fully raised by private capital, the fundamental change in capital structure shifts the audit focus from reviewing the compliance of fiscal fund payments to conducting penetrating verification of the authenticity of private capital's equity funds and the risks of market-based financing [11]. In audit practice, the paid-in status and compliant source of project equity capital constitute the first line of defense against risks. Auditors should focus on verifying whether the private party has fully paid in equity capital as agreed and should resolutely prevent false capital contributions or subsequent capital withdrawal that would transfer investment risks to the public finance. At the same time, attention should be paid to the accounting boundary of financing costs. Financing expenses directly related to the project should be strictly distinguished from the enterprise's overall financial expenses, in order to prevent enterprises from packaging unrelated financing costs into total project costs and artificially increasing the price of wastewater treatment service fees [9].

The wastewater treatment pricing mechanism is the most important and difficult audit issue in the operation of the project's funding closed loop. Project pricing is mainly composed of construction amortization, operation and maintenance costs, renewal and renovation costs, and other reasonable returns. It is the foundation for maintaining the financial sustainability of concession projects and ensuring the efficiency of fiscal fund use. Therefore, auditing should penetrate and verify the basis for cost allocation between the plant and the network. Because the sewer network is a hidden work, the verification of its cost is inherently difficult. In addition to conventional cost review, auditors should introduce methods such as geological-condition comparison and geophysical spot checks to cross-verify the actual quantities of works on key road sections. On this basis, the achievement of network performance indicators, such as whether COD collection concentration has significantly improved and whether the structural integrity rate meets standards, should be clearly set as a precondition for initiating the next round of price adjustment. Payment should be genuinely linked with performance, thereby establishing an audit and regulatory closed loop of pricing based on true costs and payment based on comprehensive performance [7]. This approach can prevent the government from paying for ineffective services when the price is higher than the market level, and it can also provide an effective safeguard against delayed operation and maintenance or shutdowns caused by excessively low pricing.

5. Conclusion and Implications

This study shows that the audit core of integrated plant-network wastewater treatment projects under the concession model lies in the pricing mechanism. The pricing mechanism is not only the hub of the funding closed loop, but also the key audit node that connects investment and financing risks, cost authenticity, and performance achievement. The study finds that the causes of inaccurate pricing are complex. They may stem from disguised debt financing under the appearance of equity investment and inflated construction-period costs in the investment

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and financing stage, and they are also constrained by the dual-structure dilemma in which network performance is difficult to quantify and monitor. Audit work needs to realize a paradigm shift from compliance inspection to whole-process auditing. First, the audit threshold should be moved forward to the investment, financing, and construction stages, and a mandatory completion-settlement audit should be used to lock in the pricing cost base and eliminate source distortion. Second, the integration of business and finance should be promoted. Geological and geophysical exploration, Internet of Things data, and other means should be used to cross-verify network costs and operating costs, transforming engineering technical indicators into auditable performance evidence. Third, digital auditing should be explored by establishing an industry data benchmark database and realizing intelligent warnings for abnormalities. From the perspective of governance, concession agreements should be optimized, the rigid linkage between performance and payment should be refined, and a pricing model based on full life-cycle costs and industry benchmarking should be promoted. In this way, an incentive-compatible regulatory system can be built at the institutional level, ultimately achieving the threefold goals of fiscal fund security, improved public services, and sustainable enterprise development.

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