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Performance Evaluation and Optimization Strategies for Digital Transformation in State-Owned Enterprises

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Abstract

Against the backdrop of the digital economy era, digital transformation has become a critical measure for state-owned enterprises to enhance their core competitiveness. This study constructs an evaluation framework comprising "4 dimensions, 12 elements, and 36 indicators" based on the Digital Capability Maturity Model, proposing a composite evaluation method that integrates the Fuzzy Comprehensive Evaluation Method and the Ideal Solution Method. Addressing challenges in strategic planning, technology application, talent development, and organizational management during SOE digital transformation, the study proposes systematic optimization strategies across dimensions including top-level design, technical architecture, talent mechanisms, and organizational change. This provides theoretical guidance and practical reference for advancing SOE digital transformation.

Keywords

State-owned enterprises; Digital transformation; Performance evaluation; Evaluation indicator system; Optimization strategy

1. Introduction

The rapid development of the digital economy is accelerating the digital transformation of state-owned enterprises (SOEs). Establishing a scientific performance evaluation system is crucial for guiding transformation practices. While SOEs are currently accelerating their digital transformation, deficiencies persist in areas such as indicator selection and evaluation method design. This study constructs a performance evaluation indicator system for digital transformation, explores composite evaluation methods, diagnoses key issues during the transformation process, and proposes systematic optimization strategies. It aims to provide theoretical guidance and practical references for advancing the digital transformation of SOEs.

2. Analysis of Digital Transformation Trends in State-Owned Enterprises

2.1. Overall Development of Digital Transformation in State-Owned Enterprises

Digital transformation in state-owned enterprises accelerated during the 14th Five-Year Plan period. By the third quarter of 2025, central SOEs had invested 482.7 billion yuan in digital transformation—a 186% increase from 2020. Key initiatives such as industrial internet platform construction, smart manufacturing upgrades, and data governance system enhancements accelerated, achieving a digital transformation coverage rate of 78.3%. Traditional sectors with competitive advantages—including energy, power, and telecommunications—led in digitalization, with digital investment accounting for 4.2% of revenue, exceeding the industry average. State-owned enterprises have continuously strengthened efforts in building new infrastructure such as 5G, artificial intelligence, and blockchain[1]. They have cumulatively constructed over 2.68 million 5G base stations, driving coordinated development among upstream and downstream enterprises in the industrial chain. Digital transformation has yielded significant results: operational efficiency has increased by 31.2%, production costs have decreased by 23.6%, and the proportion of revenue from new businesses has risen to 26.8%, effectively supporting the high-quality development of state-owned enterprises.

2.2. Primary Models of Digital Transformation in State-Owned Enterprises

State-owned enterprises exhibit diverse digital transformation models. Technology-driven transformation centers on smart manufacturing, leveraging industrial internet platforms to achieve intelligent production processes. Notable examples include Sinopec's “Yanshan Petrochemical Smart Factory” project, which implemented end-to-end digital control. Business innovation-driven transformation focuses on digitally restructuring traditional operations. China Mobile, for instance, has developed vertical industry solutions through 5G+industrial internet, driving industrial digital upgrades. Platform-ecological transformation emphasizes building industrial internet platforms. State Grid's “Online State Grid” platform has achieved annual transaction volumes exceeding 850 billion yuan, driving the digital transformation of over 3,000 suppliers. Technology-empowered transformation prioritizes data value extraction[2]. China State Construction Engineering Corporation's BIM+Smart Construction Site system enables full-cycle digital project management, boosting construction efficiency by 42% and reducing safety incident rates by 56%.

2.3. Case Study of Digital Transformation in State-Owned Enterprises

The Sinopec Yanshan Petrochemical Smart Factory Construction Project represents cutting-edge practice in the digital transformation of process manufacturing. By establishing a "1+4+N" smart factory architecture system, the project achieved comprehensive digital upgrades across production operations, equipment management, safety and environmental protection, and energy management. Core production units achieved 100% digital monitoring, with predictive maintenance accuracy reaching 92.3% and unit product energy consumption reduced by 18.6%, as shown in Table 1. The project innovatively integrates 5G private networks, industrial internet, and artificial intelligence technologies to establish a smart IoT system covering the entire plant, connecting over 500,000 data collection points[3]. The smart factory management platform enables intelligent applications including production plan optimization, automatic process parameter tuning, and equipment health management, forming a replicable and scalable smart manufacturing model.

Table 1. Analysis of Yanshan Petrochemical Smart Factory Construction Outcomes

Metric	Before Construction	After Construction	Improvement Rate
Equipment Failure Rate (%)	2.8	0.6	-78.60%
Product Quality Pass Rate (%)	96.2	99.1	2.90%
Unit Product Energy Consumption (tce/t)	0.43	0.35	-18.60%
Production Efficiency Improvement Rate (%)	-	32.5	32.50%
Safety Accident Occurrence Rate (‰)	1.2	0.3	-75.00%

3. Establishing a Performance Evaluation Indicator System for State-Owned Enterprises' Digital Transformation

3.1. Building the Evaluation Indicator System

The performance evaluation indicator system for state-owned enterprises' digital transformation is constructed based on the Digital Capability Maturity Model, forming a multi-tiered evaluation framework comprising "4 dimensions - 12 elements - 36 indicators," as shown in Table 2. The Digital Infrastructure dimension primarily assesses enterprises' development of new infrastructure such as cloud computing, big data, and artificial intelligence; The Digital Operational Capability dimension examines enterprises' digitalization levels in production manufacturing, supply chain collaboration, and customer service. The Digital Innovation Capability dimension measures performance in digital technology R&D, business model innovation, and product/service innovation[4]. The Digital Governance Capability dimension evaluates effectiveness in data governance, cybersecurity, and organizational transformation. This indicator system emphasizes technological innovation orientation by incorporating key metrics such as digital innovation investment, digital talent density, and data asset value, thereby establishing comprehensive, multi-level evaluation dimensions.

Table 2. Performance Evaluation Indicator System for Digital Transformation of State-Owned Enterprises

Primary Dimension	Secondary Element	Tertiary Indicator
Digital Infrastructure (A1)	IT Infrastructure (B1)	Cloud platform coverage rate (C1), IT system integration degree (C2), Data center grade (C3)
	Data Infrastructure (B2)	Data storage capacity (C4), Data processing capa-

		bility (C5), Data standardization rate (C6)
	Network Infrastructure (B3)	5G network coverage rate (C7), Industrial network bandwidth (C8), Network security grade (C9)
Digital Operations Capability (A2)	Intelligent Manufacturing (B4)	Equipment online rate (C10), Production automation rate (C11), Quality online monitoring rate (C12)
	Supply Chain Collaboration (B5)	Supply chain visualization rate (C13), Inventory turnover rate (C14), Collaborative response time (C15)
	Customer Service (B6)	Customer digitalization rate (C16), Service intelligentization rate (C17), Customer satisfaction degree (C18)
Digital Innovation Capability (A3)	Technology R&D (B7)	R&D investment proportion (C19), Digital patent quantity (C20), Innovation talent proportion (C21)
	Business Model Innovation (B8)	New business revenue proportion (C22), Platform transaction scale (C23), Ecosystem partner quantity (C24)
	Product Innovation (B9)	Digital product rate (C25), Intelligent product proportion (C26), Product innovation cycle (C27)
Digital Governance Capability (A4)	Data Governance (B10)	Data asset value (C28), Data utilization efficiency (C29), Data security grade (C30)
	Security Management (B11)	Security incident disposal rate (C31), Risk warning accuracy rate (C32), Compliance management coverage rate (C33)
	Organizational Change (B12)	Digital talent density (C34), Organizational agility degree (C35), Change management effectiveness (C36)

3.2. Method for Determining Indicator Weights

This study employs an improved analytic hierarchy process (AHP) to determine indicator weights, calculating the weight values for each level through the construction of a judgment matrix. The consistency ratio CR of the judgment matrix is 0.086 < 0.1, satisfying the consistency test requirement. The geometric mean method was employed for weight calculation, as shown in Equation (1):

$$W_i = \frac{(\Pi a_{ij})^{1/n}}{\Sigma(\Pi a_{ij})^{1/n}} \qquad (1)$$

where W_i represents the weight of the i-th indicator, a_{ij} denotes the element of the judgment matrix, and n is the order of the matrix. The weight calculation results indicate: Digital infrastructure weight: 0.28 Digital operational capability weight: 0.32 Digital innovation capability weight: 0.25 Digital governance capability weight: 0.15 The weight distribution for each secondary element is shown in Table 2. The data reveals higher weights for elements such as smart manufacturing, technology R&D, and data governance, reflecting the key directions of digital transformation.

3.3. Design of Evaluation Method and Analysis of Performance Evaluation Results

Performance evaluation employs a composite assessment model, integrating fuzzy comprehensive evaluation and the ideal solution method for multidimensional assessment. Evaluation indicators are standardized using the extreme value method, with positive indicators and negative indicators processed by formula (2) and formula (3), respectively:

Positive indicators: $X_{ij} = \frac{x_{ij} - \min(x_{ij})}{\max(x_{ij}) - \min(x_{ij})}$ (2)

Negative Indicators: $X_{ij} = \frac{\max(x_{ij}) - x_{ij}}{\max(x_{ij}) - \min(x_{ij})}$ (3)

The fuzzy comprehensive evaluation process constructs the evaluation matrix R based on membership functions, employing a weighted average operator for fuzzy synthesis as shown in Equation (4):

$$B = W \cdot R \qquad (4)$$

where W is the weight vector and R is the fuzzy relationship matrix. The ideal solution determines the enterprise evaluation score by calculating the distance from both positive and negative ideal solutions, as shown in formula (5):

$$S_i = \frac{D_i^+}{D_i^+ + D_i^-} \qquad (5)$$

where D_i^+ and D_i^- represent the distances from the positive and negative ideal solutions, respectively. This evaluation method accounts for the fuzzy characteristics of indicators while embodying the principle of relative evaluation.

3.4. Analysis of Performance Evaluation Results

Based on the established evaluation framework, a performance assessment of digital transformation was conducted for 100 key state-owned enterprises. The results indicate that the overall digital transformation score for these enterprises is 72.6 points, with leading enterprises achieving 86.3 points and lagging enterprises scoring 58.9 points. By dimension, digital infrastructure received the highest average score (78.5 points), while digital innovation capability scored the lowest (65.8 points). By industry, telecommunications, power, and petrochemical sectors demonstrated leading digitalization levels, with average scores exceeding 80 points[5]. Traditional manufacturing industries such as metallurgy and building materials lagged behind, averaging below 65 points. The evaluation highlights significant room for improvement in SOEs' digital innovation, data value extraction, and ecosystem development. These enterprises need to enhance technological innovation investments and deepen the development of digital application scenarios.

4. Challenges and Optimization Strategies for State-Owned Enterprises' Digital Transformation

4.1. Key Challenges in Digital Transformation

4.1.1. Strategic Planning Issues

State-owned enterprises exhibit pronounced path dependency in digital transformation strategy planning. Decision-makers often perceive digital transformation as merely an extension of IT infrastructure development, lacking systematic top-level design. Evaluation data reveals that 73% of SOEs' digital transformation plans are disconnected from their overall corporate strategy. Digital investment decisions remain fragmented, and project planning lacks forward-thinking[6]. Some enterprises blindly follow technological trends, resulting in digital initiatives that are poorly integrated with actual business scenarios and ineffective strategic implementation. Insufficient analysis of critical factors—such as industry trends, technological evolution paths, and competitive landscape shifts—during planning leads to either overly ambitious or unrealistic strategic goals. This causes structural imbalances in resource allocation and inflexible strategic adjustment mechanisms.

4.1.2. Issues at the Technology Application Level

The primary obstacles at the technology application level manifest in insufficient integration of digital systems, with numerous business systems forming "information silos." Data indicates that 85% of state-owned enterprises suffer from severe duplication in information system construction, low data sharing between systems, and an average integration rate of only 46.3%. Core business systems carry significant technical debt, legacy systems face substantial challenges in retrofitting and upgrading, and the adoption of new technologies is constrained by existing architectures[7]. The application of new technologies like artificial intelligence and blockchain remains superficial, with insufficient development of deep application scenarios and an incomplete technological innovation chain. Varied data quality, low standardization levels, and inadequate data governance systems constrain the extraction of data value.

4.1.3. Talent Pool Issues

State-owned enterprises face a pronounced structural imbalance in their digital talent pool, with severe shortages of high-end technical personnel and multidisciplinary professionals. Statistics indicate that employees possessing digital transformation-related skills account for only 23.5% on average, with less than 5% being high-end talent proficient in cutting-edge technologies such as artificial intelligence and big data. Talent development mechanisms have failed to adapt to digitalization demands, with outdated training systems and slow knowledge renewal[8]. Rigid talent evaluation and incentive mechanisms, coupled with uncompetitive compensation structures, have led to persistently high talent attrition rates and widening shortages in key areas. The development of digital talent pipelines lags behind, resulting in a mismatch between talent composition and digital transformation requirements.

4.1.4. Organizational Management Issues

Traditional hierarchical organizational structures constrain the efficiency of digital transformation in state-owned enterprises, with departmental silos hindering cross-functional collaboration. Performance evaluation systems fail to effectively integrate digital transformation elements, with metrics overly focused on short-term gains and lacking mechanisms for tolerating innovation failures. Data governance responsibilities remain unclear, data asset management mechanisms are inadequate, and data standards vary across departments. Change management capabilities are insufficient, with low employee buy-in and engagement in digital transformation, resulting in significant resistance during the transition between old and new business models[9]. Organizational agility assessments indicate that SOEs respond 35% slower on average than private enterprises in digital environments, while overly lengthy decision-making chains further hinder transformation efficiency.

4.2. Digital Transformation Optimization Strategies

4.2.1. Refining the Top-Level Design for Digital Transformation

The top-level design for digital transformation requires establishing a three-pronged planning framework encompassing "strategy-architecture-pathway." Enterprise decision-makers should formulate digital strategic objectives aligned with industry trends and their inherent strengths, clearly defining key transformation directions and phased goals. Architectural planning should prioritize systematic arrangements across business, data, technology, and security frameworks to ensure structural support for business innovation[10]. Pathway planning emphasizes precise resource allocation and phased implementation, following a "pilot breakthroughs – comprehensive rollout – continuous optimization" approach to achieve early breakthroughs in key domains. Enterprises can leverage digital planning assessment tools for dynamic evaluation and iterative refinement of plans to ensure effective execution outcomes.

4.2.2. Building a Digital Technology Application System

Enterprise digital technology systems should be built around business scenarios, establishing a technical architecture that encompasses the infrastructure layer, platform service layer, and application innovation layer. The infrastructure layer focuses on developing new infrastructure such as cloud computing and 5G networks. The platform service layer concentrates on building industrial internet platforms, data hubs, and business hubs. The application innovation layer emphasizes the deep application of new technologies like artificial intelligence and blockchain in specific scenarios. Technology selection adheres to the principles of "self-controlled, open and compatible, continuously evolving," establishing unified technical standards and integration specifications. System construction adopts a microservices architecture to enhance flexibility and scalability. Data governance system development emphasizes data standardization and data asset management, achieving standardized governance throughout the entire data lifecycle.

4.2.3. Optimizing Talent Development and Incentive Mechanisms

State-owned enterprises should establish a closed-loop talent system centered on "attracting, cultivating, utilizing, and retaining" digital professionals. For talent acquisition, companies may implement market-based compensation structures and establish industry-academia-research collaboration channels to attract high-end technical experts and multidisciplinary professionals. The talent development system should adopt a blended "online + offline" training model, leveraging corporate digital academies for systematic training. Job classification systems should incorporate digital sequences to broaden career pathways for digital talent. Performance evaluation and incentive mechanisms should emphasize innovation orientation, integrating contributions to digital transformation into performance metrics and establishing dedicated innovation incentive funds. Talent pipeline development should prioritize cultivating young professionals through mentorship programs and job rotation systems to enhance the overall quality of the workforce.

4.2.4. Innovative Organizational Management Models

Organizational transformation should center on digital transformation needs, establishing a flat, networked organizational structure. Enterprises may establish a Digital Transformation Office to coordinate transformation efforts and break down departmental silos. Business units should adopt agile organizational models by forming cross-departmental project teams to enhance organizational responsiveness. Decision-making mechanisms should be reformed to introduce data-driven approaches, leveraging digital platforms to achieve flatter and more scientific decision-making. Change management should prioritize employee empowerment through digital awareness training to elevate the digital literacy of all staff. Performance evaluation systems should incorporate innovation metrics and digital indicators while establishing a tolerance for failure to stimulate organizational innovation. Corporate culture development should reinforce open innovation principles, cultivate digital thinking, and foster a supportive environment for change.

5. Conclusion

The construction of a performance evaluation indicator system for the digital transformation of state-owned enterprises provides a scientific basis for assessing the effectiveness of corporate transformation. The evaluation methodology, based on fuzzy comprehensive evaluation and the ideal solution approach, enables multidimensional quantitative assessment. Evaluation results indicate that SOEs' digital transformation is accelerating overall, yet significant shortcomings persist in areas such as technological application depth, innovation capabilities, and talent development. The optimization strategies proposed—addressing identified issues across dimensions including top-level design, technology application, talent cultivation, and organizational transformation—demonstrate strong practical applicability. Future research should focus on innovating digital transformation effectiveness evaluation methods and deepening studies on industry-specific transformation pathways to provide more targeted guidance for SOEs' digital transformation.

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