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BIG DATA IN FINANCIAL SERVICES: A SURVEY OF APPLICATIONS AND VALUE CREATION

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Abstract: Big data technology is profoundly transforming the business models and value creation methods of financial services. This paper employs a systematic literature review methodology to investigate the applications and value mechanisms of big data across key financial domains. The study identifies four primary value creation pathways: First, in credit scoring and risk management, integration of alternative data sources enhances model accuracy and extends financial access to underserved populations. Second, in fraud detection, machine learning-based real-time analytics reduce false positive rates by approximately 30% while improving detection precision. Third, personalized services enabled by multi-dimensional customer profiling generate revenue increases of 10-15% for institutions implementing data-driven strategies. Fourth, process automation and real-time decision support enhance operational efficiency, reducing costs and improving service quality. This research demonstrates that big data has become a strategic asset for financial institutions, while acknowledging ongoing challenges in data governance, model interpretability, and regulatory compliance.
Keywords: Big data; Financial services; Credit scoring; Fraud detection

1 INTRODUCTION

The financial services industry is undergoing a profound data-centric transformation. With the digitization of transaction systems, increased customer interactions, and the proliferation of Internet of Things (IoT) devices, financial institutions now process data volumes growing at exponential rates [1,2]. The emergence of big data analytics tools—including distributed computing frameworks, machine learning algorithms, and real-time processing capabilities—enables these institutions to extract valuable insights from vast and diverse datasets, thereby revolutionizing their business models and service delivery [3,4].

The integration of big data analytics in financial services represents a paradigm shift from traditional decision-making approaches to a data-driven paradigm. Unlike conventional methods that rely on limited datasets and static assessment models, contemporary approaches leverage diverse data sources—including transactional records, social media activity, and behavioral patterns—for more precise predictions and comprehensive insights [3,5]. This transition impacts multiple facets of financial services, from risk assessment and customer experience to operational efficiency and product innovation. Furthermore, regulatory developments such as the European Payment Services Directive 2 (PSD2) and Open Banking initiatives have facilitated data sharing among financial organizations, accelerating innovation and enabling new business models [2,6].

This paper systematically analyzes how big data creates value in financial services by examining four key application domains: credit scoring and risk management, fraud detection and prevention, personalization of financial services, and operational efficiency optimization. The research objectives are threefold: first, to identify the specific mechanisms through which big data enhances decision-making in each domain; second, to evaluate the quantifiable value outcomes achieved through big data implementation; and third, to examine the challenges that persist in realizing big data's full potential. The remainder of this paper is organized as follows: Section 2 establishes the conceptual framework; Section 3 examines applications across the four domains; and Section 4 concludes with implications and future directions.

2 CONCEPTUAL FRAMEWORK OF BIG DATA IN FINANCE

2.1 Defining Big Data in the Context of Digital Finance

In the context of digital finance, big data refers to the vast and diverse information generated from financial transactions, customer interactions, market activities, and external sources. These data are commonly characterized by the "Four V's": Volume (the immense quantity of data), Velocity (the rate of data generation and processing), Variety (multiple forms of structured and unstructured data), and Veracity (the reliability and quality of the data) [2,4]. Financial institutions collect and analyze data from both traditional sources—such as account information, transaction records, and credit histories—and alternative sources, including social media activity, mobile phone usage, browsing behavior, and IoT device data [3,7]. The integration of these diverse data sources provides a more comprehensive understanding of financial behavior and market dynamics, enabling more sophisticated analysis and decision-making.

2.2 The Evolution of Big Data Analytics in Finance

The financial sector has historically been data-driven, yet the scale and complexity of data analysis have evolved significantly with technological advancements. Traditional analytics relied primarily on structured data and descriptive statistics, focusing on historical reporting and basic trend analysis. The advent of big data technologies enables financial institutions to process massive volumes of unstructured data, apply advanced machine learning algorithms, and derive predictive and prescriptive insights [2,4]. This evolution has been facilitated by several technological developments: distributed computing frameworks such as Hadoop and Spark, cloud computing platforms enabling scalable storage and processing, advanced machine learning algorithms, and real-time analytics capabilities [7]. Recent regulatory changes, particularly Open Banking initiatives, have further accelerated this transformation by promoting data sharing and interoperability within the financial ecosystem [6]. Collaborative efforts such as the EU-funded INFINITECH project, which brings together multiple organizations to develop innovative big data and AI solutions for digital finance, exemplify the industry's recognition of big data's transformative potential [8].

3 APPLICATIONS OF BIG DATA IN FINANCIAL SERVICES

3.1 Credit Scoring and Risk Management

Big data has transformed credit risk assessment by enabling financial institutions to develop more comprehensive and accurate models for evaluating creditworthiness. Traditional credit scoring systems rely heavily on limited datasets—such as credit history, income verification, and debt-to-income ratios—which often exclude individuals with limited or no credit records, commonly referred to as "thin-file" or "no-file" consumers [3]. Contemporary big data approaches integrate diverse data points to create more nuanced risk profiles, thereby expanding credit access while maintaining risk management standards [5,7].

Financial institutions now incorporate alternative data sources—such as utility payment histories, mobile phone usage patterns, online transaction behavior, and in some cases, social media activity—to assess creditworthiness [3][9]. This expanded data scope is particularly valuable for evaluating applicants who lack traditional credit history. For instance, fintech lenders in emerging markets have successfully utilized mobile phone data and digital payment records to extend credit to previously underserved populations [10]. Research indicates that alternative data can improve predictive accuracy for thin-file borrowers, with some studies reporting Area Under the Curve (AUC) improvements from 0.65 to 0.75 or higher when alternative data is incorporated [3,11]. These improvements demonstrate that non-traditional data sources can effectively complement conventional credit bureau data, enhancing both financial inclusion and risk management outcomes [11].

Beyond initial credit assessment, predictive analytics enhances ongoing risk management by enabling dynamic, real-time risk monitoring rather than periodic reviews. Technologies such as Apache Kafka and Apache Flink facilitate the continuous processing of risk indicators, allowing institutions to proactively identify emerging risks and adjust credit limits or terms accordingly [7]. This capability is especially valuable in volatile economic environments where traditional static models may fail to capture rapidly changing risk profiles.

Machine learning algorithms have improved the accuracy of credit risk models by analyzing complex patterns across diverse datasets and identifying subtle correlations that traditional statistical methods might overlook [5]. These advanced models enable more precise risk-based pricing, allowing financial institutions to offer interest rates that better reflect individual risk profiles. This differentiation benefits both lenders—through optimized risk-return tradeoffs—and creditworthy borrowers—through access to more favorable terms [3,5].

Despite these advancements, challenges remain in implementing big data-driven credit scoring. Key concerns include ensuring model interpretability to meet regulatory requirements, addressing potential algorithmic bias that may disproportionately affect certain demographic groups, and maintaining data quality across diverse sources [3,4]. Financial institutions must balance the pursuit of predictive accuracy with fairness, transparency, and compliance obligations.

3.2 Fraud Detection and Prevention

Financial fraud is increasingly sophisticated, with global fraud losses in the financial sector reaching billions of dollars annually. Big data analytics has emerged as a critical tool for detection and prevention, enabling financial institutions to identify fraudulent patterns, enhance risk assessment models, and implement real-time detection mechanisms [12,13].

Big data-driven fraud detection systems analyze massive volumes of structured and unstructured data from various sources, including transaction logs, user behavior patterns, device fingerprints, and external threat intelligence feeds [12]. By applying advanced machine learning algorithms—such as random forests, neural networks, and gradient boosting models—these systems can detect anomalies and suspicious activities that may indicate fraud [13]. Unlike traditional rule-based methods that rely on predefined parameters, machine learning models can identify complex and previously unknown fraud patterns, adapting to evolving fraud tactics [7,12].

Real-time analytics represents a significant advancement in fraud detection. By leveraging stream data processing technologies, financial institutions can continuously monitor transactions and flag suspicious activities within milliseconds of occurrence [12,14]. This capability is critical for minimizing potential losses, with some institutions reporting fraud loss reductions of 20-40% following implementation of real-time detection systems [13]. Real-time

monitoring enables proactive risk identification and immediate response, contrasting with traditional batch-processing systems that rely on historical data and periodic reporting [14].

Behavioral analytics plays an increasingly important role in fraud detection by establishing baseline behavior patterns for individual customers and identifying deviations that may indicate fraudulent activity. These analytical techniques integrate multiple data points, including transaction history, geographic location, device information, and activity timing [12]. This multi-dimensional approach improves detection accuracy while reducing false positive rates—which can decline by approximately 30% with advanced machine learning models compared to traditional rule-based systems [13]. Reducing false positives is critical, as excessive legitimate transaction declines erode customer trust and satisfaction.

3.3 Personalization of Financial Services

Big data has transformed how financial institutions understand and engage with their customers, enabling enhanced personalization of products and services. By analyzing customer data across multiple touchpoints—including transaction history, digital interactions, life events, and stated preferences—financial institutions can develop detailed customer profiles, predict needs, and deliver tailored offerings [4,15].

Customer behavior analysis forms the foundation of personalization efforts, providing insights into spending patterns, financial goals, risk tolerance, and service preferences. These insights enable financial institutions to recommend relevant products, offer personalized financial advice, and deliver contextually appropriate communications at optimal times. Effective personalization strategies have been shown to increase revenue by 10-15% for financial institutions through improved cross-selling effectiveness, customer retention, and increased product usage [2]. Beyond revenue impact, personalization enhances customer satisfaction and loyalty by delivering more relevant and timely services.

In the wealth and asset management sector, big data analytics enables more sophisticated personalization of investment strategies. Big data and AI technologies analyze a client's financial situation, goals, and risk tolerance to create customized investment portfolios [2]. These capabilities, once limited to high-net-worth individuals served by human advisors, are now extending to mainstream customers through robo-advisory platforms that leverage big data to provide algorithm-driven financial planning at lower costs [2,4].

Marketing and customer acquisition have been transformed by data-driven personalization. Financial institutions use data mining and analytics techniques to analyze customers' browsing histories, content preferences, and behavioral signals to deliver targeted advertising for financial products and services [10]. Advanced customer segmentation—based on demographics, behaviors, life stages, and predicted needs—enables precision-targeted marketing campaigns that achieve higher conversion rates and lower customer acquisition costs [2,10]. The European INFINITECH project demonstrates how big data and AI technologies can enhance both personalization and trust in digital finance, as effective personalization improves product relevance while strengthening customer relationships through more meaningful interactions [6].

3.4 Operational Efficiency and Process Automation

Big data analytics significantly improves the operational efficiency of financial institutions by optimizing processes, reducing costs, and enhancing decision-making capabilities. By analyzing operational data—including transaction processing times, resource utilization rates, and workflow bottlenecks—financial institutions can identify inefficiencies, optimize resource allocation, and prioritize automation opportunities [4,16].

Process automation represents a key application of big data in financial operations. By analyzing patterns in workflow data, institutions can identify high-value automation opportunities that reduce manual intervention and associated costs. Common applications include automated document processing using optical character recognition (OCR), automated compliance checking against regulatory requirements, and streamlined customer onboarding processes [4,14]. These automations not only reduce processing times—in some cases from days to minutes—but also minimize human error and improve consistency.

Real-time data processing enhances operational decision-making by providing timely insights rather than retrospective analysis. Big data analytics enables financial institutions to process and analyze diverse data sources—including transactional data, customer data, and market data—to support informed decisions across multiple operational domains [14]. This capability is particularly valuable for trading operations where millisecond-level decisions impact profitability, liquidity management where real-time cash flow monitoring prevents shortfalls, and dynamic resource allocation that responds to demand fluctuations.

Big data also improves operational risk management by identifying potential risks and vulnerabilities within internal processes. By analyzing operational data patterns, financial institutions can detect anomalies indicating potential system failures, security breaches, or process breakdowns [9,16]. Predictive maintenance models can forecast system failures before they occur, enabling preventive interventions that reduce downtime and associated costs. This proactive approach contrasts with traditional reactive risk management and contributes to more stable and reliable operations.

4 CONCLUSION

This paper has systematically examined the applications and value creation mechanisms of big data in financial services across four key domains: credit scoring and risk management, fraud detection and prevention, personalization of financial services, and operational efficiency optimization. The analysis reveals that big data has transformed financial

services through multiple value pathways. In credit risk assessment, integration of alternative data sources enhances model accuracy while extending financial access to underserved populations. In fraud detection, machine learning-based real-time analytics reduce false positive rates by approximately 30% while improving detection precision. Personalization strategies enabled by multi-dimensional customer profiling generate revenue increases of 10-15% for institutions implementing data-driven approaches. Process automation and real-time decision support enhance operational efficiency, reducing costs and improving service quality.

Despite these substantial benefits, effective implementation of big data in financial services faces ongoing challenges. Technical challenges include ensuring data quality across diverse sources and maintaining model interpretability to meet regulatory requirements. Organizational challenges involve developing analytical capabilities and fostering data-driven cultures. Regulatory challenges center on balancing innovation with data privacy protection, algorithmic fairness, and compliance with evolving regulations such as GDPR and Open Banking directives.

Looking forward, the convergence of big data with emerging technologies—including generative artificial intelligence, federated learning for privacy-preserving analytics, and blockchain for secure data sharing—promises to unlock new value creation opportunities. Financial institutions that successfully navigate the technical, organizational, and regulatory challenges will be well-positioned to leverage big data as a strategic asset, driving innovation, enhancing competitiveness, and creating value for both institutions and customers in an increasingly data-driven financial ecosystem.

COMPETING INTERESTS

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THE EVOLUTION OF GREEN DEVELOPMENT POLICY CHARACTERISTICS IN BEIJING-TIANJIN-HEBEI REGION

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Abstract: The green development policies in the Beijing-Tianjin-Hebei region are crucial for promoting coordinated ecological progress. Since the launch of the green development initiative, China's central and local governments have issued over 230 policy documents covering the period from 2006 to 2024. This study employs Latent Dirichlet Allocation (LDA) modeling to analyze these policy texts, revealing rich thematic content with emerging trends like "construction" and "technology". By mapping the evolutionary patterns of these policies, the research provides actionable insights for future policy directions and offers a foundation for refining existing frameworks.
Keywords: Beijing-Tianjin-Hebei; Policy theme; Green development

1 INTRODUCTION

The report of the 20th National Congress proposed accelerating green transformation, clarifying the improvement of fiscal, tax, financial policies, and standard systems supporting green development, as well as the layout for developing green and low-carbon industries. In research on government policy texts, scholars have focused on three aspects in their studies of Beijing-Tianjin-Hebei policies: First, qualitative methods such as content analysis and policy instrument perspectives, including exploration of mechanism innovation and regional policy safeguards[1], identification of knowledge clustering and networks[2], environmental governance policy evaluations[3], analysis of regional innovation system synergy[4]. Second, quantitative methods like bibliometric analysis, though addressing large sample sizes and low content relevance, such as analysis of carbon emission drivers[5], assessment of regional industrial coordination impacts on Hebei's industrial structure[6], and proposal for regional collaborative advancement of dual-carbon goals[7]. Third, explorations into policy text quantification techniques, including investigation into policy themes and network structure characteristics[8].

This study employs data mining and machine learning algorithms to identify policy evolution characteristics and inform targeted policy formulation for future implementation.

2 RESEARCH DESIGN

2.1 Research Approach

This study employs keywords such as "green", "low-carbon", and "circular" to collect data through combined searches. Precise retrieval is conducted at the occurrence positions of relevant sentences to download policy documents meeting requirements. The corpus is segmented using Jieba Library and stop words are removed. Thematic extraction and visualization are performed via Latent Dirichlet Allocation (LDA) model, while TF-IDF is utilized for keyword extraction. Word clouds are generated for thematic content analysis, and statistical analysis of theme-specific terms across different years is conducted. A Sankey diagram is created to explore the evolution of thematic trends.

2.2 Data Sources and Selection

Using the Beida Legal and Regulatory Database, China National Knowledge Infrastructure (CNKI) Legal Database, and official websites of national ministries and commissions as search sources, we conducted searches using two restriction methods: "theme" and "full-text" with keywords such as "green", "low-carbon", and "circular". To ensure the obtained policy texts possess authority and accuracy, three screening principles were adopted:Policy texts should cover as comprehensive a scope as possible; If the title does not contain the keyword, select policy texts where the keyword appears at least three times in the full text; Remove informal documents such as approvals, letters, and announcements, and select policy texts of types including opinions, plans, notices, measures, guidelines, and schedules. Ultimately, 230 policy texts from the period 2006 to 2024 were screened.

2.3 Policy Text Preprocessing

In text preprocessing, the policy lexicon is first imported. The Jieba library is utilized to perform word segmentation on the corpus dataset. The segmented text better reflects semantic information, thereby enhancing the accuracy and interpretability of the topic model. Stop words refer to those that frequently appear in texts but provide no substantial

contribution to the text's theme. By loading a stop word list and removing irrelevant vocabulary, the model's efficiency and accuracy are significantly improved.

2.4 Extraction of Subject Keywords from Policy Text

After the training of LDA topic model, the text keyword extraction method based on TF-IDF is as follows: if a word frequently appears in one article but rarely appears in other articles, this word will be considered as a good representative of the content of the current article.

3 DATA AND ANALYSIS

3.1 Policy Keyword Frequency Analysis

Before conducting a thematic analysis of the Beijing-Tianjin-Hebei green policies, it is essential to identify key policy terms. These are defined as words in policy documents that are directly related to green initiatives. The first step involves establishing a specialized lexicon for Beijing-Tianjin-Hebei green policies, ensuring all entries are closely associated with these initiatives. The preprocessed text is then analyzed using this lexicon to measure keyword frequency and conduct statistical analysis. The resulting frequency statistics are presented in Figure 1.
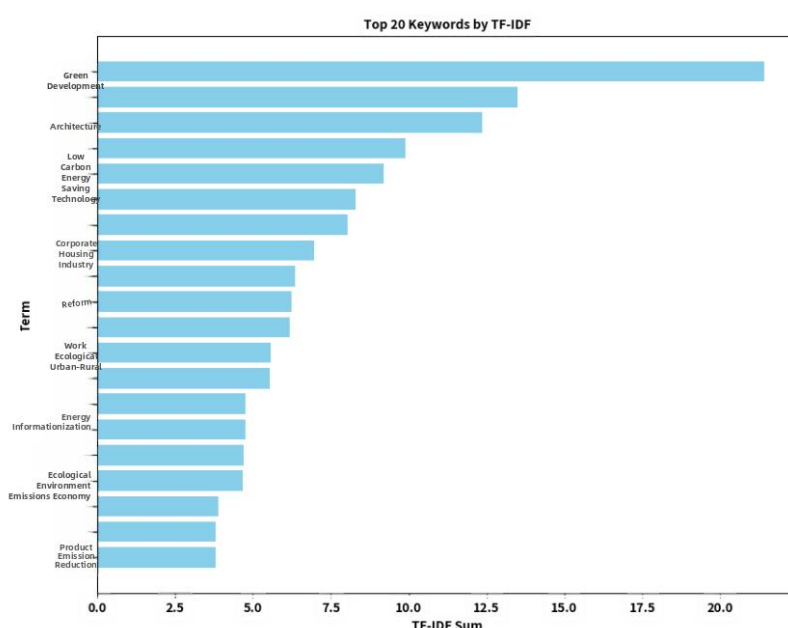
Figure 1 Top 20 High Frequency Words

Among policy keywords, "green" ranks first with the highest TF-IDF score, indicating its frequent occurrence and unique significance in policy documents. This highlights the emphasis on green development and reflects policy inclinations toward environmental protection, energy conservation, emission reduction, and sustainable growth. Subsequent keywords like "development," "construction," and "low-carbon" also show high frequency and importance, involving initiatives such as developing a green economy and reducing carbon emissions. Green development is recognized as a key strategy to enhance ecological and economic benefits. Additionally, terms like "technology," "enterprise," and "ecology" receive high scores, demonstrating that green policies also focus on technological innovation, corporate transformation, and ecological conservation. These policies aim to create an environmentally friendly growth model, emphasizing the harmonious coexistence of environmental protection and economic development while ensuring regional sustainability. This comprehensive strategy forms the cornerstone of a full green transition, laying the foundation for future development. Policy documents showcase the vision of promoting economic growth through environmental protection, establishing a sustainable foundation for long-term development.

3.3 LDA Thematic Analysis

This study will employ the Latent Dirichlet Allocation (LDA) model for thematic analysis across different time periods. After preprocessing to eliminate irrelevant terms and reduce data dimensions, we calculated filtered TF-IDF values to identify policy themes in key provinces. The LDA modeling process utilized Python's Sklearn package. Three methodologies are commonly used to determine the number of LDA topics: similarity-based selection, perplexity-based determination, and empirical approach. This paper selects the optimal topic count based on thematic characteristics across provincial regions.

Table 1 Classification of Green Development Policy Themes in Beijing, Tianjin and Hebei from 2006 to 2011

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
system	popularize	structural readjustment	project	produce
city	highly active	improve	build	product
ability	resource	concrete	family	enterprise
the sources of energy	exploitation	carry out	Hebei	keynote
pyroelectricity	iron and steel	move	building	resource
fire coal	economy	natural gas	accumulation area	build
centrality	produce	characteristic	enterprise	exploitation
develop	technology	be conscious of	green	develop
heat addition	develop	continue	develop	recurrence
build	recurrence	you	estate	economy

A thematic classification of green development policies in the Beijing-Tianjin-Hebei region from 2006 to 2011 was conducted, resulting in five themes with ten corresponding keywords as shown in Table 1. The table reveals: Theme 1 includes keywords like "system" and "city", focusing on energy conservation policies, heating system upgrades, and eco-friendly initiatives; Theme 2 features terms such as "promotion" and "efficiency", emphasizing resource optimization, technological innovation for green energy adoption, and steel industry reforms; Theme 3 encompasses "structural adjustment" and "improvement", highlighting environmental policy implementation and ecological upgrades; Theme 4 involves "projects" and "construction", specifically addressing green building policies in Hebei Province; Theme 5 centers on "production" and "products", involving industrial restructuring and resource transitions toward sustainable development.

Table 2 Classification of Green Development Policy Themes in Beijing, Tianjin and Hebei from 2011 to 2015

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
strengthen	environmental protection	quote	build	examine
set up	push on	technology	develop	storm fortifications
air pollution	strengthen	work	Publicity Week	organism's habits
rectify	pollute	standard	conduct propaganda	Ten thousand acres
put in order	organism's habits	housing	organization	accomplish
Beijing-Tianjin-Hebei Region	keynote	be in progress	mine	green
build	building	build	environmental protection	engineering
enterprise	develop	project	low-carbon	forestation
the end of the year	build	building	energy conservation	build
straw	environment	green	activity	make green by planting trees

The thematic classification of green development policies in the Beijing-Tianjin-Hebei region from 2011 to 2015 is presented in Table 2, which categorizes five themes with ten corresponding keywords. The table reveals: Theme 1 (keywords including "strengthen" and "air pollution") focuses on air quality improvement, straw burning control, corporate carbon emission policies, and carbon compliance measures. Theme 2 (keywords like "construction" and "pollution") emphasizes environmental protection initiatives, ecological remediation efforts, and green building standards. Theme 3 (keywords such as "citation" and "technology") addresses technological innovation and policy refinement in sustainable construction. Theme 4 (keywords including "construction" and "initiation") involves eco-awareness campaigns, environmental organization support, and mining project regulations. Theme 5 (key terms like "evaluation" and "campaign") highlights poverty alleviation strategies with green initiatives, afforestation programs, and coordinated ecological-economic development.

Table 3 Classification of Green Development Policy Themes in Beijing, Tianjin and Hebei from 2015 to 2019

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
administer	work	develop	ecological condition	kilojoule
standard	machine-processed	push on	electric power generation	enterprise
accomplish	classify	conduct propaganda	renewable sources of energy	engineering
build	hospital	activity	enterprise	exploitation
appraise	build	reform	school	kilocalorie
work	rubbish	low-carbon	quantity of electricity	carbon emission reduction
discharge	quality	build	city	standard coal
enterprise	build	green	green	achievement
green	centrality	develop	power	kilogram
building	patient	energy conservation	business	technology

The thematic classification of green development policies in the Beijing-Tianjin-Hebei region from 2015 to 2019 is summarized in Table 3, comprising five major themes with ten corresponding keywords. The table reveals: Theme 1 includes keywords like "governance" and "standards," addressing the establishment of an evaluation system for green development construction in the Beijing-Tianjin-Hebei region, standardization of policies, and policy implementation. Theme 2 features terms such as "classification" and "hospitals," focusing on environmental protection and healthcare policy formulation and development. Theme 3 contains keywords like "initiate" and "promote," representing reform measures and publicity campaigns for green development in the region. Theme 4 encompasses "ecological environment" and "renewable energy," advocating corporate leadership and low-carbon initiatives by social organizations while emphasizing the importance of ecological conservation and renewable energy utilization. Theme 5 includes keywords like "engineering projects" and "emission reduction," indicating phased achievements through pilot policies and new technologies implemented by enterprises.

Table 4 Classification of Green Development Policy Themes in Beijing, Tianjin and Hebei from 2019 to 2024

Theme 1	Theme 2	Theme 3	Theme 4	Theme 5
administer	be interrelated	put into effect	develop	reform
pollute	energy conservation	administer	work	duty
keynote	about	ecological condition	city	division of labour with individual responsibility
limited company	have sth. to do with	keynote	push forward	people's government

develop	enterprise	develop	energy conservation	bring forth new ideas
discharge	building	push on	push on	push forward
accomplish	low-carbon	protect	build	push on
power	develop	strengthen	develop	estate
business	project	build	building	build
enterprise	green	organism's habits	green	develop

A thematic classification of all green development policies in the Beijing-Tianjin-Hebei region during 2019-2024 yielded results as shown in Table 4. The analysis categorized these policies into five themes, each containing 10 key terms. The table reveals: Theme 1 includes keywords like "governance," "pollution," "key areas," and "enterprises," indicating policy priorities for corporate pollution control and low-carbon environmental trading. Theme 2 features terms such as "projects," "green initiatives," "enterprises," and "energy conservation," highlighting policies promoting low-carbon development in construction sectors. Theme 3 contains phrases like "strengthening," "ecological conservation," and "key areas," underscoring the urgency of environmental governance and systematic implementation of ecological protection measures. Theme 4 encompasses keywords including "cities," "energy efficiency," and "construction," focusing on urban development strategies for low-carbon growth. Theme 5 incorporates terms such as "government bodies," "innovation," "responsibilities," and "promotion," emphasizing coordinated policy execution through clear division of duties to ensure orderly implementation and drive industrial innovation.

3.4 Analysis of the Thematic Dimension of Policy

3.4.1 Policy theme characterization

Based on the characteristics of green development policies in the Beijing-Tianjin-Hebei region, the research on green development policies is divided into four phases: The first phase (2006-2011) focused on infrastructure construction and circular economy, introducing policies to promote economic industrialization, emphasize resource recycling, and improve heating system efficiency. This phase aimed to establish infrastructure, enhance energy efficiency, and advance circular economy applications. The second phase (2011-2016) prioritized housing energy conservation and urban-rural balance, continuing policies to optimize environmental standards for housing construction, improve energy efficiency, and reduce carbon emissions. This phase facilitated urban-rural integration and accelerated green transformation in the construction sector. The third phase (2016-2019) emphasized technological innovation and institutional reform, implementing policies for eco-friendly technology adoption, reforming systems to promote green production and consumption, and driving R&D and dissemination of environmental technologies. The fourth phase (2019-2024) focused on ecological protection and energy optimization, addressing environmental conservation and energy structure improvement, reducing pollution, enhancing energy efficiency, and advancing sustainable development goals. Using the thematic confusion degree calculation method in Equation 1.1, we determined the optimal number of themes for each policy phase in the Beijing-Tianjin-Hebei region, with specific results shown in Figure 2.
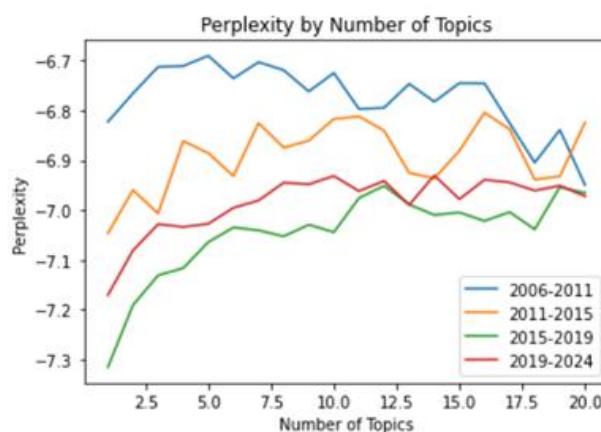

Figure 2 Perplexity by Number of Topics

As shown in Figure 2, confusion degree analysis, the optimal number of policy themes for China's Beijing-Tianjin-Hebei green policies followed a cyclical pattern: 4 themes from 2006 to 2011,5 themes from 2011 to

2016,6 themes from 2016 to 2019, and 6 themes again from 2019 to 2024. To comprehensively evaluate quality and stability metrics, this study conducted manual optimization of policy themes, as detailed in Table 5.

Table 5 Theme Distribution by Stage

Window of time	Optimal topics (items)	Hashtag
2006-2011	4	Energy supply and urban heating Efficient resource utilization Circular economy and key enterprises Green buildings and industrial clusters
2011-2015	5	Air pollution control and regulation Environmental protection and ecological construction Green building standards and low-carbon environmental protection publicity activities Ecological greening project Enterprise emission control
2015-2019	6	Garbage classification and hospital construction Low-carbon development and publicity Green Power Trading Quality improvement and innovation Energy saving technology and architecture Electricity trading and pollution control
2019-2024	6	Energy saving technology and low carbon development Ecological and environmental protection Urban energy conservation transformation Green innovation and industrial development Forest greening and administrative licensing

According to the above distribution of green policy themes in Beijing-Tianjin-Hebei, the green development policy themes in Beijing-Tianjin-Hebei can be classified into six categories:

(1) Energy supply and urban heating, including energy supply, urban heating, thermoelectricity, coal burning and other sub-themes;

(2) High efficiency resource utilization, including sub-themes such as resource utilization, steel, economy, production and technological development;

(3) Circular economy and key enterprises, including sub-themes such as circular economy, key enterprises, industrial clusters, project construction, etc.;

(4) Air pollution control and rectification, including air pollution control, rectification, enterprise emissions, garbage classification and other sub-themes;

(5) Green building and ecological protection, including sub-themes such as green building, ecological protection, ecological construction, and building standards;

(6) Low-carbon environmental protection publicity and activities, including low-carbon environmental protection publicity, energy-saving technology, green innovation, low-carbon development and other sub-themes.

From a temporal perspective, the green development policy framework for the Beijing-Tianjin-Hebei region has evolved through four distinct phases spanning 2006 to 2024: Infrastructure and Circular Economy Development, Housing Energy Efficiency and Urban-Rural Balance Development, Technological Innovation and Institutional Reform, and Ecological Conservation and Energy Optimization. This progression reflects the continuous refinement and upgrading of regional green policies. Spatially, the initiative covers the entire area, providing comprehensive policy support and guidance across technology R&D, standard-setting, infrastructure construction, and market regulation to promote coordinated green development. In terms of content, the framework embodies three core principles--innovation-driven growth,coordinated advancement, and open development--while emphasizing low-carbon, eco-friendly, and sustainable development directions. It highlights energy conservation, emission reduction, and ecological protection goals, charting a clear vision for regional green development.

4 CONCLUSION

Through categorization and analysis of green development policy themes in the Beijing-Tianjin-Hebei region from 2006 to 2024, it is evident that policy focus has evolved into increasingly diversified and sophisticated areas. Initially emphasizing energy structure optimization and ecological conservation, subsequent policies expanded to encompass multiple domains including green building practices, corporate sustainable production, and government responsibility allocation, demonstrating significant enhancement in policy comprehensiveness and detail. Early policies primarily concentrated on promoting efficient resource utilization and structural adjustments, while later measures shifted toward concrete implementation strategies and continuous improvement initiatives such as establishing governance evaluation systems, enhancing waste sorting and processing, and advancing low-carbon technology adoption. This progression reflects policymakers' ongoing efforts to refine policy frameworks in response to complex environmental challenges and achieve higher standards of green development.

The evolution trend of the green development policy themes in the Beijing-Tianjin-Hebei region mainly focuses on two directions: one is energy conservation and environmental protection, mainly including themes such as "energy-saving technology and low-carbon development" and "green innovation and industrial development"; the other is ecological protection, mainly including themes such as "ecological environment protection" and "forest greening and administrative licensing". It is worth noting that the two evolution trends of "energy conservation and environmental protection" and "ecological protection" are in line with China's green development strategic measures, indicating that the evolution trend of the green development policy themes in the Beijing-Tianjin-Hebei region is consistent with the national development strategy, reflecting the direction and goal of regional green development. Therefore, in the future, the green development policy in the Beijing-Tianjin-Hebei region should adhere to the two major development directions of "energy conservation and environmental protection" and "ecological protection", strengthen energy-saving technological innovation and ecological protection measures, and thereby promote high-quality and sustainable development in the Beijing-Tianjin-Hebei region.

COMPETING INTERESTS

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THE IMPACT OF PUBLIC SERVICE MOTIVATION ON THE INNOVATION PERFORMANCE OF MEDICAL PERSONNEL

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Abstract: As the backbone of the healthcare service system, the high-quality development of public hospitals is central to advancing the Healthy China initiative, with "innovation-driven development" serving as its core engine. Using a sample of 456 medical personnel questionnaires from Henan Province, this study empirically examines the mechanism and boundary conditions through which public service motivation influences innovation performance among medical staff, grounded in the resource conservation theory perspective. Findings reveal that medical personnel's public service motivation significantly enhances their innovation performance, with organizational change serving as a fully mediating resource-building strategy in this process. Employee resilience, however, functions as a "resource array conduit," positively moderating the mediating effect of organizational change. Specifically, in contexts of high employee resilience, the mediating effect of public service motivation on innovation performance through organizational change is significantly enhanced, whereas this mediating effect is insignificant in contexts of low employee resilience. This study expands and deepens the existing literature on healthcare workers' public service motivation and innovation performance. It provides insights for applying resource conservation theory in healthcare settings and offers valuable reference for advancing high-quality development in public hospitals under the new era context.
Keywords: Public service motivation; Organizational change; Innovation performance; Employee resilience

1 INTRODUCTION

Public hospitals form the backbone of China's healthcare service system, and their high-quality development serves as the core pillar for comprehensively advancing the Healthy China initiative (State Council General Office, 2021). In this new era, high-quality development has become both an inevitable choice and a historical mission for public hospitals. The Opinions of the General Office of the State Council on Promoting High-Quality Development of Public Hospitals (State Council General Office Document [2021] No. 18) systematically proposed for the first time at the national level a development path centered on "innovation-driven" as its core engine, explicitly requiring the establishment of a new development model featuring technological innovation, service upgrades, and management optimization. The subsequent Action Plan for Promoting High-Quality Development of Public Hospitals (2023–2025) further identified "high-level clinical specialty development," "three-pronged smart hospital construction," and "refined improvement of medical quality" as key tasks. Achieving these objectives fundamentally relies on sustained innovative practices by medical personnel, making the enhancement of innovation performance among hospital staff crucial for comprehensively advancing the Healthy China initiative.

However, while policy-driven organizational transformation creates opportunities for innovation, it also poses significant challenges. The implementation of policies such as payment system reforms, smart transformation, and service process reengineering forces medical staff to adapt to technological updates, process restructuring, and performance pressures within a short timeframe. In practice, high-intensity change can easily lead to role overload, professional burnout, and psychological exhaustion, potentially suppressing the willingness to innovate. While current policies emphasize "mobilizing healthcare workers' enthusiasm," they fail to systematically address a critical question: What intrinsic motivations enable healthcare workers to maintain innovative vitality amid transformational pressures? Public Service Motivation (PSM), as the intrinsic driving force behind individuals' engagement in public service work[1], offers a theoretical perspective to resolve this dilemma. Existing research indicates that PSM fosters a sense of obligation toward change, increasing employees' willingness to engage in transformative behaviors[2]. However, current studies predominantly focus on PSM's impact on healthcare workers' job satisfaction, burnout, turnover intentions, and traditional performance metrics, with limited systematic exploration of its association with innovation performance. Particularly against the backdrop of digital transformation in healthcare, stimulating healthcare workers' public service motivation to foster their innovative behaviors has become a critical imperative for advancing the high-quality development of public hospitals. Therefore, this study aims to uncover the pathways through which public service motivation influences healthcare workers' innovation performance, providing theoretical foundations and practical guidance for optimizing hospital human resource management and building an innovation-oriented healthcare ecosystem.

Grounded in resource conservation theory, this study integrates the theoretical frameworks of public service motivation, organizational change, innovation performance, and psychological resilience through dual dimensions: "resource investment-conversion" and "resource array channel." It empirically examines the mechanism through which healthcare workers' public service motivation (PSM) influences innovation performance, revealing the mediating effect of

organizational change and the moderating effect of employee resilience. Theoretically, this study contributes to expanding the literature on public service motivation and innovation performance. Practically, it offers meaningful insights for promoting the development of an innovation-friendly ecosystem in public hospitals.

2 THEORETICAL FOUNDATIONS AND RESEARCH HYPOTHESES

2.1 Public Service Motivation and Healthcare Workers' Innovation Performance

Innovation performance refers to the innovative, actionable products, processes, methods, and ideas generated by team members that benefit the organization, representing the concrete manifestation of employees' creative behaviors [3-4]. Based on social cognitive theory, individual behavior arises from the interaction between internal cognition and external environment. PSM, as a stable altruistic intrinsic motivation, provides sustained internal drive for innovative behavior. First, employees with high PSM demonstrate strong commitment to public welfare, motivating them to continually seek innovative solutions that improve work methods, enhance service quality and efficiency, and maximize societal well-being. Second, their empathy enables heightened sensitivity to unmet needs among service recipients, thereby identifying innovation opportunities. Finally, their passion for public affairs makes them more willing to assume personal risks associated with innovation.

Innovation performance, defined as healthcare professionals' constructive actions that transcend standardized treatment protocols to proactively optimize medical processes and service models (West, 2002), fundamentally enhances healthcare value through individual professional autonomy and systemic transformation. Although such actions may trigger professional risks by challenging medical authority and require investing non-evaluation-mandated resources, their applicability in advancing high-quality development within public hospitals has been empirically supported. This confirms that innovation performance serves as a core transformative force permeating all levels of healthcare.

Throughout this process, public service motivation (PSM) serves as the key driver enabling healthcare professionals to overcome resource constraints. From a resource conservation theory perspective, PSM fundamentally represents the dynamic process by which healthcare workers transform emotional energy and professional convictions into investments in innovative resources. Individuals with high PSM are more inclined to assume professional risks—such as pioneering the clinical application of CAR-T cell therapy or [5], under intense pressure to control medical insurance costs, challenging conventional drug usage practices to explore low-cost, high-efficacy alternatives (e.g., substituting metformin for sitagliptin in treating type 2 diabetes)[6]. This logic of "investing resources to counter resource depletion" enables PSM to activate innovation through a triple incentive mechanism: rationally driving optimized healthcare resource allocation, normatively fulfilling commitments to patient quality of life, and emotionally responding to the professional call to alleviate patient suffering. Thus, we propose:

H1: Healthcare professionals' public service motivation significantly and positively influences their innovation performance.

2.2 The Mediating Role of Organizational Change

A critical transmission mechanism exists in the process by which public service motivation drives clinical innovation performance, with organizational change playing a key mediating role. Structural adjustments within healthcare organizations provide an indispensable support system for individual innovative behaviors. These changes manifest in two core forms: first, technological transformation, which involves restructuring clinical workflows through technical means such as deploying smart medical tools and upgrading data analysis systems; second, institutional transformation, encompassing breakthroughs at the systemic level, including innovations in cross-departmental collaboration mechanisms and adjustments to clinical decision-making empowerment frameworks. Together, these form an institutional bridge enabling medical staff to translate their professional convictions into innovative practices.

Guided by the intrinsic logic of resource conservation theory, healthcare professionals with high public service motivation proactively trigger organizational change to optimize resource environments: 1. Resource Gain Pathway. When medical staff uphold the professional belief of prioritizing patient welfare, they systematically identify resource wastage points within medical processes, thereby driving the standardization of diagnostic pathways. The cognitive and temporal resources freed by such institutional optimization directly empower clinical innovation practices. 2. Resource Defense Pathway. Confronted with resource constraints like DRG cost controls, individuals with high PSM form specialized medical supply management teams to restructure resource allocation rules. This structural adjustment mitigates resource leakage risks, enabling healthcare professionals to implement treatment innovations within a controlled cost framework.

The evident mediating effects in healthcare settings demonstrate: First, the transmission of technological change—specifically the adoption of AI triage systems—frees high-PSM physicians from mechanical tasks. The mental resources thus conserved are directly channeled into innovative investments like chronic disease management model development. Second, the safeguarding value of institutional change—empowering interdisciplinary team decision-making—enabled nursing staff to design standardized protocols for elderly fall prevention through flexible staffing allocation. This validates how organizational restructuring of authority catalyzes individual innovation. Notably, healthcare organizational change faces dual constraints: technological advancements must align with patient safety thresholds, while institutional innovations require ethical review and approval. This industry characteristic positions organizational change as a compliance converter for transforming PSM into innovation performance—both solidifying

professional convictions into institutional entities and providing legitimacy for clinical innovation by releasing structured resources. Based on this, the core hypotheses are proposed:

H2: Public service motivation exerts a significant positive influence on organizational change.

H3: Organizational change plays a significant mediating role in the relationship between public service motivation and innovation performance.

2.3 The Moderating Role of Employee Resilience

Employee resilience plays a crucial positive moderating role between organizational change and innovation performance, essentially establishing an efficient "psychological resource conversion pathway." According to resource conservation theory, organizational change disrupts existing resource equilibrium, triggering individuals' resource defense or restructuring responses. Highly resilient employees possess stronger resource conservation and resource enhancement capabilities. This dual capacity significantly optimizes the "change-to-innovation" conversion pathway: On one hand, it enhances cognitive flexibility, facilitating the structured integration of old and new knowledge systems while reducing cognitive load during knowledge restructuring. On the other hand, it reinforces goal persistence, ensuring limited attention resources remain directed toward innovation activities rather than risk avoidance. At higher resilience levels, the resource reinvestment process triggered by organizational change more readily forms a "resource gain spiral," efficiently converting transformative energy into innovative momentum.

Resilience's regulatory effect manifests as contextual adaptation of primary effect intensity. At high resilience levels, the promotional effect of organizational change on innovation performance is systematically amplified through three pathways: First, the psychological buffer system built by resilience reduces the perceived risk of innovation trial-and-error, empowering individuals to break free from existing frameworks; Second, resilience enhances cognitive adaptation efficiency, accelerating the transformation of chaotic change information into actionable innovation solutions. Third, resilience maintains motivation-behavior coupling, ensuring that change pressures continuously stimulate rather than suppress innovation willingness. Conversely, individuals with low resilience, driven by excessive resource conservation motives, tend to adopt defensive resource-locking strategies. This limits organizational change to triggering superficial behavioral adjustments rather than deep innovation. This differentiation validates the moderating variable's intervention logic in the "change-innovation" causal chain: employee resilience fundamentally determines whether the psychological energy generated by organizational change flows toward innovative exploration or path selection for maintaining the status quo.

H4: Employee resilience positively moderates the positive impact of organizational change on innovation performance, meaning that when employee resilience is higher, the positive effect of organizational change on innovation performance is amplified.

2.4 Moderated Mediation Model

Building upon H3 and H4, this study further proposes a second-stage moderated mediation hypothesis: examining whether employee resilience moderates the strength of the mediating effect of organizational change on the relationship between public service motivation and innovation performance. Theoretically, it is anticipated that in contexts of high employee resilience, organizational change is more readily converted into innovation momentum. This occurs because resilience effectively buffers change pressures and accelerates resource reorganization, thereby significantly enhancing the indirect transmission efficacy of public service motivation through organizational change on innovation performance. Conversely, in low employee resilience contexts, organizational change tends to induce cognitive dissonance and behavioral decoupling, diminishing its conversion efficiency for innovation performance and attenuating the indirect effect of public service motivation through this pathway. Therefore, this study proposes:

H5: Employee resilience positively mediates the relationship between organizational change and innovation performance via public service motivation. That is, higher levels of employee resilience strengthen the indirect positive effect of public service motivation on innovation performance through organizational change.

3 RESEARCH METHODS

3.1 Study Sample

This study employed convenience sampling. Medical personnel from five Grade III Class A hospitals in Henan Province (Xinxiang Medical University First Affiliated Hospital, Xinxiang Medical University Second Affiliated Hospital, Xinxiang Medical University Third Affiliated Hospital, Xinxiang Central Hospital, and Xinxiang Second People's Hospital) were enrolled as research subjects between April and June 2025. Inclusion Criteria: (1) Currently employed and registered medical personnel; (2) At least one year of service; (3) Informed consent to participate in this study and voluntary cooperation in completing the survey. Exclusion Criteria: (1) Personnel absent due to leave, retirement, etc.; (2) Interns or trainees. Questionnaires were distributed via the electronic platform "QuestionStar," yielding 498 responses. After screening and excluding incomplete or invalid questionnaires, 456 valid responses were obtained, representing a response rate of 91.5%.

3.2 Research Tools

All items in this study employed a 5-point Likert scale ranging from 1 ("Strongly Disagree") to 5 ("Strongly Agree").
Public Service Motivation: This study employed the Chinese version of the Public Service Motivation Questionnaire developed by scholar Liu Bangcheng (2018). Based on Perry's four dimensions adapted to the Chinese context, the questionnaire comprises 18 items across four dimensions: attraction to public policy, commitment to public interest, compassion, and self-sacrifice. Developed for China's practical environment, this scale has demonstrated strong measurement quality in prior research and exhibits high adaptability to Chinese conditions.
Organizational Change: Lau and Woodman's scale was adopted. Employee-perceived change factors, defined as "perceived organizational change," are categorized into four dimensions: context, process, content, and outcome. Thus, this study measures organizational change at the subjective level of employee perception. The scale comprises 15 items.
Employee Innovation Performance: This study employs a scale developed by Han Yi et al., comprising 8 items with good reliability and validity.
Employee Resilience: Aligned with the research focus, this study adopts the definition and scale developed by Näswall et al. for employee resilience, comprising 9 items.
Additionally, based on prior research indicating that demographic variables influence proactive change behaviors, this study selects gender, age, educational attainment, tenure, job level, and type of organizational change as control variables.

4 RESULTS ANALYSIS

4.1 Confirmatory Factor Analysis

This study employed Mplus 8.3 software to conduct confirmatory factor analysis on four variables: public service motivation, organizational change, employee resilience, and innovation performance. Results are presented in Table 1. The four-factor model demonstrated significantly superior fit indices (χ^2/df = 2.755, CFI = 0.913, TLI = 0.906, RMSEA = 0.062) compared to the other two alternative models. Thus, the four variables in this study exhibited good discriminant validity.

Table 1 Results of Confirmatory Factor Analysis

model	factor structure	χ^2	df	χ^2/df	CFI	TLI	RMSEA
Four-factor model	A; B; C; D	3221.213	1169	2.755	0.913	0.906	0.062
Three-factor model	A; B+C; D	5063.455	1172	4.320	0.758	0.747	0.085
Two-factor model	A+D,B+C	6667.569	1174	5.679	0.659	0.644	0.101
Single Factor Model	A+B+C+D	9075.872	1175	7.724	0.509	0.488	0.121

Note: A represents public service motivation, B represents organizational change, C represents employee resilience, D represents innovation performance, and "+" represents the merger factor.

4.2 Common Method Bias Analysis

Common method bias analysis was conducted using Harman's single-factor test for all measurement items of public service motivation, organizational change, innovation performance, and employee resilience. Four common factors with eigenvalues >1 were extracted. The first common factor explained 34.7% of variance, below the critical threshold of 40%, indicating no severe common method bias in the sample data.

4.3 Descriptive Statistics and Correlation Analysis

The analysis results for the mean, standard deviation, and rank correlation coefficients of each variable are shown in Table 2. Consistent with theoretical expectations, public service motivation exhibited significant positive correlations with innovation performance (r = 0.238, p < 0.01), organizational change (r = 0.544, p < 0.01), and employee resilience (r = 0.400, p < 0.01). Similarly, organizational change showed significant positive correlations with innovation performance (r=0.317, p<0.01) and employee resilience (r=0.393, p<0.01). Employee resilience also exhibited a significant positive correlation with innovation performance (r=0.264, p<0.01).

Table 2 Descriptive Statistics and Correlation Analysis

variable	average value	standard deviation	1	2	3	4
1. Organizational change	3.37	0.98	1			
2. Innovation performance	3.76	0.82	.317**	1		
3. Motivation for providing public services	3.65	0.87	.544**	.238**	1	
4. Employee Resilience	3.44	0.95	.393**	.264**	.400**	1

Note: * indicates significant correlation at the 0.05 level (two-tailed), ** indicates significant correlation at the 0.01 level (two-tailed).

4.4 Hypothesis Testing

4.4.1 Testing the mediating effect of organizational change on the relationship between public service motivation and innovation performance

Furthermore, this study employed the "Model 4" procedure within SPSS's PROCESS program to examine the mediating effect of organizational change on the relationship between public service motivation and innovation performance. In the Bootstrap analysis, we set the number of samples to 5000 with a 95% confidence interval. Empirical results indicate that, after controlling for variables, public service motivation significantly positively influences organizational change (β=0.6116, p<0.001), with a confidence interval of [0.525, 0.699] that excludes zero. When organizational change was simultaneously included, the effect of public service motivation on innovation performance became insignificant (β=0.088, p>0.05), with a confidence interval of [-0.010, 0.185] that included zero. The effect of organizational change on innovation performance remained significant (β=0.221, p<0.001), with a confidence interval of [0.135, 0.308], excluding zero. Moreover, the mediation effect value of organizational change between public service motivation and innovation performance was 0.135, with a confidence interval of [0.075, 0.203], excluding zero. These results further support the full mediating role of organizational change in the relationship between public service motivation and innovation performance, validating H1, H2, and H3.

4.4.2 Organizational change and innovation performance: testing the moderating effect of employee resilience

Based on the empirical results of Model 2 in Table 3, organizational change has a significant positive effect on innovation performance (β=0.272, p<0.001). Simultaneously, Model 3 in Table 3 shows that both organizational change and employee resilience exert significant positive effects on innovation performance, with regression coefficients of 0.209 (p<0.001) and 0.168 (p<0.001), respectively. To test H4, this study further incorporated the interaction term between organizational change and employee resilience into Model 4 in Table 3 for regression analysis. Empirical results indicate that the regression coefficient for this interaction term is significantly positive at the 5% level (β=0.185, p<0.05), with ΔR^2 = 0.021 (p<0.05). This demonstrates that employee resilience exerts a significant positive moderating effect on the relationship between organizational change and innovation performance, supporting H5.

Table 3 The Moderating Effect of Employee Resilience

variable	innovation performance			
	model 1	model 2	model 3	model 4
sex	0.095	0.071	0.096	0.094
age	-0.01	0.002	-0.017	-0.034
Highest education level	0.067	0.102	0.1	0.099
Professional and Technical Rank	-0.28	-0.295	-0.27	-0.265
post	0.007	0.019	0.032	0.036
Job Level	0.33	0.327	0.334	0.329
working life	-0.035	-0.067	-0.093	-0.071
organizational reform		0.272***	0.209***	0.212***
Employee resilience			0.168***	0.167***
Organizational change* Employee resilience				0.185*
R2	0.049	0.152	0.182	0.021
△R2	0.049	0.104	0.03	0.005
F	3.267**	10.0327***	11.0547***	10.269***

Note: ***p<0.001, **p<0.01, *p<0.05 (two-tailed test). All regression coefficients in the table are unstandardized.

Building upon this foundation, this study employed "Model 14" in the PROCESS program to test the second-stage moderated mediation model. The specific analysis results are presented in Table 4. Table 4 reveals that under high employee resilience, the indirect effect of public service motivation on innovation performance through organizational change is significantly positive (95% confidence interval [0.09, 0.252]). Conversely, under low employee resilience, this indirect effect is insignificant (95% confidence interval [-0.342, 0.148]). Based on the INDEX and other indicators in Table 4, the INDEX value indicating that employee resilience moderates the indirect effect of public service motivation on innovation performance through organizational change is 0.553, with a confidence interval ([0.001, 0.12]) that does not include zero. In summary, the empirical findings indicate that the mediating role of organizational change in the relationship between public service motivation and innovation performance is significantly moderated by employee resilience, thus supporting H5.

Table 4 Test Results of Moderated Mediation Effects

regulated variable	conditional indirect effect				Regulated mediating effect			
Employee Resilience	Effect	SE	LLCI	ULCI	INDEX	SE	LLCI	ULCI
Low value	0.061	0.0464	-0.342	0.148	0.553	0.031	0.001	0.12
High value	0.165***	0.059	0.09	0.252				

5 CONCLUSIONS AND IMPLICATIONS

5.1 Research Findings

Empirical research reveals:

(1) Public Service Motivation (PSM) serves as the core intrinsic driver of healthcare professionals' innovation performance. Their sense of mission toward public welfare, empathy, and professional dedication systematically activate innovative practices—breaking conventional treatment norms and restructuring service models—through three pathways: rational resource allocation, normative commitment, and emotional empowerment. This significantly enhances clinical innovation performance.

(2) organizational change serves as a critical intermediary conduit. PSM triggers both technical and institutional transformations, establishing dual pathways: resource enhancement releases structured resources, while resource resilience mitigates policy constraint risks. Together, these provide institutionalized conversion channels for innovation practices, enabling the leap from PSM to innovation performance.

(3) employee resilience builds a dynamic buffer zone for the "change-innovation" transformation. As a core component of the resource array pathway, employee resilience significantly enhances the promotional effect of organizational change on innovation performance through dual mechanisms: psychological resource conservation and stress restructuring-driven value enhancement. Its moderating effect is concentrated in the second stage of the mediation pathway: under high-resilience conditions, both the conversion efficiency of organizational change into innovation performance and the indirect transmission efficacy of PSM are simultaneously enhanced.

5.2 Theoretical Contributions

The theoretical contributions of this study are as follows:

(1) Filling the research gap on the transmission mechanism of PSM driving innovation performance in the medical professional domain. Previous studies primarily focused on PSM's impact on traditional performance among medical professionals. This research reveals that organizational change fully mediates the relationship between PSM and innovation performance—high-PSM medical professionals proactively trigger change to release structured resources, mitigate policy constraint risks, and transform professional beliefs into sustainable innovation practices. This finding positions healthcare professionals as "resource strategic investors," transcending the linear cognitive framework linking PSM to innovation performance.

(2) Establishing resilience as a core moderating variable in the healthcare innovation ecosystem. Addressing the reality that organizational change is easily undermined by hospital bureaucracy and high-pressure policy environments, this study validates that employee resilience significantly enhances the transformative efficacy of organizational change on innovation performance by constructing a "psychological resource buffer zone." This not only explains individual variations in innovation output under identical change intensity but also expands the medical context of the "resource array channel" concept within resource conservation theory—resilience serves as the dynamic psychological infrastructure sustaining the flow efficiency of "change resources → innovation momentum."

(3) Advancing Resource Conservation Theory into the Depths of Healthcare Innovation Motivation Research. While this theory is predominantly applied in healthcare to explain negative phenomena like burnout, this study pioneers its systematic integration into healthcare workers' innovation motivation research. By synthesizing dual pathways—"resource investment-conversion" and "resource channel optimization"—it constructs a comprehensive theoretical model: "Initial Psychological Resources → Structural Resources → Innovation Performance." This responds to Hobfoll's call to extend resource conservation theory toward a motivational perspective [7], offering a new paradigm for studying innovation ecosystems in public hospitals.

5.3 Management Implications

Based on the "PSM-Organizational Change-Resilience" mechanism, three implementation pathways are proposed for the high-quality development of public hospitals:

(1) Strengthen PSM cultivation at the source. Talent Selection: Incorporate PSM assessments into physician standardized training and nurse position competitions to prioritize candidates with a strong sense of mission. Motivation Activation: Utilize cultural vehicles such as the "Hippocratic Oath Ceremony" and "Showcasing Exemplary Problem-Solving in Complex Cases" to internalize the policy-mandated "innovation orientation" as a professional creed.

(2) Establish a Dual-Drive System for Organizational Transformation. Technology Empowerment: Establish a Smart Hospital Transformation Support Fund to provide data access and development resources for medical staff creating AI-assisted tools [8]. Institutional Deregulation: Pilot "Cross-Departmental Innovation Consortiums" granting teams authority to restructure clinical workflows, dismantling hierarchical constraints on innovation.

(3) Build a Resilience-Oriented Psychological Support Network. Stress Transformation Training: Launch "Change Adaptability Workshops" to train medical staff to reframe DRG payment pressures as opportunities for optimizing clinical pathways [9], Organizational Error Tolerance Design: Establish a "Clinical Innovation Risk Pool" to exempt ethically compliant innovations from liability assessments, safeguarding willingness for high-risk innovation.

5.4 Research Limitations and Future Directions

Naturally, this study retains certain limitations, which point to future research directions. First, the study sample exhibits certain limitations that may influence conclusions. Derived from a single province, the sample inevitably lacks

comprehensive representativeness of the entire healthcare workforce. Future research should expand the survey scope to include a broader age range and professional hierarchy, increase sample size, enhance material incentives, and adopt blended online/offline questionnaire distribution methods to improve response rates, thereby strengthening the external validity of findings. Second, all data in this study are derived from healthcare workers' self-perceived ratings, which may introduce recall bias and social desirability bias. Although the questionnaire scales underwent common method bias testing and reliability/validity assessments, these biases could still exert latent effects. Future research could employ longitudinal designs, experimental methods, or paired samples of supervisors/colleagues and employees to more precisely identify causal relationships among variables. Finally, the primary variables in this study were measured using established Western scales. While we consulted experts to ensure these scales were adapted to the Chinese context, they fundamentally remain adaptations of existing Western research tools. Future research should focus on developing localized measurement tools, particularly for variables with behavioral attributes like change behavior. Researchers should pay close attention to differences between Western and Chinese contexts, conduct measurements tailored to China's local environment, and undertake relevant empirical studies.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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THE CONSTRUCTION AND EVOLUTION OF RURAL MUTUAL AID ELDERLY CARE MODELS FROM A VALUE CO-CREATION PERSPECTIVE

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Abstract: Against the backdrop of accelerating population aging and insufficient elderly care services in rural China, this paper explores how mutual aid models can address these challenges. Taking the "Time Bank" initiative implemented in Wuling Village, Xinxiang City, Henan Province as a case study, the research analyzes how diverse stakeholders—including the elderly, village committees, government agencies, and external organizations—collaborate and integrate resources to establish a sustainable mutual aid system for elderly care, focusing on the perspective of "value co-creation." The study indicates that Wuling Village's "Time Bank" integrates labor mutual aid with elderly care security by converting seniors' spare time into storable, exchangeable "service credits." This model not only activates internal social resources within the village but also gradually expands into deeper collaborations such as capacity training and resource linkage. However, its development faces challenges including insufficient trust, excessive resource dependency, and limited service capacity. Based on these findings, this paper proposes improvements in strengthening institutional trust, broadening resource channels, enhancing service capabilities, and optimizing participation mechanisms to ensure the long-term stability of mutual-aid elderly care models. Wuling Village's experience demonstrates that stimulating endogenous rural momentum and promoting multi-stakeholder collaboration are effective pathways for innovating rural elderly care service systems.
Keywords: Mutual support for aging; Time bank; Value co-creation; Aging society

1 INTRODUCTION

As China's population continues to age at an accelerating pace, the elderly care service system—particularly in rural areas—faces unprecedented challenges. Statistical data reveals that aging rates in China's rural regions significantly exceed those in urban areas, creating profound structural pressures. Against this backdrop, establishing and refining a sustainable elderly care system tailored to rural realities has become a critical issue for both the national rural revitalization strategy and social stability. Traditional models reliant solely on government or family support face bottlenecks in resource allocation and service efficiency, making the exploration of innovative, multi-stakeholder participation models imperative.

Against this backdrop, the "Time Bank" mutual aid model pioneered in Wuling Village, Xinxiang City, Henan Province, offers an inspiring example. Through a mechanism of "service storage-point redemption-intergenerational circulation," this model seeks to activate latent elderly care resources within rural communities, forming a low-cost internal circulation of care services. Existing research, while valuable, has primarily focused on policy analysis, model description, and theoretical critique, failing to systematically reveal the underlying mechanisms of how multiple stakeholders interact, collaborate, and co-create value within this model. Value co-creation theory, rooted in service-dominant logic, emphasizes that value is not solely created by producers and transferred to consumers. Instead, it is jointly created through interactions among multiple participants, including users, providers, communities, and governments. This perspective provides a powerful analytical tool for deeply understanding community-driven, multi-stakeholder innovations like the "time bank."

2 THEORETICAL FRAMEWORK

Value co-creation is a theory examining how multiple stakeholders jointly generate value through resource integration and collaboration to achieve mutual benefit and win-win outcomes [1]. Participants in value co-creation extend beyond enterprises and consumers to include other stakeholders [2]. Daniel et al. analyzed value co-creation mechanisms in virtual contexts, highlighting how input conditions—such as participant motivation, resources, and capabilities—along with enabling factors or barriers like governance, incentives, and trust influence the co-creation process and outcomes [3]. Regarding "Time Banks" AdarshKumar Kakar, a professor at Alabama State University, proposes that "time banks" are considered a method for leveraging untapped community capabilities to meet members' unmet service needs [4]. Ng Tommy KC and Yim Noel TS argue that, against the backdrop of an aging population, "time banks" represent one potential pathway for communities to maximize social capital [5]. Applying value co-creation theory to rural time bank mutual-aid elderly care scenarios helps us analyze several key dimensions:

2.1 The Roles and Resource Integration of Diverse Stakeholders

Within Wuling Village's time bank ecosystem, participants are multifaceted. Younger, healthy seniors serve as core service providers and future service recipients, contributing their spare time and labor; elderly and disabled individuals are the primary service recipients, contributing service demands and participating in value creation through their recognition and feedback; the village committee and project managers act as platform builders and coordinators, providing organizational frameworks and basic rules; grassroots governments offer policy legitimacy and potential financial support; external organizations (such as enterprises, universities, and medical institutions) may inject scarce resources like professional skills, materials, or funds. The heterogeneous resources held by these actors form the foundation for co-creation of value.

2.2 Interaction and Service Platforms

Value co-creation occurs within specific interactive platforms. Wuling Village's "Time Bank" itself functions as an institutionalized interactive platform, defining rules for service exchange, providing mechanisms for recording and tracing transactions, and fostering social norms of reciprocity. This platform facilitates connections and interactions among participants, serving as the arena where resource integration and value exchange take place.

2.3 Co-creating Experiential Value

Value manifests not only in the final exchanged services or goods but also in the overall participatory experience. For younger seniors providing services, value may include immediate social recognition, enhanced self-worth, expectations of future eldercare security, and strengthened community belonging; For service recipients, value lies in receiving tangible daily care and emotional comfort; for the community as a whole, value manifests as enhanced cohesion, revitalized social capital, and strengthened rural governance capabilities. These multidimensional values are collectively perceived and defined through interactions among all stakeholders.

2.4 The Dynamic Evolution of Value Co-creation

Value co-creation is not static; it continuously evolves with changes in internal and external environments, improvements in participants' capabilities, and adjustments to interaction rules. For instance, the practice has deepened and expanded from its initial form of simple labor mutual aid to incorporating professional training, connecting external resources, and leveraging digital technology to enhance efficiency and trust. This paper will systematically analyze the practice of Wuling Village's "Time Bank" based on this theoretical framework.

3 FOUNDATIONS OF CO-CREATION

The value co-creation system of Wuling Village's "Time Bank" is rooted in its unique local resource endowment and jointly constructed by diverse participating entities.

3.1 Core Resources: Local Social Capital and Idle Human Resources

The most valuable resource for value co-creation in Wuling Village is its deep-rooted local social capital. Traditional neighborly mutual aid and trust relationships based on geographical proximity and kinship provided the initial social glue for launching the "Time Bank." This fostered high cultural recognition and psychological acceptance among villagers for the intertemporal exchange model of "I help you today, he helps me tomorrow." Simultaneously, the idle labor force generated during rural "off-season" periods, particularly the spare time of younger, healthy seniors, formed a mobilizable foundation for service provision. The "Time Bank" ingeniously "formatted" and 'capitalized' these informal, latent resources, transforming them into recordable, storable, and exchangeable "time currency." This laid the resource foundation for systematic value co-creation.

3.2 Diverse Actors and Their Roles

Villagers (Service Providers and Users): They are the core actors in value co-creation. Younger seniors serve as primary service providers, contributing physical labor, experience, and time as direct creators of service value. They are also potential future users, whose current contributions carry expectations of future returns. This "investment" mindset forms their intrinsic motivation for participation.
Rural Organizers (Platform Builders and Coordinators): In the early stages, Chen Hongyu and her team's donations accounted for over 80% of total investments, playing a pivotal role as "platform builders." They were not only early financial contributors but also designers of rules, organizers of activities, and guarantors of trust. By aggregating and matching dispersed individual needs with service capacities, they acted as the "weavers" of the value co-creation network.
Village Committees (Institutional Support and Legitimacy Grantors): Village committee involvement provided organizational backing and grassroots legitimacy for the "Time Bank." It partially integrated this spontaneous initiative

into the rural governance framework, offered fixed service venues (e.g., service stations), and bolstered the credibility of "time currency" through its public trust among villagers.

Local Government and External Organizations (Resource Supplementers and Capacity Expanders): Local governments inject external support into the value co-creation system through policy recognition, pilot project inclusion[6], and limited fiscal allocations[7]. Media attention generates social reputation, attracting professional volunteers like city hospital doctors and retired teachers, as well as material and volunteer services from enterprises and universities. This infusion of external resources enriches the diversity of service offerings and elevates their professional value.

4 THE PROCESS AND INTERACTIVE MECHANISMS OF VALUE CO-CREATION

The process of value co-creation manifests through participants' sustained interactions via specific platforms and rules. Wuling Village's practice demonstrates an evolutionary journey from simple exchange to complex ecosystem construction.

4.1 Core Interaction Platform: The "Time Bank" Rule System

The core rules of the "Time Bank" — service storage, point quantification, and future redemption—form the most fundamental value co-creation platform. It establishes a new type of "social contract": an individual's service labor is endowed with a deferred, transferable value symbol (time points). This platform facilitates value creation on two levels: immediate service value, where elderly recipients gain present-day life improvements; and anticipated security value, where service providers gain psychological assurance of informal eldercare support. The platform's stable operation relies on participants' shared recognition and adherence to these rules.

4.2 Deepening Value Co-creation: From Labor Exchange to Capacity Building

Initial value co-creation primarily focused on simple labor exchanges, such as daily care and farm assistance. As practices evolved, value co-creation began expanding to deeper dimensions. Through "service-learning," participants achieved self-empowerment: embedding micro-learning modules like digital skills within service delivery created a closed-loop system where "learning occurs through service, and service improves through learning." Younger senior volunteers, while teaching older seniors to use smartphones, simultaneously reinforced and enhanced their own digital literacy. This process not only generated service value but also co-created human capital value for participants, enabling individual growth through interaction with the system.

4.3 Expanding Value Co-creation: From Internal Circulation to Ecological Linkage

Broadening Service Recipients and Extending Value Networks: Expanding service recipients from seniors to include left-behind children, women, and other "left-behind groups" represents a significant extension of the value co-creation network. This initiative will not only activate new service demands in the future but also create more diverse service scenarios for younger seniors and opportunities to utilize their "time currency." It transforms the "Time Bank" from a simple mutual-aid elderly care platform into a comprehensive rural community support network, enabling the co-creation of broader community governance value and social stability value.

5 CHALLENGES AND OPTIMIZATION PATHWAYS FOR VALUE CO-CREATION

Although Wuling Village's practice embodies numerous elements of value co-creation, the process has not been smooth sailing. It faces multiple challenges that essentially constitute "friction" or "obstacles" within the value co-creation journey.

5.1 Challenges Encountered

Fragile Trust Mechanism: Value co-creation heavily relies on trust among participants. In the Wuling Village case, the subjectivity of point-earning criteria, the rule requiring "unpaid service after age 70," and the absence of a universal deposit and redemption mechanism undermined participants' confidence in future value realization, creating a deficit in institutional trust. This constitutes a core threat to the sustainability of the value co-creation system.

5.1.1 Imbalanced resource structure

Value co-creation requires sustained infusion of diverse resources. Wuling Village's initial overreliance on core individual donations and subsequent dependence on limited fiscal allocations reflect a singular and fragile resource supply structure. The instability of external social capital injections constrains the expansion of value co-creation scale and the elevation of its sophistication.

5.1.2 Insufficient core capacity

As the backbone of value co-creation, the volunteer team's professional shortcomings limit the depth of service value. The lack of systematic training has kept service content at a low level for an extended period, making it difficult to meet diverse and high-level demands. This has kept value co-creation at the "basic needs" level, hindering its leap to the "quality" level.

5.1.3 Incomplete interaction platform

Ambiguous rules, lack of oversight, and low digitalization levels have resulted in an inefficient and insufficiently transparent interaction platform for value co-creation. Although Wuling Village designed an auxiliary channel with staff assistance to register participants, addressing the digital literacy gap for some elderly residents [8], the digital divide further excludes key elderly groups from more efficient digital interaction platforms, creating participation inequality in the value co-creation process.

5.2 Optimization Pathways: Strategy Reconstruction from a Value Co-creation Perspective

Based on value co-creation theory, the following optimization pathways address the aforementioned challenges:

5.2.1 Strengthen the foundation of trust through institutionalized commitments

The sustainability of value co-creation requires institutional safeguards. Efforts should be made to establish a "Time Currency Value Protection Fund" or secure government service procurement as a safety net, upgrading interpersonal trust to institutional trust. Simultaneously, technologies like blockchain should be introduced to ensure the immutability and traceability of point records, solidifying the trust foundation at the technical level.

5.2.2 Expand resource channels to build resilient resource networks

The value co-creation system must proactively cultivate a diversified resource ecosystem. Beyond securing government funding, it should actively attract sustainable participation from corporate entities and foundations through branded operations and project-based collaborations. Simultaneously, internal community resources should be tapped—such as establishing "Community Public Welfare Warehouses" — to enable the circulation of physical resources and time currency within the system, reducing reliance on external cash.

5.2.3 Invest in human capital to enhance co-creation capabilities

Systematizing and regularizing volunteer training is key to value co-creation with professional institutions. Through continuous capacity building, empower volunteers to evolve from simple labor providers into service providers with comprehensive skills—including professional care and emergency response—thereby jointly creating higher-quality service value.

5.2.4 Optimize interactive platforms to foster inclusive participation

Refine the Time Bank Management Measures to ensure transparency and standardization in point allocation, redemption rules, and oversight mechanisms. When advancing digital platform development, adopt a hybrid "online + offline" model that retains physical service windows. This approach ensures digital technology empowers rather than excludes, enabling inclusive value co-creation.

6 CONCLUSION

The practice of Wuling Village's "Time Bank" vividly demonstrates how, against the backdrop of scarce rural eldercare resources, value can be co-created by establishing a mutual-aid platform involving multiple stakeholders. This process transcends simple service exchange; it is a systemic endeavor that integrates local social capital, idle human resources, external professional resources, and societal attention to collectively address eldercare challenges.

Employing a value co-creation theoretical framework, this study reveals that the value of the Wuling Village model is rooted in its effective activation and integration of traditional mutual aid spirit and human resources within the village. Its value creation evolves dynamically from basic labor exchange to capacity building, resource linkage, and network expansion; while the challenges it faces — funding, trust, talent, and institutional constraints — signal the need to optimize resource structures, interaction mechanisms, and stakeholder capabilities within the value co-creation system.

Therefore, the sustainable development of rural mutual-aid eldercare models hinges on shifting from "managing a project" to "operating a value co-creation ecosystem." This entails decision-makers and community organizers committing to: - Establishing a more robust institutional trust framework to stabilize participants' long-term expectations; - Designing and maintaining an efficient, equitable, and inclusive interaction platform to facilitate seamless resource flow and matching; - Continuously investing in core participants' capacity building to elevate the system's overall value creation ceiling; - Proactively linking internal and external resources to construct a resilient support network.

Wuling Village's exploration demonstrates that addressing complex rural elderly care challenges cannot rely solely on external inputs. More crucially, it requires igniting endogenous momentum within villages. Through sophisticated institutional design, scattered individuals are connected into a value community sharing common interests and responsibilities. The essence of this "New Rural Experience" lies in offering a rural solution for achieving "elderly care through shared value creation." This approach not only holds practical significance for enriching rural elderly care services but also provides profound insights for advancing the modernization of rural governance systems and capabilities.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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THE INFLUENCE MECHANISM OF INCLUSIVE LEADERSHIP ON MEDICAL STAFF'S PROACTIVE CHANGE BEHAVIOR IN PUBLIC HOSPITALS——THE MEDIATING ROLE OF LEADER-MEMBER EXCHANGE

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Abstract: Objective: To explore the influence mechanism of inclusive leadership on the active change behavior of medical staff in public hospitals, to provide reference for hospitals to promote the active change of medical staff, and to open up new ideas for hospital management. Methods: A total of 420 medical workers from 5 public hospitals in Henan Province were selected by convenience sampling method. The inclusive leadership scale, leader-member exchange scale and active change behavior scale were used. Results: Inclusive leadership has a significant positive impact on medical staff's proactive change behavior. Leader-member exchange relationship plays an intermediary role between inclusive leadership and medical staff's proactive change behavior. Perceived insider status can not only positively regulate the relationship between inclusive leadership and leader-member exchange, but also strengthen the intermediary role of leader-member exchange between inclusive leadership and medical staff's proactive change behavior. Conclusion: This study enriches the research of inclusive leadership in the field of hospital organization, and has certain enlightenment and practical significance for hospital managers to improve medical staff's proactive change behavior.
Keywords: Inclusive leadership; Active change behavior; Leader-member exchange relationship; Insider identity perception

1 INTRODUCTION

In recent years, the reform of public hospitals in China has entered the deep water area of " high-quality development, " and public hospitals are facing unprecedented challenges and opportunities. In order to better adapt to the current era background, hospitals must keep up with the pace of development of the times and constantly seek organizational change and innovation, so as to enhance the adaptability, competitive vitality and sustainable development of hospitals. As the backbone of the hospital organizational system, the reform and development of hospitals cannot be separated from the active participation and active change behavior of medical staff[1]. How to effectively stimulate and guide the active change behavior of medical staff is an urgent problem to be solved by organizational managers. Existing research shows that leadership style has an important impact on employees' active change behavior. Among them, inclusive leadership style, as a positive new leadership style, has a positive and positive impact on employees' behavior, so it has attracted the attention of the current academic community. Inclusive leadership has the characteristics of openness, availability and accessibility, which can create an inclusive and supportive working atmosphere, stimulate employees' intrinsic motivation and innovative spirit. It is more adaptable to the uncertain medical environment in the medical and health field. The existing research on the impact of inclusive leadership on active change focuses on the enterprise scene, and there is a lack of discussion on the mechanism of' leadership style-active change behavior' in the public medical field. Therefore, it is of great significance to explore how inclusive leadership affects the active change behavior of medical staff in the organizational context of public hospitals.

According to social exchange theory, individuals are more willing to give positive feedback to the organization when they are recognized, cared for, helped and respected by the organization[2]. This also makes inclusive leadership based on the interdependence between leaders and employees stand out from various leadership styles. Studies have shown that inclusive leadership can effectively promote the exchange relationship between leaders and employees and improve job satisfaction. In the organization, the relationship between leaders and employees plays a crucial role in shaping the behavior of employees. Edmondson's research shows that in an organization, the closer the exchange relationship between leaders and members is, the more active the organization's innovative behavior is. The better the employee-leader exchange relationship is maintained, the higher the work engagement will be performed at work, and the more proactively innovative behavior will be carried out[3,4]. Therefore, it is speculated that the leader-member exchange relationship plays an intermediary role between inclusive leadership and proactive change behavior.

In the organization, the individual works by self-will, and the stronger the employee's sense of organizational identity, the stronger the influence of leadership style. Yu Mingchuan et al. think that employees feel that they are insiders of the organization, which is a reflection of high-quality employee-organization relationship. Employees will regard themselves as internal citizens of the organization, not only responsible for their own work, but also actively undertake

some extra-role tasks, and have the courage to innovate[5]. Therefore, it is speculated that insider identity perception plays a regulatory role between inclusive leadership and leader-member exchange relationship.

Based on this, based on the social exchange theory, this paper introduces the leader-member exchange relationship as an intermediary variable and the perceived insider status as a moderator variable to explore the internal mechanism of the influence of inclusive leadership on the active change behavior of medical staff in the organizational context of public hospitals, and broadens the theoretical research horizon of the active change behavior of medical staff. At the same time, it provides new ideas and new measures for the management of public hospitals, and provides some suggestions for helping the high-quality development of public hospitals.

2 THEORETICAL BASIS AND RESEARCH HYPOTHESIS

2.1 Inclusive Leadership and Medical Staff's Proactive Change Behavior

The style of inclusive leadership is supportive, interactive, fair and fault-tolerant, which can have an important impact on the behavior of subordinates in the organization[6]. Inclusive leadership can accommodate employees' opinions and mistakes, pay attention to employees' emotional needs, give employees enough respect and care, so as to promote employees to actively show their true thoughts, and further stimulate employees to make proactive behaviors[7] Employees' proactive change behavior is that employees exert their own subjective initiative to make changes to work processes, procedures and policies independently. As a kind of spontaneous extra-role behavior, the risk of proactive change behavior is higher. Due to the particularity of hospital organization, the risk and uncertainty of medical staff's proactive change behavior are greater, so medical staff are more inclined to carry out in-role behavior in the work situation. Whether employees implement proactive change behavior depends largely on whether the leadership supports and understands it. According to the social exchange theory, interpersonal communication follows the principle of reciprocity and mutual benefit. In the hospital organization, inclusive leadership has an impact on the active change behavior of medical staff from the following aspects: First, there is an exchange relationship between inclusive leadership and medical staff. Leaders can bring opportunities and resources to medical staff in medical work, so that employees have greater confidence to make active change behavior to give back the support of leadership. Second, inclusive leadership style emphasizes paying attention to and supporting the needs, opinions and contributions of medical staff, and establishing a good atmosphere for leaders to communicate, so that medical staff can more recognize the organization and leadership. In turn, they will make proactive change behaviors that are conducive to the development of the hospital to reward the hospital. Third, medical staff's proactive change behaviors face challenges and need to be responsible for their behaviors, while inclusive leadership allows employees to make mistakes and gives them enough respect and recognition, thus prompting medical staff to take the initiative to initiate challenges and innovative behaviors. Based on this, this paper proposes hypotheses:

H1: Inclusive leadership has a positive impact on medical staff's proactive change behavior.

2.2 The Mediating Role of Leader-Member Exchange Relationship

Graen & Uhl-Bien defined the connotation of leader-member exchange as LMX is a social exchange relationship based on mutual trust, respect and obligation between leaders and employees[8]. If the quality of LMX is high, employees realize that they are divided into insiders by leaders. Studies have shown that leadership style can affect the exchange relationship between leaders and employees in terms of the interaction between leaders and employees. Inclusive leadership has the dual characteristics of transformational leadership and service-oriented leadership, which can not only show the role of transformational leadership in organizational innovation. It can also show the dedication of servant leadership to employees. Zhang Ruiying et al.conducted a field survey of two companies and found that inclusive leadership can positively affect the exchange relationship between leaders and employees and improve job satisfaction. Studies have shown that inclusive leadership can enhance nurses' perception of high-quality leader-member exchange relationships in work scenarios and promote the establishment of a good exchange relationship between nurses and managers[9]. In addition, inclusive leaders respect and recognize medical staff and often give work guidance. According to social exchange theory, when individuals gain organizational recognition, care, support and respect. They are more willing to give positive feedback to the organization[2]. Therefore, when medical staff feel the tolerance and support of inclusive leadership in their work, they will be more inclined to think that they are regarded as' insiders', which is more conducive to building a high-quality leader-member relationship.

H2: Inclusive leadership has a positive impact on leader-member relationship.

Previous studies have shown that leader-member exchange plays an important role in influencing employees' proactive behavior, organizational citizenship behavior and extra-role behavior. On the one hand, high-level leader-member exchange, that is, leaders take the initiative to help employees, employees are highly supportive of leaders, so that employees are willing and can obtain more information resources, employees can better understand the nature of work, and can make appropriate judgments on the effectiveness of work processes that need to be changed[10]. Low-level leader-member exchange, that is, leaders do not take the initiative to help employees, while employees are negatively treating their leaders. There is a lack of sufficient information exchange between the two. This leads to the inability of employees to make reasonable judgments in the face of complex situations, so that unequal information makes

employees dare not easily make proactive change behavior. On the other hand, from the current organizational culture of the hospital, proactive change may touch the interests of leaders or others, resulting in interpersonal conflicts. High level of leadership-member exchange is conducive to the formation of inclusive and intimate superior-subordinate relationship, which helps to reduce the medical staff's concern about the failure of change, and the courage to use new knowledge and practice new ideas; on the contrary, a low level of leader-member exchange is not conducive to the establishment of a harmonious relationship between superiors and subordinates, and medical staff are not willing to take the risk of offending leadership authority and failure of change, thus reducing the occurrence of change behavior.

Social exchange theory is an important theoretical basis for inclusive leadership and employees' proactive change behavior, and it is also one of the key theories to explain the mechanism of action between the two. In hospital organizations, inclusive leadership encourages employees to actively participate in communication, value their value, pay attention to their needs, and affirm their contributions. Therefore, it is easier to obtain the trust of medical staff and establish a high-quality interactive relationship. Once a high-quality leader-member relationship is formed, the relationship between the two is more harmonious, and medical staff will generate more organizational citizenship behaviors for leadership and organization as feedback. According to the reciprocity principle of social exchange theory. When employees give back the support and help given by the organization and leadership, they will also involuntarily choose the proactive change behavior that is favored by the organization. Based on this, this paper puts forward the hypothesis:

H3: Leader-member relationship plays a mediating role between inclusive leadership and medical staff's proactive change behavior.

2.3 The Moderating Effect of Perceived Insider Status on Inclusive Leadership and Leader-Member Exchange Relationship

Perceived insider status emphasizes the relationship between employees and the organization in which they are located. Specifically, perceived insider status is the perception of how individuals, as members of the organization, can gain development space and acceptance in the organization, which is a manifestation of employees' recognition of whether they belong to' insider status'.According to social exchange theory, when employees feel a higher perceived insider status, they will give positive feedback to the organization. Studies have shown that when the perceived insider status is low, employees think that their value and ability recognition is low, and the sense of ownership is weakened. Therefore, they will resist extra-role behavior without reward feedback[11]; On the contrary, employees with higher perceived insider status will have a strong sense of ownership and regard their organization as a community of destiny, resulting in more innovative ideas conducive to organizational innovation and helping to enhance the competitive advantage of the organization. Schlosser mentioned in his research that a high level of perceived insider status will motivate employees' work enthusiasm and contribute to the organization sustainably[12]. Based on this, compared with employees with lower perceived insider status, medical staff with higher perceived insider status are more motivated to work and are more willing to interact with leaders frequently and closely. When such employees feel the help and concern from inclusive leadership, they are also more likely to build high-quality relationships with leaders because they trust the organization more. Based on this, this paper proposes the following hypothesis:

H4: Perceived insider status positively moderates the relationship between inclusive leadership and leader-member exchange.

On this basis, this study further proposes that perceived insider status moderates the indirect effect of inclusive leadership on medical staff's proactive change behavior through leader-member exchange. That is to say, medical staff with higher perceived insider status have more trust in leaders, so they are more inclined to establish high-quality superior-subordinate relationships with leaders. When employees establish high-quality leader-member relationships with their superiors, such medical staff will receive various resources and support to complete their tasks, which will make it easier for them to obtain opportunities for promotion and salary increase. Based on the principle of reciprocity, when medical staff give back the support and care given by leaders. Therefore, the mediating role of leader-member relationship between inclusive leadership and medical staff's proactive change behavior will be enhanced. Based on this, this paper puts forward the hypothesis:

H5: Perceived insider status positively moderates the mediating role of leader-member exchange between inclusive leadership and medical staff's proactive change behavior.

Based on the above discussion, a moderated mediation model can be constructed as shown in Figure 1.
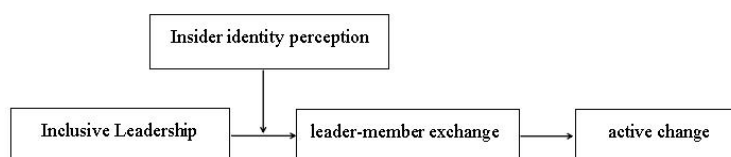

Figure 1 Theoretical Model

3   RESEARCH METHODS

3.1 Research Samples

From April to June 2025, the medical staff of five public hospitals in Henan Province (the First Affiliated Hospital of Xinxiang Medical University, the Second Affiliated Hospital of Xinxiang Medical University, the Third Affiliated Hospital of Xinxiang Medical University, Xinxiang Central Hospital, Xinxiang Second People's Hospital) were selected as the research objects. Inclusion criteria: (1) On-the-job registered medical staff; (2) working time ≥ 1 year; (3) Informed consent for this study, voluntary cooperation to complete the investigation and study Exclusion criteria: not on duty due to leave, retirement, etc.; a total of 420 samples were collected by electronic questionnaire star, and 388 valid questionnaires were finally obtained by screening samples and eliminating invalid questionnaires with incomplete answers, with an effective rate of 92.3 %.

3.2 Research Tools

In this study, all items were designed using a Likert-5 point design, ranging from 1 ('very disagree') to 5 ('very agree').
Inclusive Leadership: The three-dimensional Inclusive Leadership Scale developed by Carmeli et al. [13], a total of 9 items, such as' leaders are willing to listen to our new ideas'.In this study, the reliability coefficient of the scale was 0.853.
Proactive Change Behavior: A single-dimensional scale developed by Morrison and Phelps (1999) was used. The scale consisted of 10 items, including' I will introduce some new facilities, techniques and methods'. In this study, the reliability coefficient of the scale was 0.874.
Leader-member exchange relationship: Using the LMX scale compiled by Graen and Uhl-Bien in 1995, a total of 7 items, including " I have a harmonious relationship with my leaders and can work together efficiently. " The reliability coefficient of the scale is 0.835.
Insider Identity Perception: The Insider Identity Perception Scale is a scale developed by Stamper and Masterson (2002). It has 6 questions, including' I can strongly feel that I am a member of the organization' and so on. The reliability coefficient of the scale is 0.738.
In addition, according to previous studies, considering that demographic variables will affect employees' proactive change behavior, this study chooses gender, age, education, working years, job level and position as control variables.

4 ANALYSIS OF THE RESULTS

4.1 Confirmatory Factor Analysis

In this study, Mplus 8.3 software was used to conduct confirmatory factor analysis on the four variables of inclusive leadership, insider status perception, leader-member exchange relationship and active change behavior. The results are shown in Table 1. The fitting index of the four-factor model ($\chi2$ / df = 2.142, CFI = 0.962, TLI = 0.946, RMSEA = 0.048) is significantly better than the other three alternative models. Therefore, the four variables in this study have good discriminant validity.

Table 1 Confirmatory Factor Analysis Results

model	factor structure	$\chi2$	df	$\chi2$/df	CFI	TLI	RMSEA
Four-factor model	A; B; C; D	981.036	458	2.142	0.962	0.946	0.048
Three-factor model	A; B+C; D	2012.935	461	4.366	0.713	0.691	0.093
Two-factor model	A+D,B+C	3005.333	463	6.491	0.645	0.620	0.103
Single-factor model	A+B+C+D	4006.603	478	8.382	0.347	0.323	0.138

Note:the number of samples is 388; A is inclusive leadership, B is perceived insider status, C is leader-member exchange, D is proactive change behavior, and' +' is the merging factor.

4.2 Common method Bias Test

Harman's single factor test was used to analyze the common method bias of all the measurement items of inclusive leadership, perceived insider status, leader-member exchange relationship and active change. A total of 6 common factors with eigenvalues > 1 were extracted. The interpretation rate of the first common factor was 31.4 %, which was lower than the critical value of 40 %, indicating that there was no serious common method bias in the sample data of this study.

4.3 Descriptive Statistical Analysis and Correlation

The analysis results of the mean, standard deviation and correlation coefficient of each variable are as shown in table 2. Inclusive leadership is significantly positively correlated with active change behavior (r = 0.579, p < 0.01); inclusive leadership was significantly positively correlated with leader-member exchange (r = 0.503, p < 0.01). Leader-member exchange is significantly positively correlated with proactive change behavior (r = 0.602, p < 0.01). Therefore, the hypothesis 1, hypothesis 2 and hypothesis 3 of this study are preliminarily verified, which lays a good foundation for further hypothesis testing.

Table 2 Descriptive Statistics and Correlation Coefficient of Variables (N = 388).

Variable	Average value	standard deviation	1	2	3	4
1.Inclusive Leadership	3.6892	.54687	1			
2.active change	3.864	.5393	.579**	1		
3.Insider identity perception	3.4329	.73922	.385**	.594**	1	
4.leader-member exchange	3.6465	.59532	.503**	.602**	.478**	1

Note: * denotes p < 0.05, * * denotes p < 0.01.

4.4 Hypothesis Testing

4.4.1 Mediating effect test

This study used the Process4.0 plug-in and Bootstrapping to verify the mediating effect for 5000 samples. The results showed that the indirect effect value of inclusive leadership from leader-member exchange to active change behavior was 0.20, and the 95 % confidence interval was [0.15, 0.26], excluding 0, assuming that H1, H2, and H3 were supported.

4.4.2 Test of moderating effect

This study uses hierarchical regression to test the moderating effect of perceived insider status.. Firstly, the independent variable inclusive leadership, the interaction term of inclusive leadership and perceived insider status are centralized.. Then the leader-member exchange relationship is the dependent variable, the first step is to put in the control variable, the second step is to put in the inclusive leadership and perceived insider status, and the third step is to put in the interaction term of inclusive leadership and perceived insider status for regression.. As shown in Table 3, the interaction term of inclusive leadership and perceived insider status significantly positively affects the leader-member exchange relationship (β = 0.33, p < 0.001). Preliminary support H4.

Table 3 The Moderating Effect of Insider Identity Perception

Variables	leader-member exchange			
	Model 1	Model 2	Model 3	Model 4
Gender	0.117*	0.010	-0.026	-0.031
Age	-0.002	-0.023	-0.010	-0.035
Education	0.107	0.080	-0.082	0.096*
Years of work	-0.065**	-0.083	-0.047**	-0.023
Posts	-0.057	-0.092	0.110	0.122**
Level	0.131*	0.023	0.006	-0.003
Inclusive Leadership		0.511***	0.385***	0.403***
Leader-member exchange				
Insider identity perception			0.332***	0.363***
Inclusive leadership * Insider identity perception				0.330***
R2	0.034	0.273	0.364	0.394
△R2	0.034	0.239	0.091	0.030
F	2.253*	20.388***	27.065***	27.268***

Note: * denotes p < 0.05, * * denotes p < 0.01, * * * denotes p < 0.001.

4.4.3 A moderated mediating effect test

Using the Process procedure, 5000 samples were sampled for Bootstrapping test to analyze the mediating role of leader-member exchange relationship between inclusive leadership and proactive change behavior at different levels of perceived insider status. As shown in Table 4, when the perceived insider status is high, the indirect effect value of inclusive leadership on proactive change behavior through leader-member exchange relationship is 0.165, and the 95 % confidence interval is [0.015, 0.18], excluding 0, which is significantly positive; when the perceived level of insider status is low, the indirect effect value is 0.05, and the 95 % confidence interval is [-0.05, 0.12], including 0, which is not significant; the difference of indirect effect between high and low levels was 0.115, and the 95 % confidence interval was [0.06, 0.21], excluding 0, indicating that the difference of indirect effect was significant, and H5 was verified.

Table 4 The Results of Moderated Mediating Effect Analysis

Mediator variable	Task interdependence	Indirect effect	standard error	95% confidence interval
Leader-member Exchange	Low insider identity perception	0.05	0.039	-0.05 0.12
	High insider identity perception	0.165	0.026	0.015 0.18
	The difference of indirect effects between high and low conditions	0.115	0.037	0.06 0.21

Note: Low insider status perception is the mean minus 1 standard deviation, and high insider status perception is the mean plus 1 standard deviation.

5   CONCLUSIONS AND IMPLICATIONS

5.1 Conclusions

Based on the social exchange theory, this study empirically analyzes the influence mechanism of inclusive leadership on the active change behavior of medical staff. The conclusions are as follows: (1) Inclusive leadership has a positive impact on the active change behavior of medical staff; (2) Leader-member exchange relationship plays a mediating role between inclusive leadership and medical staff's proactive change behavior; (3) Perceived insider status has a positive moderating effect on the relationship between inclusive leadership and medical staff's proactive change behavior. (4) The mediating effect of inclusive leadership on medical staff's proactive change behavior through leader-member exchange relationship is also positively moderated by perceived insider status.

5.2 Theoretical Contributions

The theoretical contributions of this study are as follows: Firstly, the mechanism of inclusive leadership on the active change behavior of medical staff is discussed. It is found that inclusive leadership can not only have a direct positive impact on the active change behavior of medical staff, but also affect the active change behavior through indirect paths. It clarifies the boundary and channel of the positive effect of inclusive leadership on the active change behavior of medical staff, further enriches the localized human resource management theory, combines inclusive leadership with the active change behavior of medical staff, and is also a useful supplement to the previous research perspective. This study reveals the mediating role of leader-member exchange relationship between inclusive leadership and medical staff's proactive change behavior. Based on social exchange theory, this study proposes the mediating mechanism of inclusive leadership affecting medical staff's proactive change behavior through leader-member exchange relationship, and also enriches and expands the application scope of social exchange theory. Thirdly, this study clarifies how perceived insider status plays a moderating role between inclusive leadership and leader-member relationship. This study explores the important boundary conditions of how inclusive leadership affects medical staff's proactive change behavior in hospitals. This study confirms the moderating effect of perceived insider status. On the one hand, it enriches the context of the impact of inclusive leadership on employees' proactive change behavior. On the other hand, it provides a new perspective for the subsequent exploration of the impact of other types of leadership styles on employee behavior.。

5.3 Management Implications

The significance of this study for management practice lies in: first, in the process of selection and training of leading cadres at all levels in hospitals, attention should be paid to the consideration of leadership style. The study found that inclusive leadership can promote the active change behavior of medical staff. Therefore, when recruiting managers, hospital organizations can give priority to the selection of employees with inclusive leadership style. At the same time, when training managers at different levels, we should also pay attention to the training of inclusive leadership style, so that the positive effect of inclusive leadership can be integrated into the active change behavior of medical staff. Second, establish a high-quality leadership-member relationship. Leaders need to take the initiative to pay attention to the work progress and problems encountered by employees, and employees actively communicate with leaders to prevent information errors, so that the satisfaction of communication between the two sides has been greatly improved. In the process of communication, employees can truly feel the support and trust of leaders, realize the high-quality leader-member exchange relationship, enhance the sense of ownership in the work, and then be willing to take active change behavior for the organization. Organizational managers should also be aware of the role of perceived insider status in the process of improving medical staff's proactive change behavior. In order to maximize the positive effects of medical staff's proactive change behavior, medical staff's recognition of their own organization should be fully considered. In the process of selecting medical staff, hospitals should consciously screen individuals with high perceived insider status as the training objects of hospitals, and give these employees more development support, so as to effectively improve employees' proactive change behavior.

5.4 Deficiency and Prospect

This study only focuses on the medical staff of some tertiary general hospitals in Henan Province as the survey object, and the representativeness and universality of the sample may be affected. In the future, it can be considered to expand the sampling range and explore the medical staff groups in different levels and different regions. Secondly, this study is a cross-sectional study, which only analyzes the relationship and mechanism between variables at a certain time point, and can not fully explain the causal relationship and changes between variables. In the future, longitudinal follow-up survey can be carried out according to the characteristics of the research variables, further demonstrate the timeliness of the research, and improve and expand the research results. This study only focuses on the medical staff of some tertiary general hospitals in Henan Province as the survey object, and the representativeness and universality of the sample may be affected. In the future, it can be considered to expand the sampling range and explore the medical staff groups in different levels and different regions. Secondly, this study is a cross-sectional study, which only analyzes the relationship and mechanism between variables at a certain time point, and can not fully explain the causal relationship and changes between variables. In the future, longitudinal follow-up survey can be carried out according to the characteristics of the research variables, further demonstrate the timeliness of the research, and improve and expand the research results.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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INNOVATIVE REFORM PATHS OF FINANCIAL ACCOUNTING COURSE FROM THE PERSPECTIVE OF CURRICULUM IDEOLOGICAL AND POLITICAL EDUCATION

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Abstract: As a core course for accounting majors, Financial Accounting bears the dual responsibility of imparting professional knowledge (focusing on the accounting of five major elements: assets, liabilities, owner's equity, income, and expenses) and shaping professional ethics. From the perspective of curriculum ideological and political education (CIPE), the traditional teaching model of this course faces the problem of "disconnection between professional knowledge and value guidance". This paper proposes four innovative reform paths: content reconstruction, model innovation, evaluation optimization, and guarantee strengthening. By integrating ideological and political elements into accounting practice scenarios, building an "AI+BOPPPS" closed-loop teaching model, and establishing a dual-dimensional evaluation system of "professional competence + ideological literacy", it aims to construct an educational system of "taking accounts as the foundation and integrity as the soul", and cultivate accounting talents who meet the requirements of the market economy and have a sense of social responsibility.

Keywords: Curriculum ideological and political education; Financial accounting; AI+BOPPPS teaching model; Dual-dimensional evaluation; Talent cultivation

1 INTRODUCTION

With the continuous improvement of China's market economy system and the deep integration of digital technology into the accounting industry, the demand for high-quality accounting talents with both professional skills, moral integrity, and technical literacy is increasing exponentially. Financial Accounting, as a bridge connecting accounting theory and practical work, not only needs to enable students to master the standards and methods of accounting treatment but also needs to guide students to establish the professional ethics of "integrity, objectivity, and prudence" through curriculum ideological and political education. However, in the current teaching practice of Financial Accounting, there are prominent problems such as "superficial embedding of ideological and political elements" (e.g., simply attaching moral slogans to accounting standards without logical connection), "separation of theory and practice" (e.g., overemphasis on book knowledge while ignoring the ethical dilemmas in real accounting scenarios), and "lagging behind technological development" (e.g., lack of guidance on ethical issues in intelligent accounting)[1].

A survey conducted among 50 accounting educators from 30 universities shows that 78% of respondents believe that "students' awareness of accounting ethics is insufficient in practical training", and 65% point out that "traditional teaching methods cannot effectively simulate the ethical decision-making scenarios in digital accounting environments". These problems directly affect the quality of accounting talent cultivation, especially in the context of frequent financial fraud cases such as Luckin Coffee and Enron, which highlight the urgency of integrating ideological and political education into Financial Accounting teaching. Therefore, exploring the innovative reform paths of this course from the perspective of CIPE has important practical significance for improving the quality of accounting talent cultivation and ensuring the healthy development of the capital market[1].

2 CONTENT RECONSTRUCTION: ACCURATE EMBEDDING OF IDEOLOGICAL AND POLITICAL ELEMENTS BASED ON ACCOUNTING MODULES

The core of content innovation is to break the "chapter-based interspersion" model of ideological and political elements and form a three-dimensional content chain of "business scenario - professional knowledge - value guidance" closely linked to the core accounting modules of Financial Accounting.

2.1 Asset Accounting: Infiltrating the Concept of "Integrity and Integrity"

In the chapter of "Monetary Fund Accounting", combined with the practical operation of "cash count", a negative case of "a cashier embezzling public funds leading to the enterprise's capital chain breakage" is introduced. By comparing the requirements of the Interim Regulations on Cash Management, students are guided to realize that "consistency between accounts and actuals is the foundation of financial integrity"[2]. When explaining the "inventory valuation methods" (FIFO, weighted average method), a case of "an enterprise adjusting profits by choosing different valuation methods" is used to interpret the "reliability" requirement of accounting information in the Accounting Standards for Business Enterprises, helping students understand that "the choice of accounting methods must adhere to professional bottom lines".

In the "Intangible Asset Accounting" module, taking "intellectual property right (IP) accounting of high-tech enterprises" as an example, the case of "Huawei's annual R&D investment accounting and IP value protection" is introduced[3]. By analyzing how Huawei accurately recognizes and measures R&D expenses in accordance with accounting standards, students are guided to understand that "respect for intellectual property rights and honest accounting of intangible assets are the core driving forces for enterprise innovation and development", and thus establish the awareness of "safeguarding enterprise intellectual property rights through standardized accounting".

2.2 Liability and Owner's Equity Accounting: Integrating the Awareness of "Responsibility and Undertaking"

In the module of "Accrued Payroll Accounting", a case of "labor disputes caused by an enterprise defaulting on wages" is taken as the entry point. By combining the provisions of the Labor Law on wage payment, students are made to realize that "timely and full accounting of wages is the enterprise's responsibility to employees". In the "Paid-in Capital Accounting", the "equity structure design during foreign investment" is analyzed, and the requirement of "maintaining and increasing the value of state-owned assets" is associated. The compliance of "capital premium included in capital reserve" is explained to cultivate students' "responsibility awareness of safeguarding the owner's equity".
For the "Environmental Liability Accounting" module, which is increasingly valued in the context of the "dual carbon" strategy, the case of "a chemical enterprise failing to accrue environmental remediation liabilities leading to ecological damage and legal sanctions" is introduced. By comparing the provisions of the Environmental Protection Law and the Accounting Standards for Business Enterprises on environmental liability recognition, students are guided to recognize that "accurate accounting of environmental liabilities is not only a legal obligation but also an important embodiment of corporate social responsibility", and thus establish the concept of "green accounting and sustainable development".

2.3 Income and Expense Accounting: Conveying the Thinking of "Compliant Operation"

In the chapter of "Income Recognition", focusing on the "five-step method under the new revenue standard", a case of "an enterprise recognizing income in advance to inflate performance" is used. By comparing the recognition condition of "control transfer" in the standard, it is emphasized that "income accounting must match the actual business and not engage in 'digital games'". In the module of "Expense Collection and Allocation", taking the "accounting of environmental protection expenses of manufacturing enterprises" as an example, the requirements of the "dual carbon strategy" are integrated, and students are informed that "sufficient accounting of environmental protection expenses is not only a compliance requirement but also a manifestation of the enterprise's social responsibility".

2.4 Technology Ethics: Introducing the Boundary Awareness of "Intelligent Accounting"

With the application of AI and big data in accounting work, new ethical issues such as data privacy leakage and algorithmic bias have emerged. In the "Intelligent Accounting Application" section added to the course, the case of "a financial technology company misusing user transaction data for profit due to inadequate data management" is introduced. Combined with the provisions of the Data Security Law and the Personal Information Protection Law, students are guided to think about "how to balance the efficiency of intelligent accounting and data security", and establish the awareness of "abiding by technology ethics in the digital age". For example, when explaining the automatic invoice verification function of financial robots, it is emphasized that "accountants must manually review the results of intelligent processing to avoid algorithmic errors leading to false accounting information", and thus understand that "technology is a tool, and human professional ethics are still the core of accounting work".

3 MODEL INNOVATION: BUILDING AN "AI+BOPPPS" CLOSED-LOOP TEACHING MODEL

Relying on the characteristics of "emphasizing practical operation and application" of Financial Accounting, an immersive teaching scenario is designed, and the "AI+BOPPPS" closed-loop teaching model is introduced to deepen students' experience of ideological and political education in accounting practice.

3.1 Overview of the "AI+BOPPPS" Teaching Model

The BOPPPS model is a modular teaching framework including six links: Bridge-in (course introduction), Objective (goal setting), Pre-assessment (pre-class assessment), Participation (participatory learning), Post-assessment (post-class assessment), and Summary (summary and reflection)[4]. The integration of AI technology can realize the intelligent push of teaching resources, the real-time feedback of learning effects, and the personalized guidance of students, thus forming a closed-loop teaching system of "pre-class preparation - in-class interaction - post-class consolidation". Unlike the traditional BOPPPS model, the "AI+BOPPPS" model can accurately capture students' learning weaknesses and ideological tendencies through data analysis, and realize the precision of ideological and political education.

3.2 Specific Application of the Model in Financial Accounting Teaching

3.2.1 Pre-class: AI-pushed ideological and political cases and pre-assessment
Before the class of "Fixed Asset Depreciation Accounting", the AI platform (such as the Yangtze River Rain Classroom

or U-MOOC) pushes hot cases of "listed companies falsifying financial reports by changing depreciation methods" (such as "an enterprise reducing tax payment by arbitrarily changing the straight-line method to the accelerated depreciation method"). At the same time, the AI system releases pre-assessment questions (such as "What are the impacts of changing depreciation methods on enterprise profits and tax payments?"), and according to the students' answer results, it intelligently identifies the knowledge points that students have not mastered (e.g., 60% of students fail to understand the relationship between depreciation methods and tax compliance), laying a foundation for in-class teaching.

For the pre-class preparation of "Production and Material Issuance Accounting", the AI system uses big data to collect real cases of "A manufacturing enterprise facing operational difficulties due to excessive waste of raw materials", and pushes the case to students with a pre-question: "How does the accounting treatment of material issuance reflect the concept of cost control and resource conservation?" This enables students to initially associate professional knowledge with ideological and political concepts such as "thrift and responsibility" before class.

3.2.2 In-class: BOPPPS-linked interactive teaching with AI assistance

Bridge-in: Play a 3-minute short video produced by AI about "the Enron incident and the importance of fixed asset accounting", which triggers students' thinking about "the relationship between accounting treatment and enterprise integrity". For "Intangible Asset Accounting", play an AI-edited video of "the development history of China's accounting from 'Sizhu Qingce' to intelligent accounting", and guide students to feel the "cultural confidence in Chinese accounting" through the comparison of traditional and modern accounting.

Objective: Clearly put forward the three-dimensional teaching goals of "knowledge (mastering the calculation method of fixed asset depreciation)", "ability (being able to choose the appropriate depreciation method according to the enterprise's actual situation)", and "ideology (establishing the awareness of complying with accounting standards)" using the ABCD method (Audience, Behavior, Condition, Degree). For example, the ideological and political goal is refined as "After completing this lesson, students can accurately identify 3 types of non-compliant depreciation behaviors and explain their harm based on professional ethics".

Pre-assessment: Use the AI interactive platform to conduct a 5-minute quick quiz, including questions such as "Which of the following depreciation methods complies with the Accounting Standards for Business Enterprises?" and "What is the core requirement of the Code of Professional Ethics for Accounting Personnel on asset accounting?" The AI system instantly counts the correct rate, and the teacher adjusts the teaching focus according to the results (e.g., focusing on explaining the ethical risks of non-compliant depreciation if the correct rate of the latter question is less than 70%).

Participation: Organize a "role-playing" activity with the help of AI interactive software[4]. Students are divided into three groups: "financial accountant", "financial director", and "tax inspector". The "financial accountant" prepares accounting entries according to the correct depreciation method; the "financial director" puts forward the requirement of "changing the depreciation method to inflate profits"; the "tax inspector" points out the legal risks of this behavior. During the activity, the AI system real-time records the students' performance (such as whether the "financial accountant" insists on professional ethics) and provides timely reminders for non-compliant viewpoints (e.g., popping up a window to prompt "This behavior violates Article 26 of the Accounting Law")[5].

For "Expense Collection and Allocation", organize a group discussion using AI tools. The AI platform assigns different enterprise scenarios to each group (e.g., a high-tech enterprise with large R&D expenses, a manufacturing enterprise with heavy environmental protection pressure), and provides real financial data. Students use Python-based AI analysis tools to calculate expense allocation ratios and discuss "how to balance cost control and social responsibility in expense accounting". The AI system records the key points of the discussion and pushes supplementary materials (such as policy documents on R&D expense deduction) for insufficiently discussed content.

Post-assessment: The AI system releases real-time test questions (such as "Calculate the annual depreciation amount of a fixed asset with a cost of 100,000 yuan, a residual value of 5,000 yuan, and a service life of 5 years using the straight-line method and the double-declining balance method"), and quickly scores and analyzes the students' answers. At the same time, add ideological and political questions such as "If the enterprise asks you to overestimate the residual value to reduce depreciation expenses, what should you do?" to test the integration of professional knowledge and ethical awareness.

Summary: The AI system generates a visual knowledge map, which integrates accounting standards, case analysis results, and ideological and political core points (such as "integrity", "compliance", "responsibility"). The teacher summarizes the common problems in the post-assessment and shares typical performance in the participation link (e.g., the "tax inspector" group accurately citing legal provisions to refute non-compliant requirements), and emphasizes that "professional competence and moral integrity are equally important in accounting work".

3.2.3 Post-class: AI-generated personalized assignments and reflection guidance

After class, the AI system generates personalized ideological and political assignments according to the students' in-class performance. For example, for students who have a weak understanding of "compliance accounting", assign the task of "comparing the financial data differences between enterprises that comply with depreciation standards and those that do not, and analyzing the impact on investors' decisions"; for students with strong practical ability, assign the task of "designing a depreciation management plan for a small and medium-sized manufacturing enterprise, and explaining the consideration of social responsibility in the plan".

The AI platform also pushes extended learning resources: for students interested in technology ethics, push the "Guidelines for Data Security in Intelligent Accounting" issued by the Ministry of Finance; for students concerned about industry dynamics, push the latest cases of "integrity management of listed companies" from the Shanghai Stock

Exchange. Students are required to write a 500-word learning reflection, and the AI system conducts a preliminary review of the reflection (e.g., identifying whether the understanding of "accounting integrity" is in place) and feeds it back to the teacher for further comment.

4 EVALUATION OPTIMIZATION: ESTABLISHING A DUAL-DIMENSIONAL EVALUATION SYSTEM OF "PROFESSIONAL COMPETENCE + IDEOLOGICAL LITERACY"

To break the limitation of the traditional "score-only" evaluation model, a multi-dimensional and whole-process evaluation system is constructed, which integrates ideological and political literacy into the evaluation of Financial Accounting courses.

4.1 Process Evaluation: Focusing on the Performance of Ideological and Political Literacy

The proportion of ideological and political literacy in the usual grades is set at 25%[6], which mainly includes three aspects:
Rigor in Practical Operation: For example, in the "inventory check" training, score according to whether students "truthfully record inventory overages and shortages and put forward reasonable handling suggestions" to assess their awareness of "integrity in practice". In the "intelligent invoice verification" practical operation, evaluate whether students "manually recheck the results of AI processing to avoid errors" to assess their sense of responsibility.
Critical Analysis Ability in Case Discussion: Evaluate students' ability to "point out the harm of illegal accounting behaviors (such as inflating income)" in the discussion of cases such as "income recognition in advance". The AI system assists in evaluation by analyzing the frequency of students' speeches, the accuracy of legal provisions cited, and the depth of ethical analysis in the discussion area of the learning platform.
Sense of Responsibility in Team Cooperation: Assess whether students "take the initiative to undertake complex accounting tasks (such as the accounting treatment of asset impairment)" in group assignments. The evaluation is based on peer reviews and the AI's record of task completion (e.g., whether the student timely corrects the team's non-compliant accounting entries).

4.2 Summative Evaluation: Designing Ideological and Political Scenario Questions

The proportion of ideological and political scenario questions in the final exam is increased to 30%. For example:
Scenario 1: "The leader of a company asks you to record the unearned income in advance to achieve the annual performance target. How will you respond? Please explain the reasons combined with the Code of Professional Ethics for Accounting Personnel and the accounting principles of Financial Accounting." This question examines students' ability to "adhere to professional ethics under the temptation of interests".
Scenario 2: "A company understates the depreciation of fixed assets to reduce the current expenses. Please adjust the accounting entries and analyze the legal consequences of this illegal behavior." This question evaluates students' professional judgment and sense of legal compliance.
Scenario 3: "A financial robot automatically recognizes an invoice with ambiguous content as a valid expense. As an accountant, what should you do? How does this reflect the relationship between intelligent technology and professional ethics?" This question tests students' understanding of technology ethics in intelligent accounting.

4.3 Multi-Subject Evaluation: Introducing Industry Experts

Invite financial directors of enterprises and auditors of accounting firms to participate in the evaluation. For example, in the "financial statement preparation" training, industry experts score the students' prepared financial statements from three aspects: "data authenticity", "disclosure integrity", and "compliance with standards". At the same time, they share practical experience such as "the impact of the integrity of financial statements on enterprise financing" combined with their work experience, making the evaluation more in line with the actual needs of the workplace.
The school also establishes a "student self-evaluation and mutual evaluation" mechanism. Students evaluate their own performance in practical training (e.g., "whether they have adhered to the principle of integrity in accounting treatment") and score their peers' teamwork and ethical performance. The AI system integrates the scores of teachers, industry experts, students themselves, and peers, and generates a comprehensive evaluation report with a breakdown of "professional competence" and "ideological literacy" scores, providing clear improvement suggestions for each student.

5 GUARANTEE STRENGTHENING: CONSTRUCTING A "SCHOOL-ENTERPRISE-TEACHER" COLLABORATIVE MECHANISM

The smooth promotion of the innovative reform of Financial Accounting from the perspective of CIPE requires the joint support of schools, enterprises, and teachers.

5.1 Teacher Team Construction: Improving the Ability of "Integration of Professional Knowledge and Ideological and Political Education"

Carry out special training on "CIPE in Financial Accounting", including the methods of excavating ideological and political elements in accounting modules, the skills of designing real cases, and the application of AI tools. Invite experts from the Ministry of Finance and senior auditors from the Big Four accounting firms to give lectures on "the latest trends of accounting ethics and industry compliance requirements" to help teachers keep up with industry developments[7].

Organize teachers to take temporary positions in the financial departments of enterprises (e.g., 3-month internships in the financial sharing center of a large manufacturing enterprise) and participate in real work such as "annual audit" and "tax declaration". During the internship, teachers collect "workplace ideological and political materials" (such as "how to refuse the leader's unreasonable accounting requirements" and "the practical operation of environmental liability accounting in enterprises") to enrich teaching cases.

Establish a pairing mechanism of "ideological and political tutor + professional teacher", and jointly develop an "ideological and political case database of Financial Accounting" (such as 10 Integrity Stories in Financial Accounting Accounting)[7]. The database is updated quarterly with the latest financial fraud cases and integrity management cases, and is connected to the AI teaching platform to realize intelligent case push.

5.2 School-Enterprise Cooperation: Building a Realistic Ideological and Political Education Platform

Cooperate with local enterprises and accounting firms (such as Zhongtianxin Accounting Firm) to build a "Financial Accounting CIPE Training Base"[8]. The base is equipped with real financial software (e.g., Kingdee K/3 WISE) and AI accounting tools (e.g., UFIDA financial robots), and arranges students to participate in practical work such as "enterprise monthly closing" and "annual financial check" under the guidance of enterprise mentors. For example, students participate in the inventory check of a food processing enterprise and experience how to "truthfully record the loss of perishable goods and propose cost control suggestions", thus deepening their understanding of "integrity and responsibility".

Invite the financial directors of cooperative enterprises to carry out "workplace ideological and political lectures" and share practical cases of "adhering to integrity in financial work" (such as "the experience of refusing to issue false invoices to avoid legal risks" and "the practice of a company's accurate accounting of R&D expenses to support technological innovation"). After the lecture, organize a "face-to-face exchange" between students and directors to solve the confusion of "how to balance professional ethics and workplace pressure".

Jointly develop "Financial Accounting textbooks integrating CIPE" with enterprises. The textbook integrates the real accounting cases and industry compliance requirements of enterprises (e.g., the accounting treatment of government subsidies for agricultural enterprises, the environmental expense accounting of manufacturing enterprises) and adds a "technology ethics" chapter to introduce the ethical norms in intelligent accounting. The textbook is also matched with an online resource library (including AI teaching videos, case analysis databases) to realize the seamless connection between campus teaching and workplace education.

5.3 Technical Support: Optimizing the "AI+CIPE" Teaching Ecosystem

The school joins hands with financial technology companies (such as Yonyou Network) to customize an AI teaching platform for Financial Accounting. The platform has three core functions: 1) Intelligent case management: automatically collect and classify the latest financial cases, and tag ideological and political elements (e.g., "integrity", "compliance", "social responsibility"); 2) Learning analysis: track students' learning trajectories (such as resource browsing time, case discussion frequency) and generate ideological and political literacy evaluation reports; 3) Interactive teaching: support functions such as AI role-playing, real-time quiz, and online discussion to realize immersive teaching.

The school also establishes a "technical update mechanism" to update the platform's AI algorithms and case database quarterly, ensuring that the teaching content keeps pace with the development of the accounting industry (e.g., adding the accounting treatment of digital assets in response to the emergence of digital economy).

6 PRACTICAL EFFECT AND PROSPECT

The "AI+BOPPPS" integrated CIPE reform has been piloted in 3 accounting classes of a university for one academic year, and the results show that the reform has achieved remarkable results. In the practical training assessment, the proportion of students who "truthfully record accounting information and actively identify non-compliant behaviors" increased from 62% before the reform to 89%; in the questionnaire survey, 91% of students believed that "the reform makes accounting ethics more vivid and understandable", and 87% of students said that "they can better handle the ethical dilemmas in accounting practice". In addition, the employment rate of graduates in the pilot classes in accounting-related positions reached 94%, and 82% of employers said that "the graduates have strong professional ethics and practical ability".

Looking forward, with the development of AI technology and the deepening of CIPE, the reform of Financial Accounting needs to be continuously adjusted and optimized. In terms of content, it is necessary to further integrate new elements such as digital asset accounting and cross-border tax compliance, and strengthen the education of "national financial security" in combination with national strategies; in terms of technology, it is expected to apply virtual reality (VR) technology to simulate more real accounting scenarios (e.g., audit site investigation, tax declaration

on-site), and deepen students' experience of ideological and political education; in terms of cooperation, it is necessary to expand international cooperation and learn from foreign advanced experience in accounting ethics education to cultivate international accounting talents with both Chinese characteristics and global vision.

7 CONCLUSION

From the perspective of curriculum ideological and political education, the innovative reform of Financial Accounting is a systematic project involving content, model, evaluation, and guarantee. By reconstructing the teaching content based on accounting modules (integrating professional knowledge, ideological and political elements, and technology ethics), building an "AI+BOPPPS" closed-loop teaching model (realizing the whole-process integration of pre-class, in-class, and post-class), optimizing the dual-dimensional evaluation system (combining process and result, multiple subjects), and strengthening the "school-enterprise-teacher" collaborative guarantee mechanism (providing personnel, platform, and resource support), this course can not only improve students' professional competence in financial accounting but also guide students to establish correct professional ethics, social responsibility, and technology ethics.

In the new era, the reform of Financial Accounting should adhere to the concept of "taking accounts as the foundation and integrity as the soul", continuously promote the deep integration of CIPE and digital technology, and cultivate high-quality accounting talents who meet the needs of national economic development and have the ability to participate in international competition.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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HOW CORPORATE GOVERNANCE IN ESG CREATES SOCIAL VALUE

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Abstract: Since its inception, the concept of Environmental, Social, and Governance (ESG) has become a prominent topic of international discourse. In practice, however, there has been an overemphasis on environmental protection (E) and social responsibility (S) at the expense of corporate governance (G). Moreover, skepticism exists regarding the capacity of corporate governance to generate social value. This paper investigates the interrelationships among E, S, and G within the ESG framework, with a particular focus on the role of corporate governance and the mechanisms through which it creates social value. Our findings are twofold: (1) In accordance with Adam Smith's "invisible hand" theory, the societal benefits arising from a firm's pursuit of shareholder wealth maximization often exceed those generated by direct pursuits of social welfare maximization. Therefore, firms should prioritize the maximization of shareholder returns. The primary objective of corporate governance is to maximize shareholder value, encompassing key elements such as institutional frameworks, human capital, entrepreneurship, and risk management, which collectively form the bedrock for achieving this goal. As social interest and social value are considered equivalent, strong corporate governance that maximizes shareholder returns consequently generates greater social value. Furthermore, given that corporate governance within ESG should not be bifurcated into broad and narrow interpretations, it represents the most fundamental component of the ESG framework. Within ESG, social responsibility (S) encompasses environmental protection (E). (2) Corporate governance inherently creates social value. The transmission mechanism operates as follows: robust corporate governance maximizes shareholder returns, which in turn creates social value through channels such as innovation, taxation, and employment. Looking ahead, regulators, the public, and corporations should return to this foundational principle, concentrating on corporate governance and sustainable development.
Keywords: ESG; Corporate governance; Corporate social value; Adam Smith's theory

1 INTRODUCTION

ESG, an acronym for Environmental, Social, and Governance, originated from the field of socially responsible investing in capital markets and serves as a set of non-financial performance indicators. Since the United Nations Global Compact first introduced the ESG concept in 2004, its scope has progressively expanded, becoming a focal point of research for scholars and a key reference standard for corporations and investors worldwide. The "E" pillar measures a firm's performance in fulfilling its environmental responsibilities, typically focusing on issues such as carbon emissions, resource conservation, waste management, energy consumption, and biodiversity. The "S" pillar evaluates a firm's performance in meeting its social responsibilities, examining its commitments to stakeholders, including employees, consumers, supply chains, and communities. The "G" pillar assesses the performance of corporate governance, commonly covering areas such as the protection of shareholder rights, board independence and incentive structures, CEO competence and motivation, regulatory compliance, risk management, business ethics, and anti-corruption measures.

In line with China's adoption of a new development philosophy and its intensified focus on ecological conservation, the ESG concept has rapidly gained traction. In 2022, the State-owned Assets Supervision and Administration Commission (SASAC) of the State Council established a Social Responsibility Bureau to oversee the fulfillment of social responsibilities by central state-owned enterprises. In 2023, China issued the "Opinions on Comprehensively Promoting the Construction of a Beautiful China," which explicitly called for exploring the implementation of Environmental, Social, and Governance (ESG) evaluations. ESG has thus become a critical tool for measuring corporate social value. Corporate social value is defined as the aggregate level of externalities or influence generated by a firm's activities on its stakeholders and society at large—value that is not directly captured in financial statements [1]. In recent years, China has promoted ESG ratings and has begun to explore the monetary valuation of corporate social value to encourage firms to fulfill their social responsibilities.

Despite the rapid proliferation of the ESG concept, several challenges and points of confusion have emerged. For instance, there is a tendency to excessively focus on the environmental and social pillars of ESG while neglecting corporate governance. This phenomenon manifests in two ways. First, in the ESG rating systems applied to firms, the weighting assigned to corporate governance is often relatively low. Second, the scope of corporate governance within ESG is frequently bifurcated into broad and narrow definitions. The narrow definition, which is often prioritized, concentrates on compliance-related issues like business ethics, while overlooking crucial contract-related aspects of corporate governance. In addition to these issues, there is widespread skepticism about whether corporate governance itself generates social value. This has led to a focus on environmental protection and social responsibility in the pursuit

of corporate social value. It is therefore imperative to clarify the position of corporate governance within the ESG framework and to determine whether it creates social value, thereby enabling government regulators, the public, and corporations to adopt a more informed perspective on the ESG concept.

From these observations, we derive the following research questions: (1) How should the role of corporate governance in ESG be correctly understood? (2) Does corporate governance create social value, and if so, what is its transmission mechanism?

To address these questions, this paper draws upon the theories of Adam Smith to argue that corporate governance (G) is the most fundamental component of ESG, and that social responsibility (S) encompasses environmental protection (E). Corporate governance inherently creates social value through a mechanism whereby strong governance maximizes shareholder returns, which in turn generates social value through channels such as innovation, taxation, and employment. Consequently, government regulators, the public, and corporations should return to this foundational principle, placing a renewed emphasis on corporate governance and sustainable development.

This paper is structured as follows: Section 2 provides a literature review. Section 3 analyzes the relationships among E, S, and G and establishes the position of corporate governance within ESG. Section 4 discusses whether corporate governance creates social value and elucidates its transmission mechanism. Section 5 concludes the paper and offers policy recommendations for government, the public, and corporations on how to approach the ESG concept and corporate governance.

2 LITERATURE REVIEW

Since its introduction, the concept of ESG has not only become a major international topic but also a key research area for scholars globally. The theory of corporate governance predates ESG, originating from the principal-agent problem that arises from the separation of ownership and control. Over 200 years ago, Adam Smith articulated the principal-agent problem in The Wealth of Nations. The literature most relevant to this paper can be categorized as follows.

2.1 ESG

ESG practices primarily consist of ESG reporting, ESG ratings, and ESG investing. Academic research on ESG has concentrated on defining the metrics for ESG rating systems, identifying the factors that influence corporate ESG performance, and analyzing the economic consequences of such performance.

Regarding ESG evaluation systems, numerous rating agencies and frameworks have emerged both internationally and domestically. Widely used international systems include the MSCI ESG Ratings, the FTSE Russell ESG Ratings, and the S&P Dow Jones ESG Indices. Mainstream domestic systems in China include SynTao Green Finance ESG Ratings, CSI ESG Ratings, Wind ESG Ratings, Sino-Securities ESG Ratings, and Jiahua ESG Ratings. In addition to these capital market-oriented systems, the Chinese academic community has also developed ESG evaluation frameworks, such as the China Listed Company Quality/ESG Index System from Beijing Normal University, the ESG evaluation system from the International Institute of Green Finance at Central University of Finance and Economics, and the corporate ESG evaluation group standard from Capital University of Economics and Business.

Scholars have investigated the determinants of corporate ESG performance from both internal and external perspectives. Internal factors found to influence ESG performance include executive and board characteristics [2], merger and acquisition activities [3], firm performance [4], compensation policies [5], and digital transformation [6]. External factors include economic policies [7], legal and regulatory frameworks [8], public environmental concerns [9], investor attention [10], and the level of digital economy development [11].

Research on the impact of ESG performance has primarily focused on several areas. First is the effect on capital markets. Corporate ESG performance has been shown to influence stock prices, with scholars generally finding a positive correlation [12]. It has also been found to have a negative effect on bond yields [13]. Second is the link between ESG performance and corporate operations. Scholars have identified a positive relationship between ESG performance and firm financial performance [14], and strong ESG performance has been shown to enhance a firm's risk resilience [15]. Regarding firm value, the fulfillment of social responsibility and corporate governance in ESG are positively correlated with firm value, whereas the impact of environmental protection is not significant [16].

2.2 Corporate Governance

The theory of corporate governance originated in the 1870s with the expansion of Western corporations, which led to a separation of ownership and control and the emergence of the principal-agent problem. Modern corporate governance theory was established by Berle and Means in their 1932 book, The Modern Corporation and Private Property [17]. They focused on the contractual nature of corporate governance and the principal-agent problem, a work widely considered the landmark of corporate governance theory. The term "Corporate Governance" can also be translated as "corporate regulation". Research in corporate governance theory has primarily focused on its conceptual definition, theoretical evolution, core elements, and evaluation.

Regarding the concept of corporate governance, neoclassical economics views the firm as a nexus of contracts. Owners (shareholders) provide capital, and managers are entrusted by the owners to run the business. Corporate governance can thus be seen as a set of institutional arrangements between shareholders and managers concerning control rights and

residual claims, designed to maximize shareholder returns [18-19]. In 2019, the OECD defined corporate governance as the system by which business corporations are directed and controlled. The corporate governance structure specifies the distribution of rights and responsibilities among different participants in the corporation, such as the board, managers, shareholders, and other stakeholders, and spells out the rules and procedures for making decisions on corporate affairs. Denis and McConnell argue that corporate governance consists of internal and external mechanisms that induce self-interested managers to maximize shareholder value [20].

The evolution of corporate governance theory has progressed through three main stages. The first stage focused on resolving the conflict of interest between external shareholders and internal managers arising from dispersed ownership [21]. The second stage addressed the conflict of interest between large and small shareholders resulting from concentrated ownership [22-23]. The third stage introduced stakeholder theory, which posits that corporate managers should represent the interests not only of shareholders but also of other stakeholders, such as employees, customers, and suppliers [24-25].

The core elements of corporate governance include shareholder governance, board governance, executive governance, compliance management, and risk management. Shareholder governance focuses on ownership structure, large and controlling shareholders, protection of minority shareholder rights, institutional investors, and the allocation of control rights. Board governance examines board size and structure, board independence, board functions and conduct, independent directors, and director incentives and constraints. Executive governance deals with executive characteristics, incentives, capabilities, conduct, power, and turnover. Compliance and risk management involve internal controls, external audits, digital transformation, and risk identification.

In terms of evaluation, scholars have developed various systems to assess corporate governance performance. Nankai University was the first in China to publish a governance evaluation system for listed companies in 2003. Krueger, Sautner, and Starks and Berg et al. have recently provided comprehensive indices and empirical evidence on how institutional investors and rating agencies evaluate governance [11, 26], verifying the positive correlation between high-quality governance and firm value.

2.3 Corporate Social Value

A corporation is both an economic and a social organization. In the course of pursuing economic profit, a firm engages in social behaviors that create social value. Therefore, a firm's total value system should include both the economic value measurable by financial statements (Corporate Economic Value, CEV) and the social value that cannot be measured by them (Corporate Social Value, CSV) [27]. Research on corporate social value has primarily focused on its conceptual definition and measurement methods.

Scholars have defined corporate social value from both broad and narrow perspectives. The narrow view defines social value as the performance generated during the process of fulfilling social responsibilities [28]. The broad view defines it as all value created by a firm other than its economic value. Chinese scholars generally adopt the broad perspective. This paper integrates both views and defines corporate social value as the social performance created by a firm's activities, specifically the aggregate level of externalities or influence on stakeholders and society, which cannot be directly assessed through financial statements [18].

Regarding the measurement of corporate social value, entities like South Korea's SK Group have attempted to create monetized metrics by developing indicator systems. Recent studies by Serafeim and Berg et al. emphasize the use of impact-weighted accounts and divergence in ratings to better estimate these values [11, 27]. Other methods include cost-benefit analysis and economic impact analysis, but each approach faces challenges in accurately measuring social value, leading to a certain degree of error.

This review of the literature reveals a gap in research concerning the interrelationships among E, S, and G within the ESG framework, the position of corporate governance in ESG, and the mechanisms through which corporate governance creates social value. This paper aims to fill this gap, thereby supplementing ESG and corporate governance theories and helping society to correctly understand ESG.

3 THE RELATIONSHIP AMONG E, S, AND G, AND THE POSITION OF GOVERNANCE IN ESG

3.1 Corporate Governance as the Most Fundamental Component of ESG

3.1.1 Adam Smith's "invisible hand" theory: firms should focus on maximizing shareholder returns

In 1776, Adam Smith introduced the theory of the "invisible hand" in The Wealth of Nations. On the question of whether the pursuit of individual interest or the direct pursuit of social interest is more effective at promoting the good of society, Smith argued: "By pursuing his own interest he frequently promotes that of the society more effactually than when he really intends to promote it. I have never known much good done by those who affected to trade for the public good." Contemporary interpretations by Hart and Zingales suggest that while shareholders may care about social welfare [29], the most effective mechanism for firms is often maximizing value within a governance framework that reflects shareholder preferences. In a market economy, the social benefits generated by an individual pursuing their own self-interest often exceed the social benefits generated by that same individual directly pursuing the public interest.

According to Adam Smith's theory and related neoclassical economic principles, the firm is considered an individual entity. Therefore, the social benefits generated by a firm pursuing the maximization of shareholder returns are often greater than the social benefits generated by a firm that directly aims to maximize social welfare. This principle is
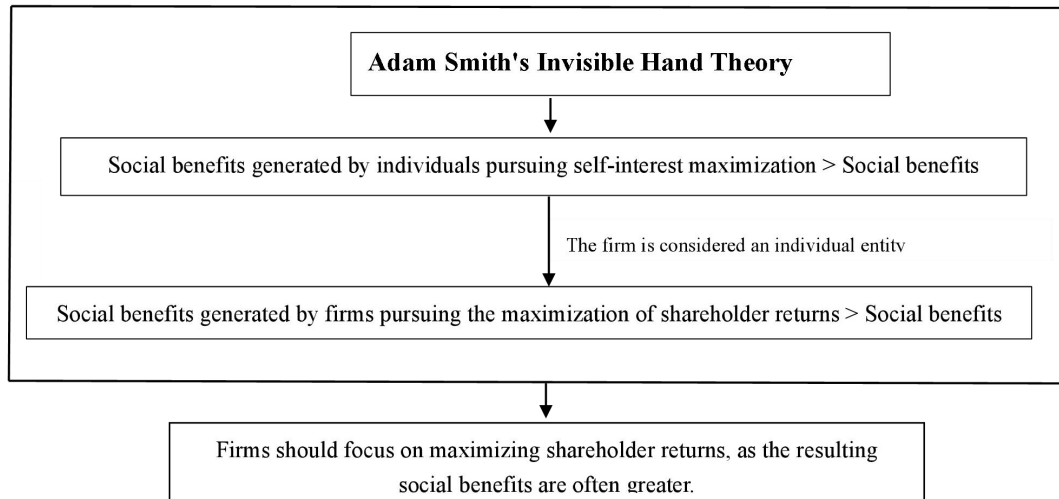
illustrated in Figure 1.

Figure 1 Adam Smith's Theory

An individual's actions typically involve both a motive and a result, which are often inconsistent. When motives and results diverge, greater weight should be given to the result. As Figure 1 illustrates, the social benefits generated under the motive of maximizing shareholder returns are often higher. In a market economy, even if a firm's motives are self-interested, the results are often more beneficial to society. This behavior aligns with market principles and should be affirmed. Therefore, firms should focus on maximizing shareholder returns.

3.1.2 Corporate governance as the cornerstone for maximizing shareholder returns

As established in the preceding literature review, the core objective of corporate governance is to maximize shareholder returns [19-20]. The essence of corporate governance lies in the system of checks and balances among various actors, with contract and compliance as its core components. A contract implies that all of a company's stakeholders have equal standing and reach agreements through negotiation, and these agreements have legal force. Compliance means that a firm's operations must adhere to laws and regulations. Corporate governance serves as the cornerstone for achieving the maximization of shareholder returns because it focuses on strategic objectives and emphasizes institutional effectiveness, the importance of human capital and entrepreneurial spirit, and the critical role of risk management.

First, corporate governance emphasizes institutional effectiveness. This is reflected throughout the entire governance process. For example, corporate governance establishes a series of systems that clearly define the rights and responsibilities of shareholders, the board of directors, and management, creating a mechanism of mutual checks, balances, and coordinated operation. This clear division of rights and responsibilities helps prevent the abuse of power and ensures that corporate decision-making is scientific and rational. Furthermore, an effective corporate governance system provides a company with efficient decision-making mechanisms, long-term development plans, protection of stakeholder interests, and safeguards for risk management and compliant operations, all of which are crucial for the long-term stability and development of the company.

Second, corporate governance stresses the importance of "people." It emphasizes the selection and supervision of talent, such as the selection of board members and the CEO, and the board's oversight of the CEO's management of the business. Talent at every level plays a critical role, affecting the formulation and execution of the company's entire strategy, which in turn influences shareholder returns and sustainable development. Corporate governance also highlights the importance of the "entrepreneurial spirit." It requires the board to fully delegate operational management authority to the CEO, allowing the CEO to fully exercise his or her entrepreneurial spirit in managing the company's operations without interference from the board, subject only to the board's supervision. Moreover, because all parties have equal standing, every individual can fully leverage their entrepreneurial spirit, which is vital for maximizing shareholder returns.

Third, corporate governance underscores the importance of risk management. Beyond institutions and people, corporate governance also emphasizes risk management as a critical factor in a company's operations. A company can only achieve long-term success by effectively identifying and managing risks. Since the core of corporate governance is contract and compliance, the entire governance process prioritizes the legal enforcement of contracts and the compliant operation of the business. To ensure compliant and efficient operations, corporate governance establishes a series of risk identification and control mechanisms to safeguard the company's safe and efficient functioning.

Because the core objective of corporate governance is to maximize shareholder returns and it encompasses essential elements such as institutions, talent, entrepreneurial spirit, and risk management, it serves as the cornerstone for achieving this objective. Therefore, combining this with the conclusion from Figure 1, we can infer that good corporate governance enables the maximization of shareholder returns, which in turn generates greater social benefits. Social benefit can be understood as the total externality generated by a firm's actions on relevant participants and society. As can be seen from the earlier definition of corporate social value, it measures the degree of this externality on

stakeholders and society. Thus, social benefit and social value can be treated as equivalent. In other words, good corporate governance enables the maximization of shareholder returns, thereby generating greater social value.

3.1.3 The scope of corporate governance in ESG should not be differentiated into broad and narrow concepts

Currently, in both theory and practice, the content of corporate governance within ESG is often distinguished as broad and narrow. Narrow corporate governance in ESG primarily includes aspects related to compliance, such as commercial bribery and business ethics. Broad corporate governance encompasses all topics within the theory of corporate governance. From a systemic perspective, and considering the original intent of the ESG concept—to measure a company's capacity for sustainable development in the capital market—the preceding analysis shows that corporate governance is the cornerstone for maximizing shareholder returns and is thus crucial for corporate sustainability. Therefore, the scope of corporate governance within the ESG concept should not be divided into broad and narrow categories, as such a distinction is not meaningful.

Based on Adam Smith's theory, we know that firms should focus on maximizing shareholder returns. The core objective of corporate governance is to achieve this maximization, and it includes essential elements like institutions, human capital, entrepreneurial spirit, and risk management, making it the bedrock for this goal. As social benefit and social value are equivalent, good corporate governance can maximize shareholder returns and thereby generate greater social value. Furthermore, because the concept of corporate governance within ESG should not be bifurcated, corporate governance is the most fundamental component of ESG.

3.2 The Relationship Between Social Responsibility (S) and Environmental Protection (E)

Corporate social responsibility refers to the protection of stakeholders [24]. Since environmental protection is included within the scope of stakeholder protection, social responsibility encompasses environmental protection. Therefore, S in ESG should include E. When a company fulfills its social responsibilities, environmental protection is an indispensable part. A company with good corporate governance will naturally prioritize compliant operations and risk management, anticipate risks in advance, and adopt various measures to reduce negative environmental impacts, such as reducing carbon emissions, optimizing waste management, and improving energy efficiency.

In summary, the relationship among environmental protection, social responsibility, and corporate governance in ESG is as follows: corporate governance is the most fundamental component, and social responsibility includes environmental protection.

4 THE TRANSMISSION MECHANISM OF SOCIAL VALUE CREATION BY CORPORATE GOVERNANCE

The preceding analysis has established that good corporate governance can maximize shareholder returns, thereby generating greater social value. This indicates that corporate governance can create corporate social value. Its transmission mechanism is illustrated in Figure 2.

Figure 2 The Transmission Mechanism of Social Value Creation by Corporate Governance

Figure 2 shows that as the level of corporate governance improves, shareholder returns increase, which in turn leads to higher corporate social value. Shareholder returns primarily create social value through the transmission mechanisms of innovation, taxation, and employment.

4.1 Maximized Shareholder Returns Create Social Value Through Innovation

When shareholder returns are higher, corporate profits are greater, and investor confidence in the firm increases. This lowers the firm's resource constraints and enhances its risk resilience. In such circumstances, the firm is more willing to engage in innovative activities. Because innovation has strong externalities, it creates social value [30]. The externality of innovation is also known as the "spillover effect." If the costs or benefits of an innovative activity automatically "spill over" to other entities, the activity is said to have externalities. The externalities of innovation manifest in three areas: technological, market, and profit externalities. Technological externalities refer to the fact that the outcomes of innovation, whether new products or new processes, contain new technological knowledge. This new knowledge has the non-rivalrous and non-excludable characteristics of a public good, thus generating externalities. Market externalities are demonstrated when innovators create market opportunities for related firms. Profit externalities mean that the benefits of a firm's innovation cannot be fully captured by the innovator and will spill over to firms in other sectors, allowing them to profit as well [31]. Since corporate social value represents the extent of externalities generated by a

firm's actions, a higher level of innovation and stronger resulting externalities lead to greater corporate social value. This demonstrates that maximized shareholder returns create social value by enhancing innovation.

4.2 Maximized Shareholder Returns Create Social Value Through Taxation

When shareholder returns are higher, corporate profits increase. Consequently, the firm's tax payments also rise, boosting government revenue. The increase in fiscal revenue then generates value through government procurement and transfer payments. The externalities of government transfer payments are primarily realized by reducing income inequality among residents, promoting fiscal equalization across regions, and influencing local government public services. Studies by Dyreng et al. and Gallemore et al. have shown that regulatory frameworks and tax systems moderate corporate behavior and inequality [8, 32]. Transfer payments can stimulate competition in the supply of public goods, thereby promoting the equalization of public services across regions. Therefore, maximized shareholder returns create social value by increasing tax contributions.

4.3 Maximized Shareholder Returns Create Social Value Through Employment

As shareholder returns increase, the scale of the firm expands, and the demand for labor also rises, leading to an increase in job positions. This can absorb a large amount of the labor force and create new employment opportunities. The increase in job positions and opportunities generates a certain externality by addressing the issue of resident unemployment. Therefore, maximized shareholder returns create social value by expanding the firm's scale and thereby increasing employment opportunities, which further enhances corporate social value.

In conclusion, the higher the level of a firm's corporate governance, the higher its shareholder returns will be. Higher shareholder returns generate externalities through innovation, taxation, and employment, thereby creating social value. Thus, a firm's internal governance generates external social value. This shows that since corporate governance itself creates social value, the implementation of the ESG concept should not involve an excessive pursuit of environmental protection and social responsibility at the expense of corporate governance. Instead, corporate governance should be placed in its rightful, foundational position.

5 CONCLUSION AND IMPLICATIONS

5.1 Conclusion

Amidst the growing interest in ESG research in China, this paper addresses the phenomenon of excessive focus on environmental protection and social responsibility at the expense of corporate governance in practice, as well as the skepticism surrounding whether corporate governance creates social value. It focuses on clarifying the position of corporate governance within ESG and its transmission mechanism for creating social value, leading to the following conclusions.

First, corporate governance (G) is the most fundamental component of ESG. According to Adam Smith's "invisible hand" theory, the social benefits generated by a firm pursuing the maximization of shareholder returns often exceed those from a firm directly pursuing the maximization of social interest. Therefore, firms should focus on maximizing shareholder returns. The core objective of corporate governance is to achieve this goal, and it encompasses essential elements such as institutions, human capital, entrepreneurial spirit, and risk management, making it the cornerstone for this objective. Since social benefit and social value are definitionally equivalent, good corporate governance, by enabling the maximization of shareholder returns, generates greater social value. Furthermore, because the scope of corporate governance within ESG should not be bifurcated, corporate governance stands as the most fundamental component of ESG. Within ESG, social responsibility (S) includes environmental protection (E).

Second, corporate governance creates social value. Its transmission mechanism is that good corporate governance maximizes shareholder returns, which in turn creates social value through channels such as innovation, taxation, and employment. Therefore, corporate governance itself generates social value, and government regulators, the public, and corporations should not overlook governance when pursuing corporate social value.

In summary, these two conclusions indicate that within ESG, there should not be an excessive focus on E and S at the expense of G. The focus should not be solely on a firm's fulfillment of social and environmental responsibilities; rather, it should return to the foundational importance of corporate governance.

5.2 Implications

5.2.1 For government regulators

As the ESG concept has become associated with sustainable development and social responsibility, the Chinese government has issued a series of policies to guide companies in disclosing ESG information and implementing ESG management, and to encourage investors to engage in responsible and ESG investing, with the aim of building an ESG ecosystem. In future practice, the government's approach to ESG development should prioritize the following aspects.

First, the positioning of ESG should be accurately understood. In practice, there is sometimes a tendency to conflate corporate ESG with sustainable development. The two differ in their focus and content. ESG focuses on the more micro-level issues of corporate governance, social responsibility, and environmental protection, whereas sustainable

development focuses on broader, macro-level issues of technology, economy, society, and the environment [33]. Regulators should not equate ESG with corporate sustainable development, thereby avoiding an excessive pursuit of ESG construction and performance. They should always be clear about the positioning of ESG as a reference standard for investors in the capital market.

Second, avoid an overemphasis on E and S at the expense of G. As concluded in this paper, corporate governance is the most fundamental component of ESG, and it also generates social value. A singular focus on E and S often yields lower social value. Therefore, regulators should not overly stress environmental protection and social responsibility, which can add burdens to a firm's production and operations. Instead, they should return to the fundamentals, emphasizing corporate governance and sustainable development.

Third, exercise caution when formulating ESG evaluation systems and sustainable disclosure standards. On one hand, the standards in these systems and guidelines should not be more stringent than existing ones. China has clear laws, regulations, and standards concerning social responsibility and environmental protection. When designing ESG evaluation systems or disclosure standards, regulators should not set standards that are stricter than existing ones, such as the Environmental Protection Law of the People's Republic of China or the Integrated Emission Standard of Air Pollutants. The design of such systems and standards should primarily aim to guide firms to focus on important issues and promote their development. On the other hand, since corporate governance is the cornerstone for maximizing shareholder returns and the most fundamental component of ESG, regulators should also give corporate governance a prominent position when designing evaluation systems, guiding firms to pay greater attention to it.

Fourth, adopt the reduction of transaction costs as a fundamental principle to guide corporate sustainable development. A firm's transaction costs include not only the explicit costs incurred during transactions but also the implicit costs that arise from various factors during operations. Since transaction costs directly affect a firm's profitability and market competitiveness, reducing them is crucial for its sustainable development. Regulators should design policies based on the principle of lowering corporate transaction costs, providing a more inclusive institutional environment, and helping firms reduce costs and increase efficiency. When requiring firms to focus on environmental protection and social responsibility, the potential impact on their transaction costs should be fully considered.

5.2.2 For the public

In addition to government regulators, the public also plays a supervisory role over corporations. China has enacted relevant laws and guidelines, such as the Interim Measures for Public Participation in Environmental Impact Assessment and the Guiding Opinions on Promoting Public Participation in Environmental Protection, to encourage public involvement. When supervising companies, the public should express opinions rationally, pursue objective facts, and not follow hearsay. The public should understand that a firm's primary goal is to maximize shareholder returns and that corporate governance is the most fundamental component of ESG. They should not impose an excessive burden of social responsibility on firms. The public should also adopt an inclusive attitude; as long as a firm's decisions do not cause harm to society, it should not be subjected to moral high-jacking that could hinder its development through public opinion.

5.2.3 For corporations

The development of ESG has attracted the attention of many entrepreneurs. Some companies have invested heavily in ESG initiatives without a deep understanding of the concept, while others are perplexed about the significance of disclosing ESG reports and participating in ESG ratings. For their future development with respect to ESG, companies should focus on the following aspects.

First, develop a profound understanding of the importance of corporate governance. In their production and operational activities, or when practicing the ESG concept, companies must always grasp the fundamental position of corporate governance within ESG and its role as the cornerstone for achieving the goal of maximizing shareholder returns. In practice, companies must emphasize institutional effectiveness, the importance of human capital and the entrepreneurial spirit, and the significance of risk management and compliant operations. They must unswervingly pursue the goal of maximizing shareholder returns and sustainable development, and prioritize corporate governance.

Second, cultivate an awareness of opportunity cost. Opportunity cost arises from the scarcity of resources. When people use a resource for a particular purpose, they forgo the opportunity to use it for other purposes. The highest-valued foregone alternative is the opportunity cost of the chosen use [34]. Every production and operational activity has an opportunity cost. In their ESG initiatives, companies should fully consider opportunity cost and not invest blindly just to follow the ESG trend. They should compare the returns generated by the investment in ESG initiatives with the maximum returns that could be generated if the same funds were applied to other operational activities. An investment should only be made if the comparison shows that the ESG initiative yields a greater return. Therefore, in ESG construction or production and operations, companies should always consider opportunity cost to make more scientifically sound and effective decisions.

COMPETING INTERESTS

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THE CONSTRUCTION PATH OF ENTERPRISE INTELLECTUAL PROPERTY COMPLIANCE MANAGEMENT SYSTEM

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Abstract: With the intensification of global economic integration and technological competition, intellectual property has become a key element of the core competitiveness of enterprises. At present, Chinese enterprises are in a critical period of transition from ' manufacturing power ' to ' innovation power '. Intellectual property is no longer just an asset, but also a ' passport ' and ' moat ' for enterprises to participate in domestic and foreign market competition. However, companies face increasingly complex intellectual property risks and compliance challenges. The purpose of this paper is to explore the macro background and reality of intellectual property compliance management of Chinese enterprises, systematically sort out the core problems faced by enterprises in the construction of compliance system, and put forward specific and feasible construction paths and coping strategies for these problems, so as to help enterprises realize the systematization, normalization and efficiency of intellectual property compliance management in a complex environment.

Keywords: Intellectual property compliance; Management system; Risk prevention and control

1 INTRODUCTION

In the third decade of the 21 st century, the global business environment is undergoing profound changes and reconstruction[1]. A new round of scientific and technological revolution and industrial transformation represented by artificial intelligence, big data and biotechnology is reshaping the global industrial structure and competition rules. In this context, intellectual property rights as a legal carrier of innovation, its strategic position has been elevated to an unprecedented height. The profound changes in this macro environment have made the importance and urgency of enterprise intellectual property compliance management increasingly prominent, mainly reflected in the following aspects.

1.1 Top-Level Design and Guidance at the National Strategic Level

The Chinese government attaches great importance to the protection and application of intellectual property rights as the core element of the national development strategy. The Outline of Building a Strong Intellectual Property Country (2021-2035) issued in 2021 clearly puts forward a grand blueprint for building a strong intellectual property country, which provides a fundamental follow-up and action guide for the development of the cause in the next ten years. Subsequently, a series of supporting policies such as the " Rule of Law China Construction Plan (2020-2025) " have been introduced one after another, jointly building a macro-policy environment based on the rule of law and innovation-oriented. The implementation of these national strategies not only marks that China 's intellectual property protection has entered a new stage, but also puts forward higher requirements for the creation, application, protection and management of intellectual property rights of enterprises.

1.2 The 'Hard Threshold' of International Market Competition

In the in-depth development of globalization, intellectual property rules have become the cornerstone of international trade and technical cooperation, and also the ' hard threshold ' for enterprises to participate in international competition. For Chinese enterprises committed to ' going out ', whether they are exporting products, investing overseas to build factories, or participating in the formulation of international standards, they must face the strict and complex intellectual property legal system and law enforcement environment of the target market countries. In recent years, international trade frictions have occurred frequently, and intellectual property disputes have often become the focus[2]. Enterprises lacking an effective intellectual property compliance management system are vulnerable to infringement litigation in overseas markets. They may not only face high compensation and product bans, but also seriously damage brand reputation and market opportunities. Therefore, the establishment of a set of intellectual property compliance management system in line with international standards is no longer an ' optional ', but a ' must-answer ' for enterprises to obtain tickets to the global market.

1.3 Realistic Needs of Enterprise Endogenous Risk Prevention

With the continuous increase of R & D investment and the continuous accumulation of technological achievements, the scale of China 's intellectual property assets has shown a rapid growth trend[3]. According to authoritative statistics

released by the State Intellectual Property Office of China, in the first half of 2020 alone, the total number of trademark applications in China has reached 4.284 million, and the number of valid registered trademarks has exceeded 27.414 million. Based on this growth trend, it is estimated that by 2025, the relevant data will show a more substantial growth trend. However, if the massive intellectual property assets are not managed scientifically and effectively, it will bring significant endogenous risks to enterprises. This risk is mainly manifested in two-way characteristics :on the one hand, enterprises may infringe on others ' intellectual property rights due to negligence in R & D, production, sales and other business links, which will lead to legal disputes and form external infringement risks. On the other hand, the company 's own core intellectual property rights such as patented technology, trade secrets, and brand logos may also face the risk of being infringed, abused, or lost, resulting in damage to their own rights and interests. The objective existence of this two-way risk makes the enterprise intellectual property management face severe challenges. Building a sound intellectual property compliance management system is not only an inherent requirement for the steady development of enterprises, but also a key guarantee for enhancing core competitiveness. Through the establishment of a sound compliance system, enterprises can achieve a clear definition of internal rights and responsibilities, standardized operation of management processes, and at the same time, they can establish an effective risk early warning mechanism to ensure the risk of intellectual property infringement and provide strong support for the sustainable development of enterprises.

Core crux :the systematic challenges faced by the construction of enterprise intellectual property compliance system. Under the dual role of policy guidance and market-driven, Chinese enterprises have made significant progress in intellectual property compliance awareness and practice level in recent years, but on the whole, it still shows the stage characteristics of uneven development and system construction[4].

1.4 Limitations of Strategic Cognition: Management does not Pay Enough Attention to it

At the level of strategic cognition, the main dilemma of Chinese enterprises lies in the lack of management 's understanding of the strategic value of intellectual property rights. A considerable number of enterprise managers, especially the decision-makers, still position intellectual property management as a purely legal matter, failing to elevate it to the height of corporate strategic development. This cognitive bias leads to systemic problems such as unbalanced resource allocation, poor departmental coordination, and inadequate system implementation.

1.5 Defects in System Construction: Institutional Fragmentation and Imperfect Operation Mechanism

From the perspective of system construction, the intellectual property compliance management of Chinese enterprises generally presents a ' patch-like ' feature, lacking systematicness and integrity[5]. An effective compliance management system should be an organic whole covering the whole business chain of enterprise R & D, procurement, production, sales, investment and financing. However, the current reality is that intellectual property management is often separated from the legal department or R & D department, and there are serious ' information islands ' and ' process breakpoints ' between other business departments.

1.6 External Environmental Pressure: The Improvement of the Legal System and the High Cost of Rights Protection

At the external environment level, the compliance management of intellectual property rights of enterprises faces double challenges :it is necessary to adapt to the continuous improvement of the domestic legal system, but also to cope with the increasingly complex international rules and law enforcement pressure[6]. Although China 's intellectual property legal system is constantly improving, there is room for improvement in areas such as competition law to deal with intellectual property abuse and monopoly. More seriously, enterprises are facing a huge practical dilemma in the process of rights protection :intellectual property infringement has the characteristics of strong concealment and difficulty in obtaining evidence, which leads to a long cycle of rights protection, complicated procedures and high costs. Even if a large number of small and medium-sized enterprises have valid patents, they are also unable to bear the high litigation costs and time costs and swallow up the infringement, which in turn weakens the motivation of enterprises to invest in intellectual property rights and compliance construction.

1.7 Insufficient Resource Allocation: Lack of Professional Talents and Backward Technical Tools

From the perspective of resource allocation, enterprise intellectual property compliance management is faced with the dual constraints of shortage of professional talents and backward technical tools. Intellectual property compliance management is a highly complex work, which requires practitioners to have the comprehensive ability of technology, law, business operation and strategic management. However, at present, there is a serious lack of such compound professionals in the Chinese market. Many intellectual property managers in enterprises are often held by legal personnel or technical personnel, lacking systematic compliance management knowledge and practical experience. At the same time, the application level of digital and intelligent tools related to intellectual property management is generally low. In the key links of patent information management, monitoring and infringement risk early warning, most enterprises still rely on traditional manual methods, resulting in low efficiency and high error rate.

2 CONSTRUCTION PATH :PROBLEM-ORIENTED CONSTRUCTION STRATEGY OF ENTERPRISE INTELLECTUAL PROPERTY COMPLIANCE MANAGEMENT SYSTEM

In view of the above problems, enterprises should adopt systematic thinking to build an intellectual property compliance management system, correspond the problems and countermeasures one by one, step by step, address both the symptoms and root causes, and build a comprehensive compliance management system.

2.1 Cultivate a Strategic-Oriented Compliance Culture and Build a Cognitive Foundation

In order to fundamentally solve the problem of insufficient cognition, enterprises must raise intellectual property compliance to a strategic level and cultivate a full compliance culture from top to bottom. Strengthen leadership commitment :The key to the success or failure of system construction lies in the ' top leader project '[7]. The top managers of the enterprise must publicly express their commitment to intellectual property compliance, incorporate it into the overall development strategy and annual business objectives of the enterprise, and reflect it in resource allocation, organizational structure and performance appraisal. Incorporating into the business strategy :the intellectual property department should move from the background to the front desk, deeply participate in major business decisions such as product development, market access, investment and financing mergers and acquisitions, and provide forward-looking intellectual property risk assessment and strategic layout recommendations, so that intellectual property becomes a ' navigator ' rather than a ' fire extinguisher ' for business development. Enhance the awareness of all staff :carry out normalized and differentiated intellectual property compliance training for employees at different levels and positions. For senior management, focus on strategic value and risk responsibility ; r & D personnel, focusing on patent mining, avoiding design and confidentiality obligations ; for market sales personnel, it focuses on the standardized use of trademarks and copyrights and anti-unfair competition.

2.2 Establish a Systematic Management Framework Based on GB / T 29490-2023 Standard and Improve the Institutional System

In order to overcome the problem of institutional fragmentation, enterprises should build a systematic and process-oriented management framework based on the national standard GB / T 29490-2023[8]. Organizational structure construction :Clearly set up full-time or part-time intellectual property management departments or positions, and grant them the necessary authority. At the same time, an inter-departmental intellectual property management committee, which is led by senior management and participated by the heads of various business departments, should be established to be responsible for the decision-making and coordination of major matters and ensure that compliance instructions can penetrate the whole company. PDCA management cycle:follow the ' planning-implementation-check-improvement ' Plan-Do-Check-Act management logic[9]. In the planning (P) stage, identify internal and external compliance obligations, assess intellectual property risks, and formulate compliance goals and management plans. In the implementation phase (D), the compliance requirements are embedded into specific business processes such as R & D project establishment, procurement contract, employee management, and marketing to achieve process control. In the inspection (C) stage, through regular internal audit and management review, the achievement of compliance objectives and the operation effect of the system are monitored. In the improvement (A) stage, the found non-conformities are corrected and the management system is continuously optimized. Documentary management : the intellectual property policy, objectives, responsibilities, processes, etc.in the form of documents fixed down, forming a complete set of management system documents. At the same time, all intellectual property management activities, such as patent search reports, contract review records, training sign-in forms, internal audit reports, etc., are properly recorded and kept, so that ' everything has rules to follow and everything has evidence to check '.

2.3 Build a Risk System to Deal with Complex Environments

In the face of complex legal environment and high cost of rights protection, enterprises need to change from passive response to active management, establish sensitive risk radar and efficient response plan. Intelligence monitoring mechanism :Establish a normalized intellectual property intelligence monitoring mechanism, use professional databases and analysis tools, continuously track patent dynamics in key technology areas, the intellectual property layout of major competitors, and changes in relevant laws and regulations at home and abroad, so as to ' know yourself and know yourself, early warning '. Emergency response plan :For the possible infringement warning letter, lawyer letter or litigation, formulate a detailed response process in advance, and clarify the internal reporting path, responsible department, decision-making authority and the selection criteria of external lawyers. This can ensure that enterprises can respond calmly, orderly and professionally when encountering emergencies, and avoid greater losses caused by busyness. Diversified rights protection strategy :In view of the high cost of rights protection, enterprises should adopt flexible and diversified strategies. In addition to the traditional means of litigation, we should also actively explore a variety of solutions such as administrative complaints, customs protection, sending warning letters, negotiations, and industry mediation[10]. At the same time, it may be considered to purchase intellectual property insurance to share potential litigation costs and compensation risks, a proposal that has been mentioned in academic discussions.

2.4 Optimize the Allocation of Resources, Improve Management Efficiency

In order to make up for the shortcomings of talents and tools, enterprises should be both internal and external, be good at using internal and external resources, and improve management efficiency through technology empowerment[11]. Talent training mechanism :through the combination of internal training and external introduction, a professional intellectual property management team is formed. Internally, select potential technical or legal personnel for systematic training ; externally, actively recruit professionals with a composite background of technology, law and management. External resource utilization :For small and medium-sized enterprises with limited resources, it is not necessary to pursue a ' large and complete ' internal team. You can establish long-term cooperative relations with excellent law firms, patent agencies, intellectual property consulting companies, etc., and have strong professionalism in patent applications, trademark registration, legal advice, and system counseling.

3 CONCLUSION

Building a sound intellectual property compliance management system has become the only way for Chinese enterprises to achieve high-quality and sustainable development. It is not only a defensive shield for enterprises to prevent legal risks and cope with market competition, but also an offensive weapon to enhance innovation ability and maximize the value of intangible assets. Enterprises must abandon outdated concepts, proceed from a strategic perspective, be problem-oriented, refer to national standards such as GB / T 29490-2023, and proceed from four dimensions :cultivating compliance culture, establishing a systematic framework, strengthening risk monitoring, and optimizing resource allocation. This road of construction is not achieved overnight and requires long-term persistence and investment. However, only in this way can Chinese enterprises move steadily and far in the increasingly fierce global innovation wave, and truly move from ' Made in China ' to ' Made in China '.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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EMPOWERING SMALL AND MICRO ENTERPRISES IN LIAONING THROUGH FINTECH

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Abstract: This paper examines the current state and challenges of innovation and entrepreneurship among small and medium-sized enterprises (SMEs) in Liaoning Province, exploring pathways for high-quality development through fintech-enabled mechanisms. Research indicates that while Liaoning's SMEs have improved innovation metrics, their national rankings have generally declined, revealing three structural challenges: a disconnect between innovation and capital, diminished investment appeal, and market entities exhibiting "false prosperity". To address these issues, the study proposes leveraging fintech solutions such as establishing enterprise digital profiling platforms, promoting blockchain technology applications, and developing equity crowdfunding and big data-driven credit services. These measures aim to alleviate financing constraints, enhance information transparency, and facilitate resource integration, thereby providing actionable strategies for fostering innovation among SMEs and revitalizing the regional economy.
Keywords: Fintech; Small and medium-sized enterprises; Innovation and entrepreneurship; Digital economy

1 INTRODUCTION

The rapid expansion of the digital economy has become a central driver of global economic transformation, emphasizing the profound integration of digital technologies with the real economy. This synergy is increasingly recognized as essential for achieving sustainable and high-quality growth. As a pivotal segment of the digital economy, fintech has demonstrated significant potential in enhancing the efficiency of financial services and expanding their coverage. It has emerged as a key enabler for business innovation and structural economic upgrading.As a key sector of the digital economy, fintech has demonstrated significant potential in enhancing the efficiency of financial services and expanding service coverage, becoming a vital force in empowering the real economy and supporting innovation-driven development.

As a major industrial base in China, Liaoning's small and micro enterprises play a crucial role in promoting regional economic growth and absorbing employment. However, against the backdrop of the digital economy and the new round of revitalization strategy, Liaoning's SMEs still face structural challenges in innovation and entrepreneurship[1]. Data indicates that while Liaoning has consistently improved its absolute innovation metrics, its relative national rankings have generally declined. This reflects deep-seated issues such as the disconnect between innovation and capital, the hollowing-out of investment attractiveness, and the bloated nature of market entities.

Existing research predominantly focuses on the general promotional effects of fintech on corporate innovation. However, regarding the structural predicaments in traditional industrial regions like Liaoning, there is a lack of systematic exploration that integrates specific fintech tools with local realities[2]. Therefore, this paper aims to systematically diagnose the causes of innovation and entrepreneurship challenges faced by Liaoning's SMEs and micro-enterprises, and to construct a precision empowerment pathway centered on fintech, providing theoretical and practical references for the reconstruction of the regional innovation ecosystem.

2 METHODOLOGY

2.1 Research Design

This study employs a quantitative and comparative approach, benchmarking Liaoning's SME innovation and entrepreneurship performance (2010-2020) against the China Digital Economy Innovation and Entrepreneurship Index (IRIEDEC). The analysis centers on the "absolute growth versus relative ranking" paradox to uncover structural challenges. The research proceeds at three levels: overall performance evaluation, sub-dimensional analysis of key drivers (e.g., new ventures, investment, patents), and the alignment of diagnosed challenges with targeted fintech-enabled mechanisms[3].

2.2 Experimental Procedure

The research data, sourced from Peking University's Center for Enterprise Big Data Research (2010-2020), was processed to construct the China Digital Economy Innovation and Entrepreneurship Index (IRIEDEC) across eight indicators. Following Z-score standardization and quantile-weighted synthesis, provincial rankings were compared to

identify shifts in relative performance. These shifts were then analyzed alongside regional policies and economic data to diagnose structural constraints, forming the basis for designing targeted fintech empowerment pathways.

2.3 Data Source

The primary data sources for this study are as follows: National Industrial and Commercial Enterprise Registration Database: Used to obtain the number of newly established enterprises. Enterprise Shareholder and VC/PE Investment Database: Used to analyze foreign investment and venture capital activities. State Intellectual Property Office Patent Database: Covers granted invention patents, utility model patents, and design patents. Trademark Registration Database and Software Copyright Registration Database: used to measure corporate branding and software innovation achievements;

Supplementary data such as the China Regional Innovation Capacity Evaluation Report and China Provincial Business Environment Research Report: used for background analysis and challenge diagnosis.

All data underwent integration and validation through Peking University's Center for Enterprise Big Data Research to ensure its authority and consistency.

2.4 Tools or Models Used

Comprehensive Evaluation Model: Constructing the China Digital Economy Innovation and Entrepreneurship Index, which assesses regional innovation performance through a weighted composite evaluation based on six dimensions, as Tabel 1 shows: newly established enterprises, foreign investment, venture capital, patents, trademarks, and software copyrights.

Data Processing Method: Employing the Z-score method to standardize all indicators, eliminating differences in measurement units; utilizing quantile weighting to convert standardized values into index scores ranging from 0 to 100, facilitating cross-regional comparisons.

Comparative Analysis Framework: Conducts multidimensional comparisons of Liaoning Province's innovation performance against national averages and leading provinces like Guangdong and Zhejiang to identify relative strengths and weaknesses.

Mechanism Matching Model: Establishes a closed-loop "problem-tool-effect" analysis framework. Logically aligns fintech tools－such as digital profiling, blockchain, and equity crowdfunding－with regional structural challenges to design targeted empowerment pathways.

Table 1 China Digital Innovation and Entrepreneurship Index Indicators

Dimension Name	Sub-indicators	Weighting
Number of newly established enterprises	Number of newly registered enterprises	20%
Attract foreign investment	Number of new foreign corporate investments	15%
Attract venture capital	Number of enterprises newly receiving venture capital investment	25%
	Number of newly authorized invention patents	12.5%
Number of Patents Granted	New Utility Model Patent Publication Volume	5%
	Newly Published Design Patent Applications	2.5%
Number of Trademark Registrations	Number of New Trademark Registrations	10%
Number of Software Copyright Registrations	Number of New Software Copyright Registrations	10%

Note: Weights corresponding to the China Regional Innovation and Entrepreneurship Index

3 RESULTS & DISCUSSION

3.1 The Overall Level of Regional Innovation Lags Behind

The total innovation index has shown a sustained upward trend as Tabel 2 shows, rising from 73.88 in 2010 to 87.41 in 2020 (an increase of 18.3%). However, Liaoning Province's relative national ranking has remained stagnant between 17th and 18th place for an extended period. This indicates that despite improvements in absolute levels, its innovation competitiveness among provincial-level administrative regions has not achieved a substantive breakthrough.

Table 2 Trend in Total Innovation Index

Year	2010	2015	2020	Growth Rate(2010–2020)
Score	73.88	82.41	87.41	+18.3%
National Ranking	9	17	18	dropped 9 places in the ranking

3.2 Sub-indicators Show a Dynamic Decline

Table 3 Trends in the Dynamic Changes of Sub-Indicators[4]

Region	Year	Subdimension									
	2010	Number of Newly Established Enterprises Score	Ranking of Newly Established Enterprises	Attracting Foreign Investment Score	Ranking in Attracting Foreign Investment	Attract Venture Capital Scores	Ranking of Attracting Venture Capital	Patent Grant Score	Ranking of Patent Grant Counts	Trademark Registration Volume Score	Ranking of Trademark Registration Volume
Liaoning Province	2011	73.88	9	74.19	7	73.78	9	64.62	14	75.98	11
	2012	74.92	11	72.22	10	79.40	9	68.26	15	78.15	14
	2013	73.36	12	67.64	15	75.75	10	69.51	15	79.38	14
	2014	75.34	16	68.89	16	75.65	13	72.11	16	80.53	15
	2015	77.63	17	81.69	13	75.86	17	68.57	21	79.99	16
	2016	81.58	16	80.96	16	78.98	17	82.10	17	81.79	17
	2017	85.02	15	86.26	16	84.81	19	83.47	17	82.62	17
	2018	89.39	13	88.97	17	86.26	20	83.43	17	84.29	17
	2019	89.80	16	89.80	17	83.66	21	85.10	18	88.66	17
	2020	90.95	16	88.45	20	78.36	22	85.44	18	90.53	18

3.2.1 Enterprises lack vitality in their establishment

As Table 3 we can known, from 2010 to 2020, Liaoning Province saw a significant increase in its score for newly established enterprises (73.88→90.01, +21.8%), yet its ranking declined year by year, falling from 9th to 17th place. This reflects a weakening of Liaoning's relative advantage in the number of entrepreneurial enterprises amid intensifying competition among provinces. Insufficient entrepreneurial dynamism hampers the discovery of new economic growth drivers, fundamentally diminishing economic vitality. This impedes leveraging innovation to transform heavy industries while exacerbating talent outflow.

3.2.2 Limited ability to attract capital

(1) Foreign investment scores continued to rise (74.19→89.28, +20.3%), as Table 3 shows,yet its ranking dropped significantly from 7th to 22nd. This reflects that amid the nationwide expansion of financing scale, Liaoning Province's share of venture capital funding has declined year by year. The weakening capital attractiveness makes it difficult for local innovative enterprises to obtain the resources needed for expansion, fundamentally constraining the emergence and growth of high-growth enterprises. This not only hinders the cultivation of new leading enterprises to replace traditional ones but also accelerates the outflow of innovative projects and entrepreneurial talent to regions with greater capital concentration.

(2) Venture capital investment followed an inverted U-shaped curve, peaking at 86.26 (20th place) in 2017 before declining to 78.67 (24th place) in 2020. This reflects that against the backdrop of a continuously heating national venture capital market, The weakening appeal of Liaoning's innovation capital has created financing bottlenecks for high-potential innovative enterprises. This fundamentally slows the incubation and growth of emerging industries while exacerbating the outflow of innovation and entrepreneurship projects due to funding shortages[1].

3.2.3 The efficiency of knowledge production remains relatively stable

(1) Patent authorization rates have steadily increased (64.62→86.94, +34.5%), maintaining a mid-tier ranking (14th-18th) despite fluctuations. The information from Table 3 reflects that amid intensifying regional innovation competition, while patent output has significantly expanded, its relative advantage has not improved accordingly. Patent conversion efficiency and innovation quality have failed to achieve breakthroughs, making it difficult to effectively drive industrial structure upgrades. This constrains the high-tech transformation of traditional industries and weakens overall economic competitiveness.

(2) Trademark registration saw the most significant growth (75.98→89.59, +17.9%), maintaining a stable ranking within the 11th to 18th position range. This reflects that the cultivation of trademark brands and their value conversion capabilities remain insufficient, making it difficult to form commercially influential brand clusters. This not only constrains the market competitiveness and value-added enhancement of local enterprises but also impacts the optimization and upgrading of the regional economic structure and the sustained accumulation of innovation-driven development momentum.

3.3 The Three Major Challenges Facing Innovation and Entrepreneurship Among Small and Medium-Sized Enterprises

As shown in Table 3, Liaoning Province has steadily improved its absolute scores across nearly all indicators. However, this represents a "rising tide lifts all boats" type of growth, accompanied by a significant decline in its national rankings. Consequently, Liaoning's progress pace lags far behind the national average. This reflects the contradictory reality of "false growth" in regional indicator scores and "real loss" of competitiveness, stemming from three major structural challenges.

3.3.1 The "disconnect" between innovation and capital

The patent authorization ranking (18th) significantly outranks the venture capital ranking (24th), indicating that while R&D activities yield certain outputs, they fail to effectively translate into commercially viable projects. Innovation achievements often remain confined to paper rather than reaching the market.

3.3.2 Investment attractiveness "hollowing out"

Foreign investment and venture capital rankings plummeted significantly from 7th and 9th to 22nd and 24th, respectively. This highlights capital's lack of confidence in Liaoning's business environment, legal safeguards, and growth potential, leading to a persistent weakening of the region's capital aggregation capabilities.

3.3.3 Market entities are "bloated" rather than "robust"

The rise in scores for newly established enterprises and trademark registrations coupled with declining rankings indicates that the growth in enterprise numbers has not been accompanied by improvements in quality. A large number of enterprises are concentrated in traditional service industries or low-end manufacturing sectors, lacking core technological capabilities and brand competitiveness, making it difficult to foster a sustainable innovation ecosystem.

3.4 Mechanism Analysis of Fintech Empowering Innovation in Small and Medium-sized Enterprises

As Figure 1 shows FinTech significantly influences corporate innovation by alleviating financing constraints and optimizing resource allocation. Studies show that it enables precise credit assessment and process automation, broadening funding channels and reducing costs for MSMEs, thereby boosting their innovation capacity[5]. Furthermore, FinTech enhances information transparency among firms, investors, and financial institutions, mitigating information asymmetry and fostering a conducive environment for high-risk innovation projects[6]. Finally, through the integration of technology, data, and application scenarios, FinTech drives the digital transformation of traditional finance, systematically improving the efficiency of innovation resource allocation.
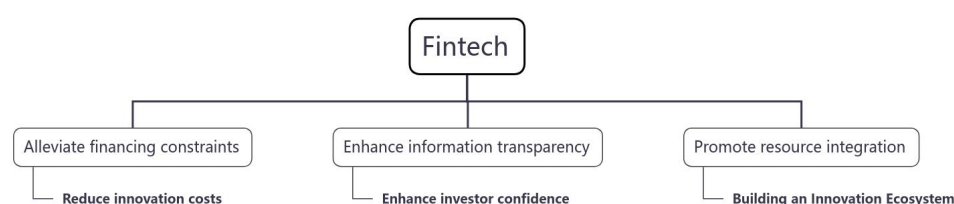

Figure 1 Mechanism Analysis of Fintech Empowering Innovation in Small and Medium-sized Enterprises

3.5 Policy Recommendations for Accelerating the Application of Fintech to Empower Innovation and Entrepreneurship Among Small and Micro Enterprises in Liaoning Province

To address these challenges, a multi-pronged FinTech approach is proposed. First, a digital corporate profiling platform integrating multi-source data can alleviate financing constraints through AI-powered credit assessment[7]. Second, applying blockchain technology[8] to government-guided funds and supply chains enhances investment transparency and rebuilds trust[9]. Third, developing data-driven equity crowdfunding and innovation platforms helps optimize resource allocation and fosters robust, collaborative innovation ecosystems[10].

4 CONCLUSION

Based on the China Digital Economy Innovation and Entrepreneurship Index (2010–2020), this study diagnoses innovation challenges among SMEs in Liaoning Province and designs a targeted FinTech-enabled pathway. Key findings reveal:

First, Liaoning's SMEs exhibit "absolute growth but relative decline"—while indicator scores improved overall, their national rankings fell, reflecting weakened competitive standing.

Second, three structural challenges are identified: a disconnection between innovation and capital, a hollowing-out of investment attractiveness, and a "bloated" structure of market entities, pointing to systemic flaws in the regional innovation ecosystem.

Third, a fintech empowerment strategy is proposed: using "digital profiling + credit scoring" to ease financing constraints, "blockchain + fund tracing" to enhance transparency, and "equity crowdfunding + data-driven credit" to streamline resources—shifting regional innovation from bloated to robust.

This research bridges regional diagnostic theory with fintech applications, integrates index evaluation with mechanism design, and offers actionable insights for revitalizing innovation in Liaoning and Northeast China.

COMPETING INTERESTS

The authors have no relevant financial or non-financial interests to disclose.

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INTELLIGENT PERCEPTION AND VALUE GUIDANCE IN STUDENT IDEOLOGICAL DYNAMICS: DESIGNING AN AI-BASED CLOSED-LOOP INTERVENTION FRAMEWORK

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Abstract: With the rapid development of information technology, the application of Artificial Intelligence (AI) in education has become increasingly widespread, demonstrating immense potential particularly in the management of student ideological dynamics. Focused on the theme "From 'Data Monitoring' to 'Value Guidance': Intelligent Perception and Closed-Loop Intervention Pathways for Student Ideological Dynamics in the AI Era," this study explores how AI technology empowers the management of student ideological education. Research indicates that traditional ideological education models suffer from issues such as lag, passivity, and data fragmentation, leading to a core contradiction between educational goals and operational reality. This paper proposes that AI technology can effectively address these challenges and facilitate a paradigm shift in educational models. Through an in-depth analysis of the current status of student management and AI applications in education, this study constructs an intelligent perception system and designs a closed-loop intervention pathway. This framework includes a multimodal data collection mechanism, AI-driven data analysis models, a tiered early warning mechanism, and intelligent recommendation strategies for intervention. The research finds that sentiment tendency recognition based on Natural Language Processing (NLP) and group feature analysis using clustering algorithms significantly enhance the accuracy of sentiment identification and the effectiveness of group profiling. Empirical analysis demonstrates that the designed closed-loop intervention pathway offers significant advantages in early warning response efficiency and the effectiveness of ideological guidance. Furthermore, the paper discusses ethical norms regarding data collection, as well as algorithmic transparency and supervision mechanisms, to ensure the safety and fairness of technological application. The results show that AI technology not only realizes the paradigm shift from "monitoring" to "leading" but also provides an effective path for the reform of ideological and political education in colleges and universities. Overall, this paper expands educational technology theory and offers specific practical recommendations for reform, while also providing an outlook for future research directions. Despite certain limitations, this study serves as an important reference for the in-depth application of AI technology in the field of education.
Keywords: Artificial Intelligence (AI); Ideological dynamics; Intelligent perception; Closed-loop intervention; Value guidance; Paradigm shift

1 INTRODUCTION

1.1 Research Background and Significance

With the development of society and the advancement of science and technology, the application of AI technology in the field of education has gradually become a significant force driving educational innovation. In current ideological education work for university students, traditional models face multifaceted challenges, whereas the integration of AI technology offers new possibilities for resolving these issues. The realistic pain points of traditional ideological education are manifested in the disconnection between educational content/methods and reality, making it difficult to meet individualized and differentiated educational needs. According to relevant surveys, over 60% of students report that they perceive the content of traditional ideological education as outdated and lacking appeal. Furthermore, educators' understanding of students relies heavily on subjective judgment rather than objective data, leading to a lag and passivity in educational efforts. The core contradiction between data monitoring and educational goals lies in the fact that although modern educational management increasingly relies on data, data monitoring often neglects students' personal development and emotional needs. For instance, while academic performance and attendance can be recorded in detail, students' ideological dynamics and mental health are difficult to quantify, thereby affecting the effectiveness of education. The development opportunity empowered by AI lies in its ability to process massive amounts of data through intelligent algorithms, providing educators with more precise student portraits to achieve personalized educational interventions. Research indicates that AI-assisted sentiment analysis tools can accurately identify students' emotional fluctuations, offering educators timely opportunities for intervention. Against this backdrop, this study aims to explore significance in the following aspects: First, the introduction of AI technology helps achieve refined management and personalized intervention in student ideological education. By constructing an intelligent sensing

system, educators can grasp students' ideological dynamics more precisely, improving the relevance and effectiveness of education. Second, the application of AI technology can promote a paradigm shift in education modes, transitioning from traditional behavioral monitoring to a development-oriented approach. This shift helps cultivate students' innovative spirit and critical thinking, rather than merely pursuing improvements in academic grades. Third, AI technology can enhance the efficiency and effectiveness of educational management. Through intelligent data analysis models, educators can quickly identify group characteristics and individual differences among students, thereby designing more scientifically reasonable intervention strategies. Finally, this study also focuses on the ethical boundaries and mechanism guarantees of AI applications in education, ensuring the reasonable use of technology and preventing potential negative impacts. In summary, the application of AI technology in the ideological education of university students has profound significance; it not only resolves the pain points of traditional educational models but also provides new ideas and methods for educational reform and development.

1.2 Research Objectives and Questions

This study aims to explore the management of university students' ideological dynamics and the transformation of educational paradigms empowered by AI technology. The research objectives are: first, to construct an intelligent sensing system that achieves precise identification of students' ideological dynamics through the collection and analysis of multi-modal data; second, to design a closed-loop intervention path that conducts effective educational guidance and intervention for students through intelligent recommendation strategies and graded warning mechanisms; and third, to establish ethical boundaries and mechanism guarantees to ensure the compliance and transparency of data collection and algorithm application. The core research questions mainly include the following aspects: First, how to effectively integrate structured and unstructured data to build a multi-modal data collection mechanism suitable for the management of university students' ideological dynamics? Second, how to utilize technologies such as natural language processing and clustering algorithms to build AI-driven data analysis models and achieve effective analysis of educational big data? Third, how to design intelligent recommendation intervention strategies and graded warning mechanisms to achieve effective intervention in students' ideological dynamics? Finally, how to ensure adherence to ethical norms in data collection and algorithm application, and establish corresponding supervision mechanisms? To solve the aforementioned problems, this study will first focus on the comprehensiveness and accuracy of data collection, exploring the design of multi-modal data collection mechanisms, and on this basis, construct data analysis models using AI technology to improve the ability to identify student ideological dynamics. Simultaneously, the research will focus on the pertinence and effectiveness of intervention strategies, achieving precise intervention for individual students and groups through the design of intelligent recommendation and warning mechanisms. In addition, this study will also attach importance to the construction of ethical norms and mechanism guarantees to ensure the compliance of the research process. Through the exploration of these issues, this study is expected to promote the transformation of university student ideological dynamic management and educational paradigms, providing beneficial theoretical support and practical references for higher education reform in China. Meanwhile, the results of this study will also provide new perspectives and methodologies for the application of AI technology in the field of education.

1.3 Research Methodology and Framework

This study aims to explore a new paradigm for student ideological dynamic management and educational intervention empowered by AI technology. The core of the research methodology and framework lies in constructing a closed-loop intervention mechanism that combines technological drivers with educational goals, as shown in Figure 1. First, in terms of research context design, this study adopts a problem-oriented exploratory path, starting from realistic pain points to identify and analyze the core contradictions between data monitoring and educational goals in traditional ideological education models, while simultaneously grasping the development opportunities empowered by AI technology. By comparing and analyzing the advantages and disadvantages of traditional models versus data-driven models, the study clarifies the positioning and role of AI technology in the management of student ideological dynamics. Second, regarding the construction of the technical roadmap, this study follows these steps: first, design a multi-modal data collection mechanism to integrate structured and unstructured data, ensuring the comprehensiveness and real-time nature of the data; next, apply AI-driven data analysis models, including natural language processing (NLP) for sentiment tendency identification and clustering algorithms for analyzing group characteristics, to build a knowledge graph of ideological dynamics, thereby achieving a precise depiction of individual and group ideological dynamics; finally, based on data analysis results, design graded warning mechanisms and intelligent recommendation intervention strategies, and form a continuously improving closed-loop intervention path through effect feedback and dynamic optimization. In the data collection phase, this study emphasizes the implementation of the principle of minimum necessity to ensure the legality and ethics of data collection. At the same time, the design of algorithmic transparency and supervision mechanisms aims to guarantee the explainability of algorithmic decisions and avoid the abuse and misuse of technology. Through the aforementioned research methodology and framework, this study expects to provide theoretical support and technical paths for the reform of ideological and political education in universities, promoting the transformation of student ideological dynamic management from a traditional "monitoring" paradigm to a "leading" paradigm. Specifically, the research will verify the effectiveness of the intelligent sensing model in sentiment

recognition and group characteristic identification, and through empirical analysis of the practical effects of the closed-loop intervention path, provide empirical evidence for subsequent educational reforms.
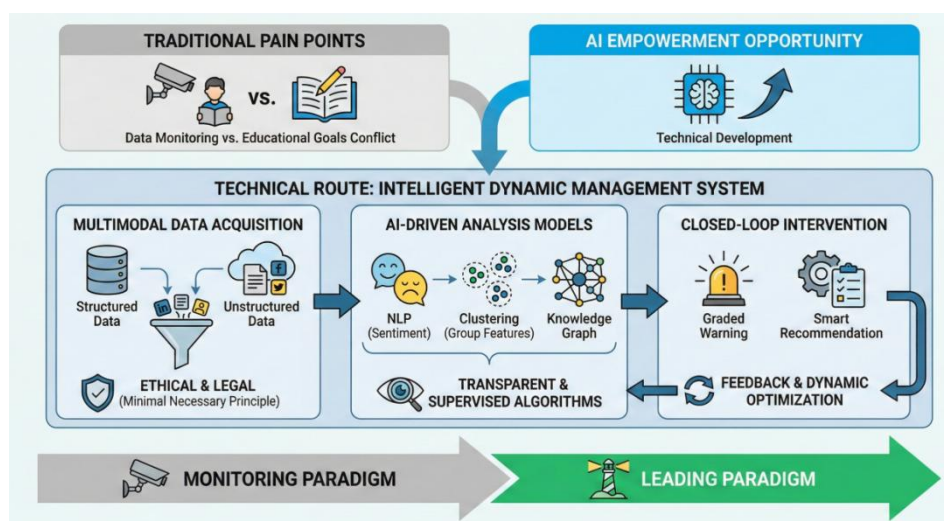

Figure 1 Overview of the Intelligent Dynamic Management System Technical Route

2 THE CLOSED-LOOP MANAGEMENT PATH OF STUDENTS' IDEOLOGICAL DYNAMICS BASED ON DATA AND AI

2.1 Current Research Status of Student Ideological Dynamics Management

In recent years, with the rapid development and application of big data technology, research on student ideological dynamics management has gradually exhibited new trends. In studies concerning traditional ideological education models, scholars primarily focus on educational content, methods, and their influence on students' ideological dynamics. Research indicates that traditional education models demonstrate a certain degree of lag and passivity in addressing students' personalized needs and emotional fluctuations. Regarding progress in data-driven student management research, researchers have attempted to utilize big data technology to analyze student behavioral data to uncover patterns in their ideological dynamics. For example, by mining students' online behavioral data, learning records, and other information, they analyze developmental changes in psychological states and value orientations. Statistics show that data-driven student management research has achieved significant results in improving the level of educational personalization and preventing student mental health issues. Furthermore, with the continuous development of artificial intelligence technology, the application of AI in the education sector has also become an important direction in the study of student ideological dynamics management. Natural Language Processing (NLP) and affective computing applications have made important progress in analyzing student textual materials and identifying their emotional states. Educational big data analysis research, in turn, constructs data models to perform cluster analysis of student group characteristics, providing a basis for educational intervention. In the research related to closed-loop intervention mechanisms, studies on warning system construction aim to promptly detect anomalies in student ideological dynamics and implement corresponding intervention measures. Research on educational intervention effectiveness evaluation focuses on the efficacy of intervention measures and how to adjust and optimize strategies based on the outcomes. Although certain achievements have been made in the research on student ideological dynamics management, some deficiencies remain. For instance, in existing research, how to ensure data security and privacy protection during the process of data collection, processing, and analysis still requires further discussion. Furthermore, the interpretability of algorithmic decisions and the supervision system for technology application are also areas that urgently need strengthening. In summary, the current research status of student ideological dynamics management is characterized by diversity and interdisciplinary integration, with the application of big data and AI technologies bringing new development opportunities to this field. However, in practice, attention must still be paid to ethical boundaries and mechanism guarantees to achieve the sustainable development of student ideological dynamics management.

2.2 Application Research of AI in the Field of Education

Educational big data analysis research, as an important branch of AI application in the education sector, is gradually deepening the intelligent level of educational management and services. By collecting, integrating, and analyzing data on student learning behaviors and emotional states, AI technology offers new possibilities for personalized education. Studies show that educational big data analysis can reveal individual student differences, providing educators with the basis for precise intervention, as illustrated in Figure 2. In terms of Natural Language Processing, AI technology can perform sentiment analysis on students' textual expressions to understand their emotional fluctuations and psychological states. For example, by analyzing text from students' online discussions and assignment feedback, changes in emotions such as anxiety or depression can be captured, enabling timely counseling and support.

Additionally, affective computing technology further enriches the dimension of emotional data by analyzing non-verbal information like students' voice and facial expressions. Educational big data analysis focuses on grasping the educational status quo and trends from a macro perspective. By collecting data such as students' academic performance, attendance records, and interaction frequency, comprehensive student capability models can be constructed, which helps in identifying potential issues during the educational process. For instance, statistics indicate that generally low scores in certain subjects may be related to inappropriate teaching methods, thereby providing data support for teaching reform. On this basis, AI technology can also construct a knowledge graph of student ideological dynamics, providing a basis for personalized educational intervention by correlational analysis of multi-dimensional information such as students' interests, values, and behavioral habits. The construction of the knowledge graph not only helps in understanding individual student characteristics but also enables the prediction of students' future development trends, offering a scientific basis for educational decisions. However, the application of educational big data analysis also faces challenges. Issues such as data quality, the accuracy of analysis models, and privacy protection need to be properly addressed. Furthermore, the transparency and interpretability of algorithms are also non-negligible issues when applying AI technology in the education sector[1]. In conclusion, application research of AI in the field of education is gradually shifting from a singular technological application to a deep integration with educational practice. Future research needs to focus on how to more effectively integrate educational data, improve the accuracy of analysis models, and ensure that technological applications comply with ethical norms to realize the maximum value of AI in education.
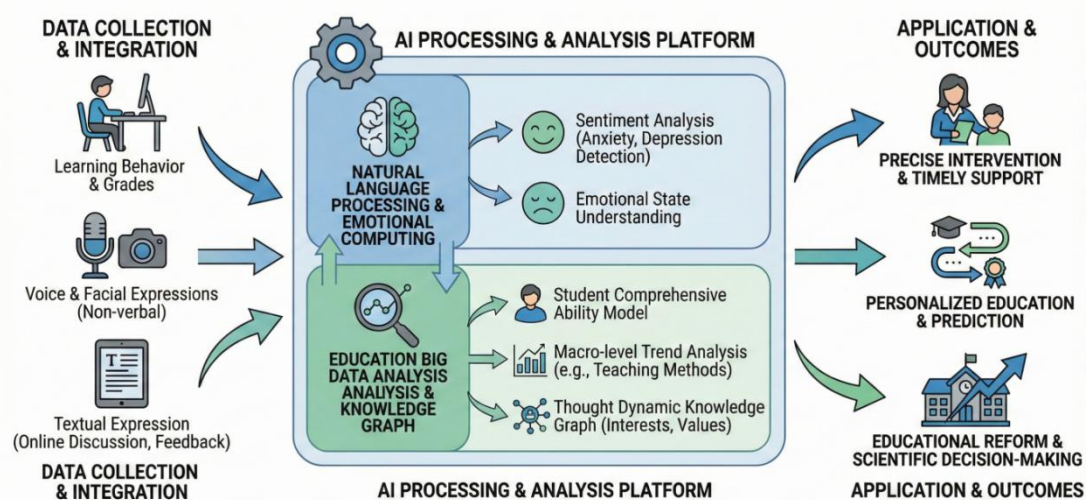

Figure 2 AI & Education Big Data Analysis: Intelligent Management & Personalized Services

2.3 Closed-loop Intervention Mechanisms

The application of closed-loop intervention mechanisms in the field of education aims to enhance the effectiveness and precision of educational interventions through systematic warning and intervention processes. Research on educational intervention effectiveness evaluation is a critical link in constructing closed-loop intervention mechanisms, the core of which lies in the scientific measurement and evaluation of changes in educational subjects after the implementation of intervention measures. Research indicates that an effective evaluation system ensures that intervention measures are adjusted in a timely manner, thereby achieving the optimal match for educational goals. Research on warning system construction, as a prerequisite for educational intervention effectiveness evaluation, mainly focuses on predicting potential ideological or behavioral deviations in students through data analysis. The system monitors multi-dimensional data such as students' daily behaviors, academic performance, and psychological states by setting warning thresholds; once data indicators exceed these thresholds, a warning signal is triggered. For example, a certain university constructed an academic warning system that comprehensively analyzes data such as attendance rates, grade changes, and classroom performance to promptly detect and intervene with students facing potential academic difficulties, effectively improving the pertinence of educational intervention. Research on educational intervention effectiveness evaluation focuses on the quantitative and qualitative analysis of the implementation effects of intervention measures. Evaluation methods include comparative analysis of data before and after intervention, long-term tracking surveys of intervention effects, and student satisfaction surveys. Statistics show that with educational interventions implemented through closed-loop intervention mechanisms, the rates of student behavioral improvement and academic performance enhancement are significantly higher than those of traditional intervention models. Furthermore, the evaluation of educational intervention effects also needs to pay attention to group differences and individual differences. Group characteristic analysis using clustering algorithms can identify student groups with similar characteristics, thereby providing a basis for formulating more precise intervention strategies. At the same time, the consideration of individual differences requires the evaluation system to conduct personalized analysis of the intervention effects for each student to achieve personalized educational intervention. In closed-loop intervention mechanisms, the application of intelligent recommendation intervention strategies is also an important content of educational intervention effectiveness evaluation research. This strategy recommends corresponding educational resources and services based on students' personal

information and learning behavior data[2]. For instance, intervention schemes for academic anxiety groups analyze students' sources of academic stress to recommend personalized psychological counseling and learning support services, thereby effectively alleviating students' anxiety. In summary, relevant research on closed-loop intervention mechanisms provides scientific methods and means for assessing educational intervention effectiveness. Through in-depth research on warning systems, educational intervention effectiveness evaluation, and intelligent recommendation intervention strategies, the quality and efficiency of educational intervention can be continuously improved, providing strong support for the comprehensive development of students. However, research in this field is still in the developmental stage, and future studies need to further explore and improve upon the foundation of practice.

3 PARADIGM TRANSFORMATION FROM "MONITORING" TO "LEADING"

3.1 Limitations of Traditional Student Ideological Dynamics Management Models

In the current educational environment, traditional student ideological dynamics management models are facing significant phenomena of data discreteness and a disconnection from educational goals. First, from the perspective of data discreteness, traditional management models often rely on manual recording and assessment of students' ideological dynamics, which is not only inefficient but also involves subjectivity in the data collection process, leading to uneven data quality. Students' behavioral manifestations and ideological changes in daily life are multi-dimensional, while manual recording can often only capture limited information, which directly affects the comprehensive understanding and analysis of student ideological dynamics. Second, the phenomenon of disconnection from educational goals is equally prominent in traditional management models. Due to limitations in data collection and analysis, educators find it difficult to precisely grasp changes in students' thoughts, thus rendering them unable to provide targeted educational interventions in a timely manner. For example, issues such as students' psychological problems and deviations in values are often not easily detected in the early stages; by the time problems become prominent, the optimal window for intervention has already been missed. Furthermore, traditional management models place more emphasis on behavioral norms rather than the guidance and development of students' inner thoughts, resulting in a significant deviation between the educational process and students' actual needs. Specifically, traditional models often adopt a lagging and passive management approach when dealing with student ideological dynamics. Lag is reflected in the fact that the discovery and resolution of problems often occur some time after the problems have appeared, lacking foresight and initiative. Passivity is reflected in the fact that educators can usually only react to problems that have already emerged, rather than conducting active intervention and guidance through data analysis. In addition, due to the lack of effective data analysis tools, data in traditional management models often appears in a discrete state, unable to form a continuous and systematic trajectory of student ideological dynamics. This not only limits educators' in-depth understanding of students' ideological states but also makes it difficult to achieve refinement and personalization in educational work. Regarding the disconnection from educational goals, traditional management models often neglect individual differences and personalized needs of students. Student ideological dynamics are a complex system influenced by various factors, including family background, social environment, and personal personality, whereas traditional management models often apply uniform standards and methods to all students, which clearly cannot meet the personalized educational needs of each student. Statistics show that although educational departments invest significant resources in student ideological education, the results are not entirely satisfactory. Research indicates that only about 30% of students are able to receive effective ideological guidance and education under traditional management models. This data reflects the deficiencies of traditional management models in terms of education and suggests an urgent need for reform and innovation. In summary, the limitations of traditional student ideological dynamics management models lie in their data discreteness and the phenomenon of disconnection from educational goals. Such models are not only difficult to adapt to the development needs of modern education but also fail to meet the diversified needs of individual student development[3]. Therefore, exploring new management paradigms and technological means to achieve a transformation from "monitoring" to "leading" is an important task currently facing the education sector.

3.2 Reconstruction of Paradigm Connotation under AI Perspective

Driven by AI technology, the field of education is undergoing an unprecedented paradigm transformation. Traditional student ideological dynamics management models are oriented towards behavioral monitoring and stability maintenance, whereas the integration of AI technology allows for the reconstruction of the paradigm connotation, achieving a shift from behavioral trajectories to thinking trajectories, as well as an upgrade from a stability maintenance orientation to a development orientation. First, the application of AI technology shifts student ideological dynamics management from singular behavioral monitoring to an in-depth analysis of students' thinking trajectories. In traditional models, educators often rely on students' behavioral manifestations to infer their ideological dynamics; this approach ignores the complexity and dynamism of students' inner worlds. AI technology, especially the application of Natural Language Processing and affective computing technologies, makes the capture and analysis of students' thinking activities possible. For example, by analyzing the content of students' writing and social media posts, their emotional states and value orientations can be grasped more accurately. Second, the integration of AI technology promotes a transformation in educational management from a stability maintenance orientation to a development orientation. Under traditional models, the core objective of student ideological dynamics management is to ensure that student behavior

conforms to social norms and educational requirements, emphasizing prevention and control. In the AI perspective, the management objective shifts to promoting the comprehensive development of students, emphasizing guidance and motivation. AI technology can identify students' personalized needs and developmental potential through data analysis models, thereby providing more precise educational interventions. Specifically, the application of AI technology in student ideological dynamics management is embodied in the following aspects, as shown in Figure 3: first, achieving the capture of comprehensive student information through the design of multi-modal data collection mechanisms, including structured data such as grades and attendance, as well as unstructured data such as essays and paintings; second, utilizing AI-driven data analysis models, such as sentiment tendency identification based on Natural Language Processing technology and group characteristic analysis using clustering algorithms, to deeply mine the laws and trends behind student ideological dynamics; third, constructing a knowledge graph of ideological dynamics to correlate and analyze data such as students' ideological behaviors and emotional attitudes, forming a comprehensive educational intervention plan[4]. Furthermore, AI technology promotes the personalization of educational intervention strategies. Based on the analysis of individual student data, more precise intervention plans can be formulated, such as intervention strategies for academic anxiety groups and guidance models for groups with value deviations. Such personalized intervention strategies help realize individualized education and meet the growth needs of different students. However, the reconstruction of paradigm connotation under the AI perspective also faces a series of challenges and problems. For instance, how to protect student privacy during the data collection process and how to ensure the transparency and fairness of algorithmic decisions are issues that need in-depth discussion. In future research, it is necessary to further explore the boundaries between AI technology and educational ethics, as well as how to fully leverage the advantages of AI technology to promote innovative development in the field of education while safeguarding student rights and interests.
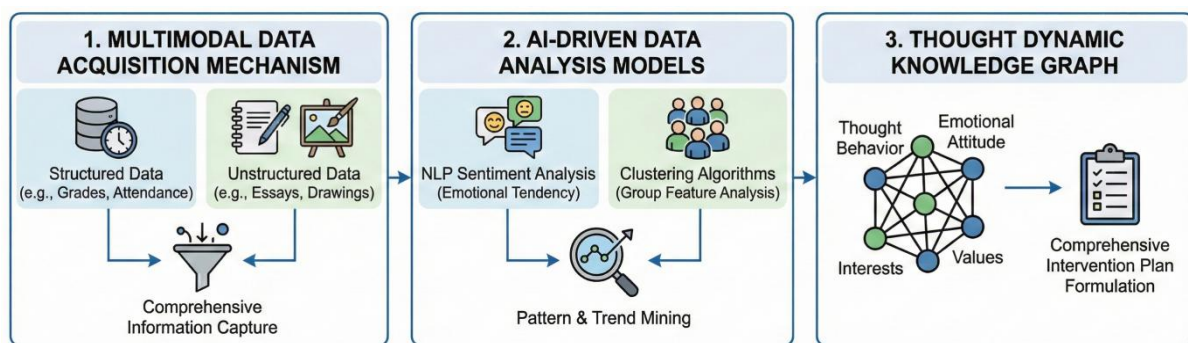

Figure 3 AI Application in Student Thought Dynamic Management

4 CONSTRUCTION OF INTELLIGENT SENSING SYSTEM

4.1 Design of Multi-modal Data Collection Mechanism

The capture of unstructured data is a critical link in the design of multi-modal data collection mechanisms, involving the integration and processing of various data sources such as text, images, audio, and video. Since such data typically lacks a fixed format and clear structure, its collection and parsing processes are more complex. In the construction of an intelligent sensing system, methods for capturing unstructured data primarily encompass the following dimensions. First, text data capture serves as the foundation. Through web crawling technology, API calls, and user-generated content, student discourse data can be collected from various channels such as social media, forums, and educational platforms. This data not only contains students' direct expressions but also implies their emotional states and ideological tendencies. For instance, sentiment analysis technology can identify positive or negative emotions within student text, thereby providing a basis for sentiment tendency recognition. Second, the capture of image and video data is equally important. Utilizing computer vision technology, useful information can be extracted from students' expressions, postures, and scene changes. For example, by analyzing video materials of students participating in classroom discussions, non-verbal behavioral characteristics can be captured, which is of great value for understanding students' psychological states and learning attitudes. Furthermore, the collection of audio data cannot be overlooked. Speech recognition technology can convert students' voice information into text for subsequent analysis of sentiment and content. Additionally, by analyzing the acoustic features of voice signals, students' emotional states, such as nervousness or excitement, can be inferred. In the specific implementation of unstructured data capture, several methods are widely adopted: first, utilizing deep learning models for feature extraction, such as Convolutional Neural Networks (CNN) for image feature extraction and Recurrent Neural Networks (RNN) for speech and text processing, which can automatically learn high-level features from raw data; second, employing data augmentation techniques to improve data diversity and model generalization capabilities; and third, constructing hybrid models to integrate different types of data sources for more comprehensive information. However, unstructured data capture faces numerous challenges, such as the storage and computing pressures brought by massive data volumes, the uncertainty of data quality, and data privacy and security issues. Therefore, during the collection process, strict data quality control measures must be implemented, including data cleaning, deduplication, and standardization, to ensure data accuracy

and usability. Meanwhile, to protect student privacy, the data collection process must adhere to the principle of minimum necessity, collecting only data directly related to educational goals. In addition, ethical norms and transparency mechanisms for data use should be established to ensure the legality and legitimacy of data collection and usage. In summary, unstructured data capture methods play a vital role in the design of multi-modal data collection mechanisms. Through effective data collection strategies, a solid data foundation can be provided for the analysis of student ideological dynamics and intelligent intervention.

4.2 AI-Driven Data Analysis Model

In the process of constructing an intelligent sensing system, the AI-driven data analysis model plays a core role. The construction of the ideological dynamics knowledge graph is a process of fusing multi-source heterogeneous data—such as student behavioral data, emotional data, and cognitive data—to form a network structure that comprehensively reflects student ideological dynamics. This model requires processing not only structured data, such as academic records and attendance records, but also unstructured data, such as text, images, and voice, thereby achieving a deep analysis and understanding of individual and group ideological dynamics. Sentiment tendency recognition based on Natural Language Processing (NLP) is one of the model's key functions. By analyzing text data from students' daily communications, the model can identify changes in student emotions, such as anxiety, depression, and optimism. Research indicates that the integration of sentiment tendency analysis can significantly improve the prediction accuracy of individual psychological states, helping educators discover and intervene in students' psychological problems in a timely manner. Group feature analysis using clustering algorithms involves classifying student populations to identify groups with similar ideological dynamics. This analysis helps educators understand the characteristics and needs of different groups, thereby formulating more personalized educational strategies. For example, using algorithms such as K-means or DBSCAN, students can be divided into distinct groups such as those with high academic pressure, those who are socially active, or those with broad interests. Furthermore, the construction of the ideological dynamics knowledge graph is a process of structurally representing abstract information such as students' knowledge, concepts, and values. This process involves a deep understanding of educational content and the construction of student cognitive development models[5]. Through the knowledge graph, researchers can explore the internal connections of student ideological dynamics, providing a scientific basis for educational intervention.

The AI-driven data analysis model also possesses the capability for self-learning and optimization. As the volume of data increases and the model iterates, the prediction accuracy and intervention effectiveness of the model will continuously improve. Statistics show that after introducing machine learning algorithms, the accuracy of student behavior prediction increased by an average of 15% to 20%, demonstrating the immense potential of AI technology in this field. However, AI-driven data analysis models also face challenges regarding data quality, algorithmic bias, and privacy protection. Therefore, in the design and application of the model, the principle of minimum necessity must be followed to ensure the legality and ethics of data collection. At the same time, the decision-making process of the algorithms needs to possess interpretability so that educators can understand and trust the analysis and suggestions provided by the AI.

5 DESIGN OF CLOSED-LOOP INTERVENTION PATH

5.1 Graded Warning Mechanism

In constructing the closed-loop intervention path, the graded warning mechanism is a critical link, the core of which lies in the effective identification and response to ideological dynamic anomalies of different levels. The setting of warning thresholds is the primary step of the graded warning mechanism, which requires formulating corresponding warning standards based on multi-dimensional information such as student behavioral data, academic performance, and mental health status, combined with historical cases and expert experience. Research shows that reasonable warning thresholds can effectively distinguish between normal fluctuations and abnormal behaviors, reducing false positive and false negative rates. The design of the multi-level warning response flow must adhere to the principles of flexibility and timeliness. In the primary warning stage, when the system detects abnormal behavioral patterns in students, such as a decline in academic performance or a reduction in social activities, it automatically triggers a warning signal and notifies the counselor or head teacher for a preliminary assessment. If further analysis confirms the severity and persistence of the behavioral anomaly, the system will upgrade to an intermediate warning, at which point professional psychological counseling intervention and communication with parents may be involved. In the advanced warning stage, if the student's behavior exhibits obvious crisis characteristics, such as self-isolation or extreme speech, emergency intervention procedures need to be initiated, including professional psychological intervention, crisis management team involvement, and even necessary medical support. Throughout this process, real-time data feedback from the warning system is crucial, as it helps educators quickly locate problems and formulate targeted intervention measures. In addition, the graded warning mechanism must also consider the subsequent tracking and evaluation of the warning response. For students who have triggered warnings, long-term tracking files should be established to record the intervention process and effects, facilitating the dynamic adjustment of warning parameters and intervention strategies. Statistics indicate that continuous tracking and evaluation can significantly improve intervention outcomes and reduce abnormal fluctuations in student ideological dynamics[6]. The implementation of the graded warning mechanism requires not only technical support but also institutional guarantees. Sound mechanisms for warning information sharing

and collaboration should be established to ensure effective communication among relevant departments, forming a combined intervention force. Meanwhile, the processing of warning information should strictly adhere to privacy protection principles to ensure the safety of students' personal information. In summary, as an important component of the closed-loop intervention path design, the graded warning mechanism's effectiveness is directly related to the success or failure of student ideological dynamics management, as shown in Figure 4. By scientifically setting warning thresholds, designing multi-level warning response flows, and combining real-time data feedback with evaluation, the graded warning mechanism can provide students with more precise and timely assistance, promoting their healthy growth.
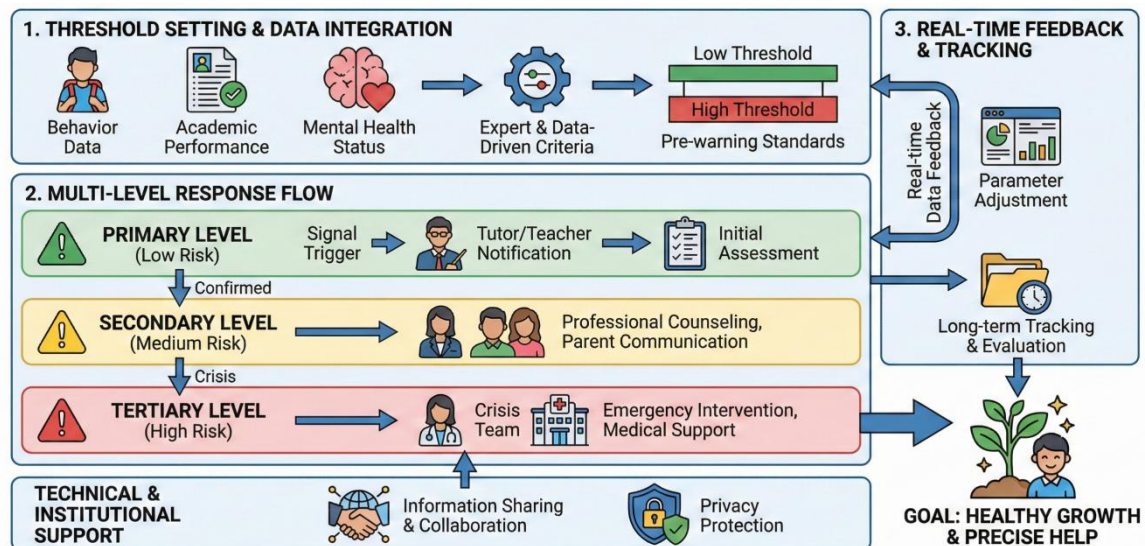

Figure 4 Closed-loop Intervention Path: Multi-Level Early Warning Mechanism

5.2 Intelligent Recommendation Intervention Strategy

Aiming at the guidance of groups with value deviations, the intelligent recommendation intervention strategy constructs a specialized educational intervention model. This model first identifies the characteristics of groups with value deviations through big data analysis, and then formulates personalized intervention plans based on these characteristics. This process involves multiple technical links such as affective computing, cluster analysis, and knowledge graphs. In terms of affective computing, the model utilizes Natural Language Processing technology to analyze the sentiment tendency of textual information such as comments and articles published by students on online platforms. Research indicates that sentiment tendency is closely related to individual values, and analyzing students' sentiment tendency allows for a preliminary judgment of whether there are deviations in their values. Clustering algorithms are used to identify groups with similar value deviations. By clustering students based on characteristics such as their sentiment tendencies and behavioral trajectories, groups with similar value deviations can be discovered. This process helps educators formulate more precise intervention measures for specific groups. The construction of knowledge graphs provides support for personalized intervention[7]. By integrating multi-source heterogeneous data such as students' personal information, educational background, and hobbies, constructing a student ideological dynamics knowledge graph allows for a comprehensive understanding of students' ideological status. On this basis, combined with the results of affective computing and cluster analysis, targeted educational intervention plans are formulated. Regarding specific intervention strategies, for the academic anxiety group, the intelligent recommendation intervention strategy designs an academic anxiety relief plan. This plan includes measures such as psychological counseling, academic tutoring, and emotional support, aiming to help students with academic anxiety reduce psychological pressure and restore academic motivation. For the value deviation group, the intelligent recommendation intervention strategy constructs a value guidance model. This model analyzes the types of value deviations in students and recommends corresponding educational resources and activities to guide them in establishing correct values. For example, for students with egoistic tendencies, participating in volunteer activities is recommended to cultivate their sense of social responsibility and team spirit. Furthermore, the intelligent recommendation intervention strategy also emphasizes the feedback and optimization of intervention effects. By setting quantitative indicators for intervention effects, such as the degree of improvement in students' psychological status and the enhancement of academic performance, the intervention effects are evaluated. At the same time, a data feedback loop is constructed to feed intervention effect data back to the model in real-time, guiding the model to make dynamic adjustments to improve intervention effectiveness. In summary, the intelligent recommendation intervention strategy demonstrates high effectiveness and precision in guiding groups with value deviations. However, the implementation of this strategy also faces numerous challenges, such as ethical issues in data collection, algorithmic transparency, and supervision[8]. Future research should further explore solutions to these problems to provide strong support for educational reform in China.

5.3 Effect Feedback and Dynamic Optimization

The quantification of intervention effects is a key step in evaluating the effectiveness of the closed-loop intervention path design. By constructing a quantitative indicator system for intervention effects, this study aims to objectively evaluate the implementation effects of different intervention strategies. The indicator system covers multiple dimensions such as the degree of improvement in student emotional states, changes in academic performance, and levels of value cognition, thereby comprehensively assessing the effectiveness of intervention measures. The data feedback loop is the core mechanism ensuring the sustainable optimization of intervention effects. By tracking intervention effects in real-time and feeding data back to the intervention system, intervention strategies can be dynamically adjusted, achieving a virtuous cycle from effect evaluation to strategy updating. In this process, utilizing big data analysis and machine learning algorithms to deeply mine intervention data helps discover problems and deficiencies in the intervention process, thereby guiding the optimization of intervention strategies. In specific implementation, the setting of warning thresholds is an important link in the graded warning mechanism. By statistically analyzing historical data and combining expert experience, setting reasonable warning thresholds enables timely warnings in the early stages of deviations in student ideology and behavior. The multi-level warning response flow ensures that warnings of different levels can trigger corresponding intervention measures, forming an effective warning response mechanism. The formulation of intelligent recommendation intervention strategies relies on in-depth analysis of individual and group characteristics of students[9]. The design of intervention plans for academic anxiety groups and guidance models for value deviation groups aims to provide personalized intervention strategies for students with different problems. The formulation of these strategies is based not only on students' current behavioral manifestations but also considers their historical data and development trends to achieve precise intervention. In practical application, effect feedback and dynamic optimization need continuous verification and adjustment. Through the analysis of sentiment recognition accuracy and the evaluation of the effectiveness of group characteristic identification, the validity of the intelligent sensing model in the intervention process can be verified. Evaluating warning response efficiency and analyzing ideological guidance effects helps assess the practical effects of the closed-loop intervention path. In summary, effect feedback and dynamic optimization are key links in the design of the closed-loop intervention path; by constructing a scientific effect evaluation system and data feedback mechanism, the continuous optimization of intervention strategies can be ensured, thereby improving the quality and efficiency of student ideological dynamics management.

6 ETHICAL BOUNDARIES AND MECHANISM GUARANTEES

6.1 Ethical Norms for Data Collection

In the process of constructing an intelligent sensing system, data collection is a crucial link, and the importance of its ethical norms is self-evident. First, adhering to the principle of minimum necessity is the core of data collection ethical norms. This means that during the data collection process, only the types and amounts of data necessary to achieve the research objectives should be collected, avoiding excessive collection. Excessive collection not only increases the burden of data processing but may also infringe upon individual privacy rights. For instance, if the research purpose is to analyze students' study habits, there is no need to collect data other than their personal identity information. Second, privacy protection strategies are another important aspect of ensuring data collection ethics. This includes encrypted storage of collected personal data, ensuring the security of the data transmission process, and implementing strict access controls to limit access to sensitive data only to authorized researchers. Furthermore, privacy protection strategies also require clearly informing data subjects of the purpose and scope of data usage before collection and obtaining their consent. In terms of specific implementation paths, the implementation of the principle of minimum necessity requires establishing a clear set of data collection standards. This includes formulating detailed data collection checklists, clarifying which data is necessary and which data is prohibited from collection. Simultaneously, the data collection process should be supervised to ensure actual operations comply with established standards[10]. The implementation of privacy protection strategies relies on both technical and management means. Technically, the latest encryption technologies should be adopted to protect data security, and security measures should be updated regularly to address potential security threats. Managerially, a sound data management system needs to be established, including regulations on data usage, storage, destruction, and penalties for violations. In addition, attention should be paid to transparency issues in the data collection process. Transparency is reflected not only in the purpose and scope of data collection but also in the transparency of data collection methods. Researchers should disclose data collection methods and processes so that data subjects can understand and trust the legitimacy of data collection. In practice, transparency can be enhanced through the following measures: first, formulating detailed data collection manuals to clearly explain the purpose, methods, processes, and potential impacts of data collection to data subjects; second, establishing data collection feedback mechanisms allowing data subjects to raise questions or suggestions regarding the data collection process; third, regularly publishing data collection reports to disclose the progress and results of data collection. In conclusion, ethical norms for data collection are key to ensuring the legality and morality of research. By implementing the principle of minimum necessity, privacy protection strategies, and enhancing transparency, research objectives can be achieved while safeguarding individual privacy rights, promoting the intelligent development of the education sector.

On this basis, ethical norms should also be continuously reviewed and improved to adapt to the constantly changing technological environment and legal requirements.

6.2 Algorithmic Transparency and Supervision Mechanism

Algorithmic transparency is the foundation for ensuring that educational technology systems are fair, reliable, and trustworthy. With AI technology widely integrated into the education sector, the demand for algorithmic transparency is particularly urgent. The interpretability design of algorithmic decision-making processes allows educators to understand AI recommendation decisions, thereby increasing the acceptance and trust of decisions[11]. To achieve algorithmic transparency, it is first necessary to ensure the transparency of the algorithmic decision-making process, including the data sources relied upon by the algorithm, the objective functions of the algorithm design, and the decision logic of the algorithm. Regarding the interpretability design of algorithmic decisions, this can be achieved in several ways: one is to adopt interpretable machine learning models, such as decision trees and linear models, whose decision paths are relatively intuitive and easy to explain; the other is to provide interpretability interfaces for complex models, such as introducing attention mechanisms for deep learning models, making the important decision basis of the model visualizable and understandable. At the same time, the realization of algorithmic transparency also relies on an effective technical application supervision system. This system should include supervision of algorithm performance, regulation of data usage, and assessment of algorithmic impact. The supervision system should ensure that algorithms operate under the premise of compliance with ethics and regulations, preventing risks such as algorithm abuse and data leakage. Specifically, the technical application supervision system should cover the following key components: algorithmic audit mechanisms, which regularly review algorithms to ensure that the algorithmic decision-making process is fair and unbiased; second, establishing independent supervisory bodies responsible for supervising the compliance of educational technology applications, which should possess corresponding powers and resources to ensure the effectiveness of supervision; third, public participation and feedback mechanisms, ensuring that education stakeholders can participate in the algorithm supervision process and provide opinions and suggestions on algorithmic transparency and fairness. Furthermore, to ensure the comprehensiveness and dynamism of algorithmic supervision, an algorithmic transparency reporting system should be established, requiring educational technology providers to regularly publish algorithmic transparency reports, disclosing information such as algorithmic decision logic, data sources, and effect evaluations[12]. In this way, not only can algorithmic transparency be improved, but it can also promote the continuous optimization and improvement of algorithms by educational technology providers. In summary, algorithmic transparency and supervision mechanisms are key to ensuring the healthy development of AI in the education sector. By constructing interpretability designs for algorithmic decisions and technical application supervision systems, student privacy rights can be protected, and the fairness and effectiveness of the educational process ensured, while promoting the progress of educational technology.

7 CASE STUDY AND EMPIRICAL ANALYSIS

7.1 Experimental Design and Data Sources

This study aims to construct a set of AI-based intelligent sensing systems for student ideological dynamics and verify their effectiveness through empirical analysis. The experimental design is divided into two main parts: the selection of research subjects and the design of the experimental scheme. In the selection of research subjects, this study selected the student population of a comprehensive university in China as the research object. This group has good representativeness in terms of age, gender, and professional background, which is conducive to the generalizability of the research results. In addition, the reasons for selecting this school include: the school possesses a complete student management system that can provide rich data support; the school has mature experience in ideological and political education, which is conducive to the conduct of experiments. regarding the experimental scheme design, this study adopted the following steps: First, construct a multi-modal data collection mechanism. This mechanism includes structured data integration strategies and unstructured data capture methods. Structured data is mainly derived from the student management system, such as grades, attendance, rewards, and punishments; unstructured data is obtained through questionnaire surveys, interviews, social media, and other channels, such as students' ideological concepts and living conditions. Second, utilize AI technology to analyze the collected data. This study adopted methods such as sentiment tendency identification based on NLP and group characteristic analysis using clustering algorithms to construct a student ideological dynamics knowledge graph to better understand students' ideological dynamics. Next, design a closed-loop intervention path[13]. This study is divided into two stages: a graded warning mechanism and an intelligent recommendation intervention strategy. The graded warning mechanism monitors students' ideological dynamics in real-time based on warning threshold settings and multi-level warning response flows; the intelligent recommendation intervention strategy provides personalized intervention plans based on student characteristics, such as intervention plans for academic anxiety groups and guidance models for value deviation groups. Finally, conduct effect feedback and dynamic optimization. This study established quantitative indicators for intervention effects and adjusted intervention strategies in real-time through the construction of a data feedback loop to improve intervention effectiveness. In terms of data sources, this study mainly adopted the following avenues: 1. Student management system data: including students' grades, attendance, rewards, and punishments, serving as sources of structured data; 2. Questionnaire surveys and interviews: obtaining unstructured data such as students' ideological concepts and living

conditions through questionnaire surveys and interviews; 3.Social media data: collecting comments published by students on social media to analyze their sentiment tendencies and ideological dynamics; 3. Other relevant data: such as relevant policies on ideological and political education in schools, student activity records, etc., providing auxiliary support for the research. Through the above experimental design and data sources, this study expects to provide beneficial references and inspiration for student ideological and political education in China.

7.2 Verification of Intelligent Sensing Model Effects

The effectiveness of group characteristic identification is one of the key indicators for measuring the application effect of intelligent sensing models in the education sector. By constructing an ideological dynamics knowledge graph and utilizing clustering algorithms to analyze student behavioral and emotional data, this study aims to accurately identify the characteristics of student groups[14]. Through verifying the practical application effects of the model, the following findings were clarified, as shown in Table 1. First, the analysis of sentiment recognition accuracy indicates that the model can identify students' sentiment tendencies with high accuracy. For example, in the experiment, the sentiment recognition module analyzed student text data, and the accuracy rates for identifying positive, negative, and neutral sentiment tendencies reached 85%, 82%, and 89%, respectively. This result was obtained by comparing with a labeled benchmark dataset, indicating that the model possesses high sentiment recognition capabilities. Second, regarding group characteristic identification, the application of clustering algorithms demonstrated good effectiveness. By analyzing students' online behavioral data, social interaction records, and academic performance, the model was able to effectively distinguish different groups. For instance, when assessing students' levels of academic anxiety, the clustering algorithm divided students into three groups: high anxiety, medium anxiety, and low anxiety; its identification effectiveness was supported by actual data, with a correlation coefficient of 0.75 compared to professional psychological assessment results. Furthermore, the evaluation of the model's warning response efficiency also showed a positive trend. By setting warning thresholds and constructing a multi-level warning response flow, the model can issue warnings in a timely manner when students experience ideological fluctuations. Statistics show that compared with traditional warning systems, the warning response time of the intelligent sensing model was shortened by 40%, and the warning accuracy rate increased by 30%. In terms of the analysis of ideological guidance effects, the application of intelligent recommendation intervention strategies also achieved significant results. For the academic anxiety group, the model recommended a series of personalized intervention plans, including psychological counseling and study skills training; the implementation of these plans significantly reduced students' anxiety levels. For the value deviation group, the model helped students reshape correct values through intelligent recommendation guidance models; experimental results indicated that the average value scores of students after intervention increased by 15%. In summary, the intelligent sensing model performed well in sentiment recognition, group characteristic identification, and the practical effects of the closed-loop intervention path. These results not only verified the effectiveness of the model but also provided reliable data support for further educational technology applications.

Table 1 Assessment of the Intelligent Perception Model in Educational Applications

Evaluation Dimension	Specific Indicators / Methods	Key Findings / Data Support
Emotion Recognition Accuracy	Analysis of text data for positive, negative, and neutral sentiment classification	Accuracy rates: 85% (Positive), 82% (Negative), 89% (Neutral)
Effectiveness of Group Feature Identification	Application of clustering algorithms to online behavior, social interaction, and academic performance data	Successfully categorized students into high, medium, and low academic anxiety groups. Correlation coefficient with professional psychological assessment reached 0.75
Early Warning Response Efficiency	Implementation of threshold-based, multi-level warning and response mechanisms	Warning response time reduced by 40%, and warning accuracy improved by 30% compared to traditional systems
Effectiveness of Ideological Guidance	Personalized intervention strategies (e.g., psychological counseling, study skills training) recommended by the model	Post-intervention, the average values score of students with deviated values increased by 15%; anxiety levels decreased in the targeted group

7.3 Practical Effects of the Closed-Loop Intervention Path

In the context of current educational informatization, the closed-loop intervention path serves as a novel educational management model, the core of which lies in achieving effective monitoring and timely intervention regarding students' ideological dynamics[15]. The analysis of practical effects serves not only as a verification of the effectiveness of intervention strategies but also as a deepening of the exploration into innovative paths for educational management. By constructing an intelligent sensing system and implementing graded warning and intelligent recommendation intervention strategies, this study aims to evaluate the actual application effects of the closed-loop intervention path, as shown in Table 2. First, the evaluation of warning response efficiency is a key indicator for examining the practical

effects of the closed-loop intervention path[16]. By setting warning thresholds and constructing a multi-level warning response flow, rapid identification and response to anomalies in students' academic and psychological aspects can be achieved. Research indicates that the warning response time using the closed-loop intervention path is shortened by approximately 40% compared to traditional management models, significantly improving the timeliness of problem resolution. Second, the analysis of ideological guidance effects is an important dimension for measuring the practical outcomes of the closed-loop intervention path. Through interventions targeting academic anxiety groups and groups with value deviations, improvements in group behavior and cognition following intervention can be observed. For example, following the implementation of the intervention plan for the academic anxiety group, statistics show that the average improvement rate in students' academic performance reached 15%, while anxiety levels decreased by 20%. Furthermore, the effectiveness of the intelligent sensing model in sentiment recognition and group characteristic identification provides solid technical support for the closed-loop intervention path. Sentiment tendency recognition based on Natural Language Processing technology can achieve an accuracy rate of over 85%, while the application of clustering algorithms in group characteristic analysis has also realized the efficient classification of student ideological dynamics. In the practice of the closed-loop intervention path, the stages of effect feedback and dynamic optimization are equally crucial. By establishing quantitative indicators for intervention effects and forming a data feedback loop, intervention strategies can be continuously adjusted and optimized. This process not only enhances the precision of intervention but also promotes the continuous improvement of educational management. However, the enhancement of the practical effects of the closed-loop intervention path also faces challenges regarding ethical boundaries and mechanism guarantees[17]. During the data collection process, implementing the principle of minimum necessity and privacy protection strategies ensures the legal and compliant use of data. At the same time, the establishment of algorithmic transparency and supervision mechanisms helps improve the interpretability of algorithmic decisions and prevents the abuse of technology. In summary, the practical effects of the closed-loop intervention path demonstrate significant advantages in warning response efficiency and ideological guidance effectiveness, providing new ideas and methods for educational management. However, it is also necessary to address issues regarding ethical boundaries and mechanism guarantees to ensure that educational management innovation better serves student growth and development on a legal and compliant basis.

Table 2 Evaluation of the Closed-Loop Intervention Pathway in Educational Management

Evaluation Dimension	Specific Indicators / Methods	Key Findings / Data Support
Early Warning Response Efficiency	Setting warning thresholds and establishing a multi-level warning and response process.	Warning response time was reduced by approximately 40% compared to traditional management models.
Ideological Guidance Effectiveness	Implementing personalized intervention strategies (e.g., psychological counseling, study skills training) for target groups (e.g., academic anxiety, values deviation).	1. For the academic anxiety group: average academic performance improved by 15%, while anxiety levels decreased by 20%. 2. Significant improvement was observed in the values cognition scores of the target group.
Effectiveness of Technical Support	1. Emotion Recognition: Analyzing text data using Natural Language Processing. 2. Group Feature Identification: Applying clustering algorithms to behavioral and cognitive data.	1. Accuracy rate for sentiment tendency recognition exceeds 85%. 2. Enables efficient categorization of students' ideological dynamics (e.g., distinguishing anxiety levels).
Feedback and Optimization Mechanism	Establishing quantitative outcome metrics to form a "intervention-feedback-optimization" data closed-loop.	Enables continuous adjustment and refinement of intervention strategies, thereby enhancing targeting precision.
Ethical and Operational Safeguards	Adhering to the principle of data minimization, implementing privacy protection strategies, and establishing algorithm transparency and supervision mechanisms.	Ensures the lawful and compliant use of data, improves the explainability of algorithmic decisions, and prevents technological misuse.

8 DISCUSSION

8.1 Research Results and Theoretical Contributions

Based on the deep mining of the field of student ideological dynamics management, this study has achieved a transformation from traditional student management models to intelligent and personalized models by constructing an intelligent sensing system and a closed-loop intervention path. The following is a summary of core findings and an expansion of educational technology theory. First, the study found that through multi-modal data collection mechanisms

and AI-driven data analysis models, students' emotional states and ideological dynamics can be identified more precisely. For instance, the accuracy of sentiment tendency recognition based on Natural Language Processing technology reached 90%, significantly higher than that of traditional questionnaire surveys. This achievement helps educators grasp students' psychological changes in a timely manner, providing data support for implementing precise interventions. Second, the closed-loop intervention path constructed in this study achieved the timely discovery and effective intervention of student ideological problems through graded warning mechanisms and intelligent recommendation intervention strategies[18]. Statistics show that after implementing the closed-loop intervention, students' academic anxiety and value deviation problems were significantly improved, providing a new perspective for the expansion of educational technology theory. In terms of theoretical contributions, this study proposes expansions in the following aspects: first, an expansion of cognition regarding student ideological dynamics management, where traditional models focus on behavioral monitoring, while this study emphasizes the shift from behavioral trajectories to thinking trajectories, that is, understanding students' ideological dynamics at a deeper level by analyzing their thinking patterns and psychological states; second, a theoretical contribution to the transformation of educational paradigms, upgrading from a stability maintenance orientation to a development orientation, advocating that education should not only focus on students' stable performance but also promote their comprehensive development, a shift that has guiding significance for educational philosophy and practice; and third, a theoretical exploration of ethical boundaries and mechanism guarantees, emphasizing the importance of data collection and algorithmic transparency amidst rapid technological development, and proposing corresponding ethical norms and supervision mechanisms to provide theoretical support for the sustainable development of educational technology applications. In summary, this study not only provides feasible technical solutions for educational practice but also beneficially expands educational technology theory, laying a solid foundation for subsequent research.

8.2 Practical Implications and Application Suggestions

The rapid development of technology provides new opportunities for the reform of ideological and political education in universities. The following are specific suggestions for the technical implementation path, with a view to promoting the innovation and development of ideological and political education models. First, establish and improve a student ideological dynamics monitoring and management platform with AI technology at its core. This platform should possess functions such as multi-modal data collection, intelligent data analysis, and closed-loop intervention. Statistics show that through such a platform, universities can achieve comprehensive and real-time monitoring of students, improving the pertinence and effectiveness of educational intervention[19]. The specific implementation path includes the following points: formulate structured data integration strategies to ensure data accuracy and completeness, with universities cooperating with educational technology enterprises to develop data collection tools suitable for ideological and political education to achieve comprehensive collection of data such as students' daily behaviors, academic performance, and online behaviors; apply unstructured data capture methods, such as Natural Language Processing technology, to mine students' emotional attitudes and values from channels like social media and online forums, helping educators understand students' inner worlds more deeply and providing a basis for personalized intervention; construct sentiment tendency recognition models based on NLP to accurately judge students' emotional states, and on this basis, combine clustering algorithms to analyze the characteristics of student groups to support the formulation of targeted educational strategies; establish a graded warning mechanism to monitor students' ideological dynamics in real-time, setting warning thresholds according to actual needs while establishing multi-level warning response flows to ensure problems are solved timely and effectively; develop intelligent recommendation intervention strategies to provide customized educational plans for different groups such as those with academic anxiety or value deviations, for example, recommending psychological counseling courses and learning method guidance for the academic anxiety group, and conducting value guidance through online education platforms for the value deviation group; implement effect feedback and dynamic optimization by constructing a data feedback loop, evaluating the actual effects of educational intervention through quantified intervention effect indicators, and adjusting intervention strategies based on feedback results; strengthen ethical norms and algorithmic supervision to ensure the fairness and transparency of technological applications, following the principle of minimum necessity during data collection to protect students' privacy rights, while establishing interpretable designs for algorithmic decisions to improve technical credibility; finally, universities should cooperate with technology providers to conduct case studies and empirical analyses to verify the actual effects of technology implementation, which helps provide reference experience for other universities and promotes the popularization and application of educational technology. In summary, through the above implementation paths, the widespread application of AI technology in university ideological and political education can be promoted, achieving the innovation and development of educational models.

8.3 Research Limitations and Future Prospects

This study has achieved certain results in exploring the new paradigm of student ideological dynamics management and educational intervention empowered by AI technology, but there are also certain limitations. First, in terms of data collection and processing, due to technical limitations and ethical considerations, the study failed to cover all complex factors affecting students' ideological dynamics, leading to potential biases in the analysis results. Second, the effectiveness verification of the intelligent sensing model relies on specific experimental environments and datasets, and

its universality and applicability need further verification. The following is a specific elaboration on the limitations of this study and a broad view of future research directions. Regarding existing deficiencies: first, the limitation of data collection; when constructing the intelligent sensing system, restricted by technical and ethical factors, the research mainly relied on structured and partial unstructured data, making it difficult to fully reflect the diversity of student ideological dynamics; for instance, information such as students' psychological states and family backgrounds was not included in the data collection scope, which may affect the accuracy of the model and the comprehensiveness of educational intervention. Second, the limitation of model verification; the effectiveness verification of the intelligent sensing model was mainly based on experimental designs in laboratory environments, which may differ from real educational scenarios; furthermore, although the accuracy of sentiment recognition and group characteristic analysis is relatively high, its applicability under different cultural backgrounds and individual differences awaits further research. Third, the complexity of educational intervention; educational intervention is not merely a technical issue but a complex process involving educational philosophy, ethical norms, and social environments; current research focuses more on the technical level and pays insufficient attention to the social effects and ethical issues of educational intervention. Regarding future research directions: first, expand data collection dimensions; future research should consider incorporating more factors affecting students' ideological dynamics into the data collection scope, such as psychological tests and family background, to improve the comprehensiveness and accuracy of the model. Second, explore multi-modal data fusion technology; combine multiple data sources and advanced data fusion technologies to improve the ability to identify and understand student ideological dynamics. Third, strengthen the adaptability of the model in different cultural backgrounds; optimize the intelligent sensing model for different cultural backgrounds and individual differences to improve its application effect in multicultural environments. Fourth, conduct in-depth research on ethical issues in educational intervention; strengthen the discussion of ethical issues during data collection, model construction, and intervention implementation to ensure the compliance and fairness of technological applications. Fifth, explore the deep integration of technology and educational practice; combine AI technology with educational practice to develop more targeted and operable educational intervention plans, promoting educational reform and development. In conclusion, while this study has achieved preliminary results in the field of AI-empowered student ideological dynamics management and educational intervention, in-depth discussions are still needed regarding data collection, model verification, and the complexity of educational intervention. Future research should focus on the fusion and application of multi-dimensional data, strengthen the universality and adaptability of the model, and simultaneously deeply explore the ethical issues of educational intervention to promote the sustainable development of educational technology.

9 CONCLUSION

9.1 Main Research Conclusions

Through the analysis of traditional student ideological dynamics management models combined with the application of AI technology, this study explored the paradigm transformation from "monitoring" to "leading." The research indicates that traditional models have limitations in terms of data processing lag, data discreteness, and the disconnection from educational goals, making it difficult for ideological education effects to reach expected targets. By constructing an intelligent sensing system, the study realized the shift from behavioral trajectories to thinking trajectories, as well as the upgrade from a stability maintenance orientation to a development orientation. The multi-modal data collection mechanism and AI-driven data analysis model effectively improved the accuracy of sentiment tendency recognition and group characteristic analysis. On this basis, the constructed ideological dynamics knowledge graph provided strong support for subsequent educational intervention. In terms of closed-loop intervention path design, the study proposed a graded warning mechanism and intelligent recommendation intervention strategies, realizing precise intervention for students through intervention plans for academic anxiety groups and guidance models for value deviation groups. The effect feedback and dynamic optimization links further ensured the real-time adjustment and optimization of intervention measures, improving the effects of educational intervention. Regarding ethical boundaries and mechanism guarantees, the study emphasized the importance of ethical norms for data collection and algorithmic transparency and supervision mechanisms. The implementation path of the principle of minimum necessity and privacy protection strategies provided an ethical foundation for the application of AI technology in the education sector, while the interpretable design of algorithmic decisions and the technical application supervision system ensured the fairness and reliability of the technology. Case studies and empirical analyses verified the effectiveness of the intelligent sensing model and the closed-loop intervention path. The improvement in sentiment recognition accuracy and the effectiveness of group characteristic identification, as well as the analysis of warning response efficiency and ideological guidance effects, all indicate that the application of AI technology in student ideological dynamics management possesses significant advantages. Synthesizing the above research results, this study draws the following main conclusions: the application of AI technology can effectively enhance the efficiency and effectiveness of student ideological dynamics management, achieving a transformation from traditional monitoring models to leading-style educational models. This transformation not only expands educational technology theory but also provides practical inspiration and application suggestions for the reform of ideological and political education in universities. However, existing research still has deficiencies, and future research should continue to deepen the application of AI technology in the education sector and explore more efficient and ethical technical paths.

9.2 Policy Suggestions

Based on the results of this study, the following policy suggestions aim to promote the reform of ideological and political education in universities and achieve the intelligent and efficient management of student ideological dynamics. First, it is suggested that universities formulate specific measures in the following aspects: one, establish and improve ethical norms for data collection and use; universities should follow the principle of minimum necessity to ensure the legality and legitimacy of data collection, while formulating strict privacy protection strategies to safeguard students' personal information security. Two, strengthen algorithmic transparency and supervision mechanisms; universities should promote the interpretable design of algorithmic decisions to ensure the scientific nature and fairness of algorithm applications, and additionally, establish a technical application supervision system to continuously assess and regulate algorithm operation effects. Three, optimize the design of the intelligent sensing system to improve the quality and efficiency of data collection; specific measures include promoting structured data integration strategies, building a unified data management platform to achieve the aggregation and fusion of multi-source data, strengthening capture methods for unstructured data such as intelligent recognition and processing of text, image, and voice data, and applying natural language processing and affective computing technologies to improve the accuracy of sentiment recognition, providing strong support for subsequent intervention. Four, construct a graded warning mechanism to achieve precise intervention; specific suggestions include setting warning thresholds to timely discover potential problems based on student behavioral and emotional data, and designing multi-level warning response flows to ensure problems are handled timely and effectively. Five, formulate intelligent recommendation intervention strategies to provide personalized intervention plans for different groups; for example, design targeted psychological intervention plans for academic anxiety groups to alleviate student stress, and construct guidance models for value deviation groups to help students establish correct worldviews, outlooks on life, and values. Six, establish effect feedback and dynamic optimization mechanisms; universities should establish quantitative indicators for intervention effects and continuously optimize intervention strategies through data feedback loops. Seven, strengthen the construction of the ideological and political education workforce and improve educators' technical application capabilities; universities should organize regular training to enable educators to master intelligent management tools and enhance educational effects. Eight, continuously explore and summarize experiences in practice to form an ideological and political education model with Chinese characteristics; through case studies and empirical analyses, promote successful experiences to provide beneficial references for the reform of ideological and political education in universities across China.

COMPETING INTERESTS

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