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Analysis of Opportunities and Challenges for State-Owned Enterprises in Participating in the Elderly Care Service Industry Development

Hui Ran, Yaguang Chen, Hongzhi Gao, Jin Dai*, Yali Huang

School of Economics and Management, Dalian Jiaotong University, Dalian 116028, Liaoning, China

*Corresponding author: Jin Dai, Econoedu2019@126.com

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Abstract: The intensification of population aging and the emergence of the silver economy have made it an inevitable trend for state-owned enterprises (SOEs) to participate in the elderly care service industry. By systematically analyzing the opportunities and risks of participation of state-owned enterprises in the service sector, the paper identifies the advantages and disadvantages of participation in the service sector, and proposes further strategic options. The study aims to provide practical reference for State-owned enterprises to organize their services in an orderly manner and to achieve synergy between their own development and industrial upgrading, while supporting the high-quality development of the service sector in support of the elderly and addressing the challenges of population ageing.

Keywords: State-owned enterprises; Elderly care service industry; Opportunities and challenges

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1. Introduction

With the deepening of population ageing and the rapid growth of the silver economy in China, the participation of SOEs in the development of the old-age services sector has been a major trend. However, as the elderly care service industry remains an emerging sector in China—with its business model not yet fully established and industrial policies still in the exploratory stage—SOEs face significant strategic uncertainties in how to engage in this field. Therefore, a systematic strategic analysis of the opportunities and risks associated with SOE participation in elderly care services is essential. This involves identifying the favorable and unfavorable conditions for such involvement and, based on this, proposing feasible and realistic strategic pathways for SOEs to engage in the elderly care service industry.

2. External opportunities for SOEs in participating in the elderly care service industry

Against the backdrop of the rapid rise of the silver economy and the country's vigorous implementation of the active ageing response strategy and the Healthy China strategy, SOEs face highly favorable external opportunities in participating in the development of the elderly care service industry, mainly including market opportunities and policy opportunities.

2.1. Market opportunities

With the intensification of population aging and the increasing prevalence of small, empty-nest, and elderly-only households, traditional home-based elderly care models—reliant on filial support—and welfare-oriented elderly care systems can no longer meet the growing demand for elderly care services. Enhancing the marketization and industrialization of elderly care services and actively developing the elderly care service industry have emerged as effective solutions to address the “care difficulty” and meet escalating demand.

The scope of the elderly care service industry has been defined differently across policy documents. *The Opinions on Accelerating the Development of the Elderly Care Service Industry* (GOSC Document No. 6 (2006)) describes it as a service sector providing daily care and nursing for the elderly to meet their special needs. *Several Opinions of the State Council on Accelerating the Development of the Elderly Care Service Industry* (State Council Document No. 35 (2013)) expands this to include elderly living assistance, elderly products, health services, fitness, cultural entertainment, financial services, and tourism. Synthesizing these, this paper categorizes the basic business models of the elderly care service industry into four types:

Basic elderly care services: These include essential services such as daily living assistance and medical nursing for the elderly, primarily aimed at meeting the fundamental care needs of the elderly, especially those with middle- and low-income levels.

Upgraded elderly care services: High-end offerings such as premium elderly apartments and insurance-backed retirement communities, which provide higher-level daily care and medical services primarily for middle- and high-income elderly individuals.

Enrichment-oriented elderly care services: These mainly consist of services such as elderly sports and fitness, cultural and recreational activities, and tourism, with the primary goal of enriching the lives of the elderly.

Supportive elderly care services: This category includes elderly financial services and the marketing of elderly care products. These services are designed to provide the necessary support and guarantees for the elderly to access the aforementioned types of care services.

In recent years, China's elderly care service industry has experienced rapid development, demonstrating vast market potential. According to the 2023 Elderly Care Industry Development Report: Breaking Barriers in Institutional Care, jointly released by the China Research Center on Aging and SDIC Health Industry Investment Co., Ltd., the elderly care service sector—as the core component of the broader elderly care industry—had surpassed a market size of RMB 1 trillion by 2020 ^[1]. The National Information Center forecasts that by 2030, individuals aged 65 and above will account for 20% of China's total population. Meanwhile, *the White Paper on the Development of China's Elderly Care Industry*, released by the Chinese Academy of Social Sciences, projects that China's elderly care market could reach RMB 13 trillion by 2030 ^[2].

At present, China has largely established a “9073” elderly care model, wherein 90% of the elderly receive home-based care, 7% are served by community-based elderly care services, and 3% are cared for in institutional

settings. Different care models align with diverse service types, giving rise to an increasingly diverse and segmented market.

Meanwhile, rising living standards have led more elderly to pursue high-quality, diversified, and personalized elderly care services. Their expenditure on daily necessities and medical expenses has gradually declined, while spending on cultural activities and non-regular expenditures has increased. As a result, a variety of emerging elderly care services are attracting increasing attention.

2.2. Policy opportunities

In February 2006, the *Opinions on Accelerating the Development of the Elderly Care Service Industry* (GOSC Document No. 6 (2006)) issued by the General Office of the State Council, first proposed the term “elderly care service industry” at the government level. This marked the transformation of the elderly care service sector from a purely welfare-oriented undertaking to a structure where welfare-based institutions and market-oriented industrial sectors coexist.

In May 2013, the State Council issued *Several Opinions of the State Council on Accelerating the Development of the Elderly Care Service Industry* (State Council Document No. 35 (2013)), which emphasized “fully leverage the fundamental role of the market in resource allocation and gradually enable social forces to become the principal drivers of elderly care service development.”

Subsequently, in August 2014, the Ministry of Finance, in collaboration with the Ministry of Commerce, issued *the Notice on Piloting Market-Oriented Development of the Elderly Care Service Industry*, proposing the establishment of “a long-term mechanism to promote the development of elderly care services through socialization, marketization, and commercialization.”

From a policy perspective, over 40 national-level policy documents related to elderly care service development were issued from 2016 to the end of 2018 alone, of which as many as 20 were released in 2016^[3]. In January 2024, the General Office of the State Council issued *Opinions on Developing the Silver Economy and Enhancing the Wellbeing of the Elderly*, putting further forward a series of guiding opinions on expanding elderly care service-related formats from the perspective of developing the silver economy.

Among the various policy documents successively issued to promote the development of the elderly care service industry, a series of relevant policies have also been proposed for SOEs to participate in this sector. These policies support SOEs in reallocating their idle resources to the field of elderly care services, thereby providing a new pathway for SOEs to address resource idleness and engage in the elderly care service industry.

3. Internal advantages of SOEs in participating in the elderly care service industry

SOEs possess distinct internal advantages in participating in the development of the elderly care service industry, primarily reflected in the dynamic advantage of fulfilling CSR, idle resource utilization, and support derived from their core business operations.

3.1. Motivation for corporate social responsibility (CSR)

Compared to private enterprises, SOEs—due to their public ownership nature—exhibit stronger motivation to fulfill CSR. In March 2019, according to the *Performance Evaluation Measures for Central Enterprise Leaders* (SASAC Order No. 40), social benefit indicators for public welfare-oriented SOEs incorporate third-

party evaluations. Enterprises with suboptimal evaluation results may face score deductions or demotions in performance assessments.

The government has placed increasing emphasis on the performance of SOEs in fulfilling their CSR. In June 2024, the State-owned Assets Supervision and Administration Commission (SASAC) issued *the Guidelines on High-Standard CSR Performance by Central Enterprises in the New Era*, which, for the first time, explicitly identified “caring for the development of elderly care service industry” as a key component under the dimension of “enhancing the level of services for people’s better life” in the high-standard fulfillment of CSR by central SOEs.

These target requirements for CSR performance among central enterprises help establish an internal incentive mechanism for SOEs to engage in the elderly care service industry. As a result, SOEs are more proactive and motivated than other types of enterprises in fulfilling high-standard CSR through active participation in the development of elderly care services.

3.2. Idle resource advantages

Due to historical factors, some SOEs have accumulated idle resources—such as internal hospitals, sanatoriums, and former office premises—that are well-suited for the development of the elderly care services. And in recent years, some SOEs have also accumulated a batch of idle assets, such as abandoned office buildings, factories, and operation areas, during their restructuring and reorganization. Additionally, in the process of industrial transformation and upgrading of SOEs, some human resources have become underutilized due to mismatches with the technical and business requirements of new enterprise operations.

Through appropriate integration and adaptive reuse, repurposing these assets for the elderly care service industry can not only enhance the efficiency of resource allocation within SOEs but also help reduce land acquisition costs and infrastructure construction expenses associated with providing such services, thereby forming a distinct cost advantage.

3.3. Core business support advantage

SOEs are generally large in scale and operate under relatively standardized operations, with few undesirable commercial behaviors such as operator absconding or customer fraud. As a result, elderly care services provided by SOEs tend to earn greater trust from older adults and enjoy higher credibility.

Furthermore, some SOEs, such as state-owned real estate companies, state-owned commercial insurance companies, and state-owned tourism companies, have core businesses that exhibit strong industrial complementarity with the elderly care service sector. This enables them to provide strong business support for SOEs engaging in elderly care services in aspects such as property provision, pension insurance services, and travel-residence elderly care services.

4. External challenges for SOEs in the elderly care service industry

While SOEs possess external opportunities and internal advantages in engaging with the elderly care service industry, they also encounter certain challenges. These primarily manifested in the following aspects: the increasingly intense industry competition, the long investment payback period coupled with relatively low profit margins, and underdeveloped regulations within the sector.

4.1. Intensifying industry competition

In recent years, as the government has gradually liberalized the elderly care service market and an increasing amount of private capital has entered the sector, the operational landscape of the elderly care market has become increasingly diversified. The growing number of market participants has inevitably heightened competitive pressures within the industry, placing mounting challenges on SOEs seeking to engage in elderly care services.

At the same time, the industry is characterized by long investment payback periods and relatively low profit margins. Although the cash flows generated from investments are generally stable, the prolonged payback period and low average return on investment (ROI) in the industry impose considerable financial pressure on SOEs operating in elderly care services.

4.2. Underutilized effective market demand

Compared with Western countries, population aging in China is gradually shifting from “aging before affluence” to “aging while becoming affluent.” As of 2023, there were 132 countries and regions worldwide that had entered an aging society, among which 62.1% had a per capita Gross National Income (GNI) exceeding USD 14,000. In contrast, China’s per capita GNI stood at USD 13,400 ^[4].

Although China’s per capita income has increased significantly from USD 7,900 in 2015, the elderly population’s asset ownership in China remains at a lower-middle level globally ^[5]. According to a survey released by the People’s Bank of China in 2024, elderly individuals aged 65 and above nationwide owned elderly-related assets equivalent to approximately 5.2% of the country’s total disposable income ^[6]. While this represents a substantial increase from the 2% recorded in 2015, it remains considerably lower than that of high-income countries. For example, in the United States, the population aged 55 and above holds about 70% of the nation’s disposable income.

From the perspectives of elderly care support sources and demographic structure, currently, 42% of China’s elderly aged 65 and above rely on family support, and 35% depend on public pensions and subsistence allowances to maintain their basic livelihoods. Meanwhile, the number of high-age, disabled, and chronically ill elderly individuals continues to rise. The population aged 80 and above has exceeded 35 million, and disabled elderly individuals are estimated to be around 35 million ^[7–8]. These groups remain in urgent need of basic, welfare-oriented elderly care services.

In summary, although China has a large elderly population, the relatively low per capita income and limited asset ownership among the elderly mean that a significant proportion still depend on home-based care and publicly funded welfare elderly care institutions. As a result, the effective demand within the elderly care service market is far smaller than the potential demand. This also means that SOEs participating in the development of elderly care services face the same challenges commonly encountered by other specialized elderly care providers, such as shortages in client resources and high housing vacancy rates.

4.3. Inadequate industry regulations

At present, China’s elderly care service industry remains in its early stages, with blurred boundaries between elderly care as a welfare service and as a market-oriented industry. Previously established regulations designed for managing welfare-oriented elderly care have been applied to the market-driven elderly care service sector, leading to regulatory misalignment.

Additionally, some of the newly established regulatory frameworks for the elderly care service industry are

overly general and lack detailed, systematic implementation guidelines, resulting in regulatory gaps. For instance, there are currently no comprehensive or stringent regulatory measures in place to effectively prevent the abuse of elderly residents by care staff—a major concern for both seniors and their families. This regulatory shortfall often leads to serious legal disputes, exposing SOEs involved in the elderly care sector to a range of potential operational safety and legal risks.

5. Suggestion for SOE participation in the elderly care service industry

Based on the above analysis, it can be seen that SOEs participating in the development of the elderly care service industry not only have favorable market and policy opportunities as well as internal advantages, but also face challenges such as industry competition and inadequate regulations. Against this backdrop, the study further proposes strategic choices for SOEs to participate in the elderly care service industry from three aspects: their own CSR, business development, and resource allocation.

5.1. Participating in the elderly care service industry development as a new CSR approach for SOEs

With the implementation of the national strategy for actively responding to population aging, participating in the development of the elderly care service industry—which carries certain public welfare attributes—has emerged as a new strategic pathway for SOEs to actively respond to the national strategy and fulfill their CSR obligations. In June 2024, the State Council and SASAC issued the *Guidelines on High-Standard CSR Performance by Central Enterprises in the New Era*, which define the basic connotation of high-standard CSR for central enterprises. Notably, for the first time, the guidelines identify “caring for the development of aging-related causes” as a core component under the dimension of “enhancing the ability to contribute to the well-being of the people”, thereby opening up a new avenue for SOEs to fulfill their CSR responsibilities ^[9].

5.2. Participating in the elderly care service industry development as a core path for SOEs to promote industrial synergy

The core business operations of SOEs in sectors such as commercial insurance, tourism, and pharmaceuticals exhibit strong industrial linkages or significant product complementarities with the elderly care service industry. By participating in the development of elderly care services, SOEs in these industries can foster industrial synergy between their main businesses and the elderly care sector. This not only helps cultivate new growth points for future corporate development but also generates synergistic effects and facilitates positive interactions across sectors.

5.3. Participating in the elderly care service industry development as an important approach for SOEs to utilize and optimize resource allocation

Due to the relatively low investment and technical thresholds in the elderly care service industry, coupled with support from national policies, it is easy to connect with the aforementioned idle hardware and human resources of SOEs. Therefore, repurposing the idle resources of SOEs for the development of the elderly care service industry can not only reduce the operational burden on SOEs but also save land costs and infrastructure construction costs for launching elderly care services, further improving the efficiency of resource utilization and allocation of SOEs.

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The authors declare no conflict of interest.

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Practice and Prospect of Group Standard for Innovation and Transformation of Medical Equipment

Bo Xu*

China Medical Education Association, Beijing 100071, China

**Author to whom correspondence should be addressed.*

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Abstract: The importance of group standards is becoming increasingly evident. These standards are developed and released by groups following their own established procedures, intended for voluntary adoption by group members or the public. In the field of medical equipment innovation and transformation, group standards play a crucial role in multiple aspects. They provide unified technical specifications and operational procedures, clearly defining quality requirements and evaluation criteria at each stage, which helps reduce the randomness in R&D and enhances the efficiency of transformation. They also facilitate communication and collaboration among industry, academia, research, and application sectors, enabling scientific research institutions, medical facilities, and enterprises to share resources and complement each other's strengths within a common standard framework, thus accelerating the transition of innovative outcomes from the laboratory to the market. By establishing group standards, the healthy development of the industry can be guided, market order can be standardized, and the overall quality and international competitiveness of China's medical equipment products can be enhanced, promoting China's transition from a major player to a leader in medical equipment manufacturing. Through an in-depth exploration of the practical applications and development trends of group standards in the innovation and transformation of medical equipment, researchers can better understand the intrinsic connections and mechanisms between group standards and the innovation and transformation of medical equipment, providing new perspectives and theoretical foundations for future research, and enriching the theoretical framework in this field.

Keywords: Medical equipment innovation and transformation group standard; Medical device; Prospect

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1. Introduction

Medical equipment, as a vital material foundation for healthcare, directly impacts the quality and efficiency of medical services and is closely tied to public health. Globally, the medical equipment industry is undergoing rapid transformation and development^[1]. With the continuous advancement of technology, such as artificial

intelligence, big data, and the Internet of Things (IoT), these emerging technologies are deeply integrated with medical equipment, presenting unprecedented opportunities for innovation. From early simple devices like stethoscopes and thermometers to today's advanced medical imaging equipment and intelligent surgical robots, the variety and functionality of medical equipment have significantly expanded, playing a crucial role in disease diagnosis, treatment, and rehabilitation ^[2].

Innovation and transformation are the core drivers of the continuous development of the medical equipment industry. Only by continuously converting scientific research into practical medical equipment can people meet the growing clinical needs and enhance the quality of medical services. However, the process of innovation and transformation in medical equipment faces numerous challenges ^[3]. Research and development involve the interdisciplinary fields of medicine, engineering, and materials science, which are highly technical. The entire transformation cycle, from laboratory research to clinical trials and market promotion, is long and costly. Additionally, it must comply with stringent regulatory oversight and navigate a complex market environment. According to relevant studies, the rate of converting scientific research into practical applications in China's medical equipment sector still needs improvement. Many innovative technologies and products have not been effectively converted into practical productivity, which, to some extent, hinders the development of China's medical equipment industry ^[4].

2. Challenges faced by group standards for innovation and transformation of medical equipment

2.1. Technical challenges

The innovation and transformation of medical equipment group standards face many severe challenges at the technical level, which profoundly affect the formulation and implementation of group standards and restrict the development of the medical equipment industry ^[5].

The rapid speed of medical equipment technology development brings new challenges to group standards. With the rapid development of artificial intelligence, big data, Internet of Things, and 3D printing technologies, a series of new medical devices can work better and provide richer performance. For example, using AI technology can quickly analyze huge amounts of medical images and give doctors correct diagnostic suggestions, which can greatly improve the efficiency and accuracy of diagnosis. Using 3D printing technology can customize some special medical devices according to the characteristics of the disease for patients ^[6]. However, the appearance of this kind of new technology makes it difficult for existing group standards to keep up with the pace of technological innovation; that is, in the process of standard setting (which involves scientific research and draft writing, solicitation of opinions, review, etc.), after consuming time, the emergence of the next generation of products may already be completed by technological updates, so there will be a phenomenon of delayed technology or even lagging behind. If timely and effective standards cannot be formed at the stage of medical equipment innovation and transformation, it will inevitably affect the efficiency and quality of innovation and transformation, resulting in phenomena such as product quality not being stable and technical connection problems. By the time the standards are finalized, new technological advancements may have already occurred, causing the standards to lag behind the latest developments ^[7]. This lack of timely and effective standards during the innovation and transformation of medical equipment can lead to issues such as product quality instability and poor technical compatibility, thereby affecting the efficiency and quality of

innovation and transformation.

The innovation and transformation of medical equipment involve the integration of multiple disciplines, where technical languages and ways of thinking differ across disciplines, posing challenges for communication and coordination in the development of group standards. Medical equipment technology innovation transformation is an integration project of multiple disciplines, but because technical languages and ideas are different between each discipline, it becomes an obstacle to inter-disciplinary communication and coordination when formulating group standards. Medical equipment R&D involves various disciplines such as medicine, engineering, materials science, and electronic information technology. In the field of medicine, it mainly discusses how to solve clinical needs and treatment results; engineers emphasize product design, manufacturing processes, and performance; material science aims to find new materials that meet the special requirements of medical equipment; electronic information technology focuses on providing related technical support for the intelligence and informatization of medical equipment. When formulating group standards, it should take into account the needs and technical characteristics of each professional subject and strive to achieve smooth cooperation and coordination among them. Due to the differences in professional terms, technical standards, and research methods, it is easy to cause misunderstandings and deviations during interprofessional communication and coordination. During the standard-setting process for intelligent medical devices, medical experts and engineering technicians may have different opinions on functional requirements and performance indicators of intelligent medical devices. That is, medical experts tend to focus more on its effect in diagnosing and treating diseases, while engineering technicians focus more on its technological realization and stability^[8]. Therefore, disagreements and disputes often occur during the process of setting group standards, making it more complicated^[8].

As shown in **Figure 1**, the average time spent on each stage of the group standard development process is relatively long, further exacerbating the issue of standards lagging behind technological advancements^[9].

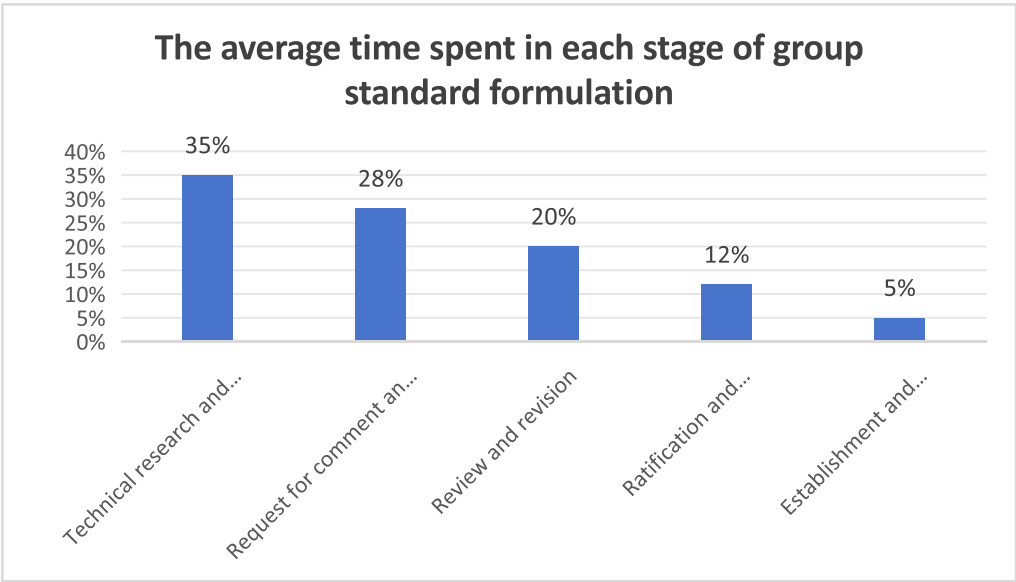


Figure 1. The average time spent in each stage of group standard formulation. Source of data: The data is derived from the analysis of the development cycle of 182 medical-related group standards in the “China Group Standardization Development Report (2023).”

2.2. Talent challenges

Talent shortage: It is one of the main factors restricting the process of innovation transformation and the group standard construction of medical equipment. It restricts the innovative ability, quickness, and effective construction and implementation of group standards in aspects of the medical equipment industry ^[10].

Innovation transformation of medical equipment and its group standard construction needs compound talents with possession of medical technique as well as standardization, but such kind of talents are few at present. The involved content scope between medical equipment field is wide, not only require comprehensive strength to be mastered, but also belong to multi-discipline techniques (such as medicine, engineering, materials), which limits high-efficiency cooperation among society according to industry, academy, research and application, then it restricts the promoting and popularizing degree of the group standards while the medical equipment innovating and transforming ^[11]. Professionals must have a solid foundation in their field and possess interdisciplinary, comprehensive qualities. Standardization work has its unique requirements, necessitating familiarity with the processes, methods, and norms of standard setting, as well as strong communication and coordination skills and effective written expression. They must accurately understand industry needs and develop scientific, reasonable, and practical standards. Cultivating such versatile professionals, who are proficient in both medical equipment technology and standardization, is challenging. Universities and vocational education institutions lag behind in setting up relevant majors and talent cultivation models, making it difficult to meet the market's urgent demand for such talents ^[12].

In the process of medical equipment innovation and transformation, the collaboration among enterprises, research institutions, and medical facilities is becoming increasingly close. This requires individuals with cross-disciplinary knowledge and communication skills to facilitate collaboration among all parties. In medical-engineering projects, it is essential for professionals to understand the distinct ways of thinking and technical languages in both medicine and engineering, building a bridge for effective communication between the two fields to ensure the smooth progress of the project ^[13]. However, such cross-disciplinary talents are still scarce. Due to the significant differences in professional knowledge and working environments across different fields, professionals face numerous challenges and difficulties in developing across disciplines, leading to a limited number of individuals who can play a coordinating role in the innovation and transformation of medical equipment. This affects the efficiency and effectiveness of cooperation among industry, academia, research, and application, thereby hindering the promotion and application of group standards in the innovation and transformation of medical equipment ^[14].

2.3. Market-level challenges

Firstly, from the perspective of the market, there are many serious challenges in the promotion and application of medical equipment innovation and transformation group standards, which affect the effective performance of group standards in the development of the medical equipment industry. There is fierce competition between companies in the field of medical equipment, so it is difficult to promote and apply group standards. Under such circumstances, some enterprises constantly produce and sell new products and services to seize more market shares, resulting in a severe situation of product homogenization in the market ^[15]. These enterprises may chase short-term benefits instead of emphasizing the importance of group standards, so they may use inferior production processes and technology under the guise of reducing costs and increasing price competitiveness.

This has caused inconsistent product quality in different manufacturers' medical devices, which affects the effectiveness and credibility of medical equipment innovation and transformation group standards. It also reduces the possibility of enterprises adopting these group standards widely, making the medical equipment innovation and transformation group standards unfeasible to promote effectively among most manufacturers. Therefore, at present, some problems still exist in promoting and applying group standards in the highly competitive medical equipment market environment.

Secondly, the issue of intellectual property protection has a huge impact on the development of medical equipment innovation and transformation group standards. The achievement of medical equipment innovation usually requires consuming much human, material, financial, and technological strength, etc., and the problem of protecting medical equipment patents has always been an important focus. At the same time, in view of the current weak protection situation of intellectual property rights in the field of medical equipment in the country, various types of infringement events often occur. For example, when companies produce and sell medical devices, some illegal operators will use other companies' patent techniques and technical secrets without authorization; In addition, imitation design and counterfeiting of product appearance by some people have seriously violated the legal interests of innovative companies^[16]. When the legitimate and normal business activities of innovative enterprises suffer heavy damage, people generally think that this is not only a violation of laws and regulations, but also an unreasonable infringement of social morality and corporate ethics. Under such circumstances, medical equipment innovation enterprises may not dare to innovate again after being damaged, and therefore they will definitely not pay attention to the group standards during subsequent product production and manufacturing processes, thus failing to effectively achieve the purpose of improving the core competitiveness of domestic related enterprises and cultivating key brand in the specific field of medical equipment through innovation and transformation group standards.

Thirdly, some low-level product producers or suppliers in the medical equipment innovation chain do not strictly follow the group standards of raw materials, parts, etc., for production and manufacturing, because of the purpose of occupying more of the relatively mature mid-low-end medical equipment market space, in order to gain more profit or cost advantages in the competition of price. Such behaviors make some products that comply with the standard lose the stable growth space in the mid-low-end medical equipment market and increase the safety hazard risks of patients using such products^[17].

2.4. Challenges at the level of cooperation

Firstly, the difficulty of the cooperation level restricts the realization and development of group standards in the process of medical equipment innovation transformation. The first problem to be solved is the medical engineering collaborative innovation discipline obstacle.

Collaborative innovation between medical institutions and industry is a key driver for the innovation and transformation of medical equipment. However, it currently faces numerous challenges. There is a lack of long-term and stable mechanisms for cooperation among medical institutions, research institutions, and enterprises. In practice, cooperation teams are often formed on a temporary basis for specific projects, and the partnership ends once the project concludes, making it difficult to establish a long-term and stable cooperation model^[18]. This short-term cooperation model results in a lack of deep communication and collaboration among all parties, hindering the full utilization of their respective strengths and the accumulation and inheritance of knowledge

and technology. In some medical equipment R&D projects, medical institutions only propose clinical needs at the initial stage of the project, with minimal subsequent involvement. Research institutions and enterprises lack clinical feedback during the R&D process, leading to a disconnect between the R&D outcomes and actual clinical needs, which affects the effectiveness of innovation transformation.

The unreasonable distribution of benefits is a significant factor hindering the collaborative innovation between medical professionals and engineers. In the process of innovating and transforming medical equipment, issues related to the distribution of interests, such as intellectual property rights and the benefits from scientific research achievements, arise. Because the mechanism of interest distribution is not scientific and reasonable, it is easy to disagree and conflict among all parties. On the one hand, research institutes and enterprises think that they have made great efforts in technology development and product transformation, so they should receive a large proportion of the benefits; on the other hand, medical institutions think that they have brought clinical needs and applications, so they should receive a huge part of the benefits. The problem of dividing the interests between the two sides may cause the breakdown of the cooperative relationship, which affects the smooth progress of innovation transformation. In a certain medical equipment R&D project, due to the failure to agree on the ownership of intellectual property rights and the sharing of benefits, the cooperating parties are in a deadlock, and the project progresses slowly, which seriously affects the transformation and application of innovative results. At the same time, there are also some obstacles to be solved in terms of interdisciplinary collaboration in the whole process of group standard construction in the process of medical equipment innovation transformation, because medical equipment innovation involves various disciplines such as medicine, engineering, materials, computer, etc., with significant barriers between disciplines. Different research methods, thinking modes, and professional terminologies make it difficult for members of different disciplines to communicate and share information. When discussing device design, medical experts pay more attention to clinical effect and safety, while engineering technicians focus on its technical implementation and performance indicators, which may cause a balance of design plans between clinical needs and technical feasibility, affecting the quality of products and competitiveness in the market. At the same time, when facing interdisciplinary project team building and management, the challenge of cross-disciplinary composition makes it difficult for members of the team from different academic background and professional categories to adapt to each other's working habits and value concepts, which poses challenges to team collaboration and management, and leads to the low efficiency of decision-making by members' opinion reaching consensus. During the execution of the project, the inability to coordinate and manage effectively causes the uncoordinated work advancement status and unreasonable task allocation of project participants, which hinders the normal project progress. A multi-disciplinary medical equipment innovation project was delayed, and the cost of multiple iterations and repeated trials was high due to poor team management, causing different members to be in charge of their own specialties without a sense of being one family, and repeated rework.

At the cooperation level, it is essential to establish a long-term and stable working mechanism of medical engineering innovative cooperation, define the rights and obligations of all parties, enhance interaction and connection, and promote each other's learning and technology exchange. A fair and reasonable profit distribution mechanism should be established, taking into account the contributions and investments of all parties, to ensure that the distribution is fair and reasonable, thereby stimulating the enthusiasm for cooperation among all parties. To overcome the barriers to interdisciplinary collaboration, efforts should be made to strengthen the training of interdisciplinary talents, improving the cross-disciplinary communication and

collaboration skills of team members. An effective team collaboration and management mechanism should also be established, with clear team goals and task assignments, enhancing internal coordination and communication within the team, and improving the team's work efficiency and innovation capabilities.

3. Development prospect of group standards for innovation and transformation of medical equipment

3.1. Trend of technological innovation and standard integration

In the era of rapid development of science and technology, the field of medical equipment is undergoing profound changes. Technological innovation presents diversified, intelligent, and integrated development directions, which also put forward new requirements and challenges for the innovation and transformation of group standards of medical equipment, and promote the deep integration of group standards and technological innovation.

The application of artificial intelligence (AI) and big data technology in medical equipment will become more profound and extensive. AI algorithms can swiftly analyze and process vast amounts of medical data, enabling early and precise disease diagnosis, the development of personalized treatment plans, and the intelligent maintenance of medical devices. In the field of medical imaging, AI technology can help doctors more accurately identify lesions in images, thereby improving the accuracy and efficiency of diagnoses. After integrating and mining different data, including patients' genetic information, clinical symptoms, and treatment experience, big data can achieve precision medicine by providing customized treatment suggestions for patients.

IoT technology and telemedicine technology will have a wide development prospect. The medical instrument is linked by IoT technology to collect and transmit the patient's physiognomic data in real-time. Doctors complete the diagnosis, treatment, and follow-up work of patients through online consultation platforms based on telemedicine technology; thus, the problem of time and space is solved, and people's access to medical care has been significantly improved. In particular, it makes great contributions to people living in remote areas and medical institutions at the grassroots level. Telemedicine technology enables these regions' patients to enjoy excellent medical service resources. At the same time, the novel application of biomaterials and 3D printing technology brings some surprises to the innovation of medical equipment. New kinds of biomaterials can increase the biomedical compatibility, stability, and practicability of medical devices. For example, some degradable biomaterials can be applied to medical equipment to avoid repeated operations when patients are implanted with the device again. At the same time, medical devices such as artificial limbs and implants made by 3D printing can be customized according to the specific circumstances of each patient, which can meet the personalized needs of patients more effectively, provide better medical treatment effects, and improve the quality of life of patients.

Therefore, people should further build the dynamic update mechanism of group standards, give full play to the monitoring and analysis role of technological innovation and market demand, revise and perfect the group standards in time, make timely supplements or changes according to the situation, so that the group standards can always keep up with the times. At the same time, encourage enterprises, scientific research institutes, medical institutions, and other units to take the lead in establishing group standards and updating them to promote the integrated development between technological innovation and group standards; strengthen international exchanges and cooperation, organize relevant personnel and professional experts to participate

actively in the formulation of related group standards and revision of international standards, study advanced foreign experiences and technologies, coordinate and solve problems existing in the implementation process, compare Chinese medicine equipment technological innovation and transformation group standards with corresponding international standards in time, make the two standards conform, thus improving the competitive ability of China's medical equipment product and occupying an important position in the international field, while taking full advantage of the country's medical equipment advantages and good achievements in technology innovation during standardization activity. Through participation in international standardization activities, China can integrate its achievements and advantages in medical equipment technology innovation into international standards, thereby increasing its influence and voice in the international medical equipment sector.

3.2. Talent training and team building strategy

The development of talent cultivation and team building is crucial for advancing the innovation, transformation, and standardization of medical equipment. To address the current issues of talent shortages, an unbalanced talent structure, and low team collaboration efficiency, it is essential to develop practical strategies to cultivate a high-quality, professional workforce and build highly collaborative, innovative teams.

In terms of talent cultivation goals and positioning, it is essential to clearly define the training of versatile talents who are proficient in medical equipment technology and familiar with standardization work, as well as collaborative innovation talents with cross-disciplinary knowledge and communication skills. Universities and vocational education institutions should optimize their professional settings and curriculum systems based on these goals. In terms of professional settings, they can offer majors or directions such as medical equipment standardization and medical-engineering integration innovation, providing students with systematic professional knowledge learning. In the construction of the curriculum system, emphasis should be placed on the setting of interdisciplinary courses, integrating knowledge from medicine, engineering, and standardization organically. Courses such as medical fundamentals, principles and design of medical devices, principles and methods of standardization, and medical-engineering collaboration practice should be offered, enabling students to acquire solid professional knowledge and develop interdisciplinary thinking and problem-solving skills.

In terms of practical skills training and internship mechanisms, it is essential to enhance practical teaching components to improve students' practical operational skills and problem-solving abilities. Universities and vocational education institutions should increase investment in practical teaching, building comprehensive laboratories and training bases equipped with advanced medical equipment and experimental devices, thus providing students with a conducive practical environment. The proportion of experimental courses should be increased to deepen students' understanding and mastery of theoretical knowledge through practical experience. Establishing internship partnerships with medical equipment companies and healthcare institutions can provide students with a wealth of internship opportunities. Through internships, students can gain insights into the industry's actual needs and development trends, apply their knowledge to real-world work, accumulate practical experience, and enhance their employability.

Introduce talents and encourage mechanisms. Actively introduce first-class talents in the fields of medical equipment technology and standards from home and abroad as well as some excellent talents in the company system itself, improve the benefits and incentives of their salaries and treatment; construct a relatively perfect

employment (work) atmosphere and career development channel to attract high-quality talents, play the advantages of talent in enterprises to the fullest, create conditions for the retention of professional talents needed by the cause and those with room for development. Officials should also accelerate the construction of their own stock of talents, set up talent training projects, improve various talent incentive measures, focus on motivating scientific and technological workers' enthusiasm for creating new achievements in the field of medical instruments, actively promoting the transformation and promotion of scientific research results, stimulating the creation ability and innovation awareness of group standards, doing more important work, creating good conditions, fully mobilizing enthusiasm, and giving certain material rewards such as Science and Technology Innovation Award and Standard Contribution Award to people who make significant achievements in technology or formulating standards.

3.3. Market expansion and international cooperation prospects

The third one is to promote group standards in depth on the domestic market for the deep development of medical equipment innovation and transformation, and make general and specific plans.

Actively participate in the formulation of international standards, making China's voice and influence more colorful and powerful in the competition of the international medical equipment market. With the rapid development of China's medical equipment industry, China's technological innovation ability and product quality level have significantly improved, and it has reached a certain level to formulate related industry standards. Actively participate in related standard organizations such as ISO and IEC, so that domestic experts in various aspects such as medical equipment and standards can attend foreign expert meetings to draft and revise related medical device industry standards, input more innovative ideas from the country, incorporate Chinese techniques and advantages, typical cases and practical experience into related medical engineering products, and contribute solutions and suggestions on the content and structure of the standard in different ways to fully consider China's strength. When proposing artificial intelligence standards for the first time during the process of forming health standards, let the proposed international standards reflect China's research results in this direction, China's own practices in this regard should play an important guiding role when proposing related artificial intelligence standard technologies, so as to gain more say in foreign standardization work in the field of medical devices, help Chinese companies achieve a prominent international position in foreign standardization in the artificial intelligence direction of medical devices by introducing China's development trends in terms of technology, application, product research, etc., promoting the export rate and utilization efficiency of China's products at home and abroad, increase its representation in relevant national standard formation negotiations with a greater proportion of domestic experts in the artificial intelligence healthcare industry than before, improve the ability of the domestic medical device industry represented by Chinese companies to lead or control global standards formation to some extent, and also help promote China's medical device industry to make full use of its strong scientific achievements in medicine, advanced research in many new branches and other factors and the relatively comprehensive existing domestic theoretical research foundations to better exert itself on the medical standards formation stage platform among the world's leading developed countries under the conditions where the era's economy is developing along a path mainly dominated by economic trade liberalization trends, so that more advanced domestic research ideas can be reflected in the development direction of human life in all directions and professional industries around the globe through

foreign standard organizations formed for discussion, thereby enhancing its power in guiding future major directions of similar standard-related matters at multiple stages and in numerous fields ^[19].

3.4. Improvement of policy support and guarantee mechanism

Policies supported, more policy support for the group of medical equipment innovation and transformation to transform into form a group of standards; improving the guarantee mechanism is key. The improvement in depth of relevant policies such as finance: Establish a special fund, subsidy and reward the related enterprises or research institutes are actively engaged in the formation and practice of the group of standards with special funds, reward according to the enterprise's group standard leading in the field situation and other situations, important and influential on the group issued standards, encourage the leader issued group standard issued by the enterprise, encourages the enterprise to play an active role in developing the group standard, transforming existing products based on forming the group of standards, reducing the innovative cost for research and development expense subsidies to purchase the equipment of the enterprise for producing medical equipment conforming to the group standard, reduced pressure from the aspects of value-added tax and corporation income tax of enterprise innovating conversion equipment, accelerated depreciation amount in conformity with the law with purchasing the equipment (to conduct the research produced medical equipment), meets with the group standard. Enterprises purchasing equipment for research and production of medical equipment that meets group standards should be allowed to accelerate depreciation, enhancing the efficiency of capital utilization ^[20].

Strengthening the protection of intellectual property rights is also a crucial aspect of improving the safeguard mechanisms. Enhance the legal framework for intellectual property, and increase the protection of intellectual property rights for innovations in medical equipment. Clarify the ownership and distribution of intellectual property rights for these innovations, encourage innovation entities to actively apply for patents, trademarks, and other intellectual property rights, and crack down on infringement to raise the cost of such acts. Establish a rapid response mechanism for intellectual property rights to shorten the time required for rights protection and reduce costs, thereby creating a favorable environment for the innovation and commercialization of medical equipment.

Strengthen the construction of the intellectual property service system to offer comprehensive services, including consultation, agency, and evaluation, for enterprises. Establish an intellectual property information platform to timely release information on intellectual property in the medical equipment sector, providing a reference for enterprise innovation and standard setting. Encouraging knowledge property service institute provides intellectual property. Special service promoting medical equipment helps the enterprise better manage and use knowledge property. Promote the transfer application medical equipment and innovative achievements. As shown in **Figure 2**, China's contribution to international standards for major medical equipment remains relatively low, and active participation in the formulation of international standards is a key path to enhancing its voice.

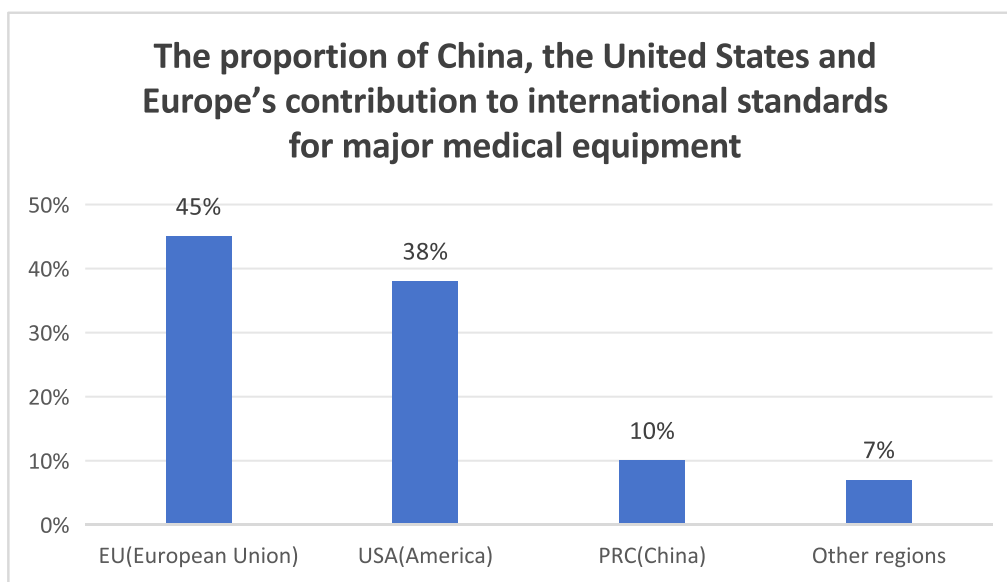


Figure 2. The proportion of China, the United States, and Europe's contribution to international standards for major medical equipment. Data source description: Contribution ratio is calculated by analyzing indicators such as standard proposals, working group conveners, and editorial staff numbers from ISO and IEC technical committees related to medical devices. The data is compiled from ISO Annual Reports, IEC Annual Reports, and analyses conducted by Tsinghua University's Standardization Research Base.

4. Conclusion

In summary, this paper makes a theoretical exploration of group standards in medical equipment innovation transformation, studies case analysis, the current situation, and difficulties. Through researching the related standards of group standards in the field of transformation of medical equipment innovation process — when introducing new products from the technical research index to the standardization of the clinical department trial process during the production process — inspecting product quality, setting evaluation requirements, the whole innovation activity is carried out according to regulations. So it not only improved efficiency and quality in transforming innovation results, promoted different parties such as medical units, scientific research institutions, enterprises with cooperative innovation to conform to the internal process between them, but also easy to coordinate between organizations; convenient for external cooperation among various departments, and accelerated the transition of innovation achievements from laboratory to clinics. In addition, the introduction of group standards provides a good foundation for supervisory authorities to regulate the order of the medical instruments market, which can effectively protect the interests of consumers and promote the orderly development of the medical instruments industry.

Disclosure statement

The author declares no conflict of interest.

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A Brief Analysis of the Characteristics of Interpretation Text of the Speech of Minister for Foreign Affairs of China at China-CELAC Forum

Zhangjun Lian*, Wanting Han

College of Humanities and Foreign Languages, Xi'an University of Science and Technology, Xi'an 710054, China

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Abstract: With the continuous improvement of China's international status, Chinese leaders often deliver speeches on some important international occasions. The English translation of diplomatic speech concerns the interests and honor of China, so the role of interpretation for diplomatic speech in this process is very important. Taking foreign minister's speech at the plenary session of the Fourth Ministerial Meeting of China-CELAC Forum as the research object, this study analyzes the characteristics of the speech in three aspects: syntactic choice, choice for figure of speech and the use of metaphor from the perspective of interpretation text, and repeatedly compares it with the speeches of previous leaders, trying to summarize the overall style of diplomatic discourse, so as to provide reference translation strategies for interpreters' real-time interpretation.

Keywords: Diplomatic speech; Diplomatic interpretation; Figure of speech; Metaphor; Translation strategies

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1. Introduction

As China plays an increasingly important role on the international stage, the speeches made by Chinese leaders at some significant international occasions have drawn more and more attention from people both at home and abroad. The English translation of these speeches plays a crucial role in promoting the image and culture of a country and facilitating the understanding of China by overseas people. Diplomatic translation has two important characteristics: first, the audience often comes from different countries and areas, with significant differences in language habits and cultural backgrounds; second, the content to be translated is highly political and has a high degree of political sensitivity. Accurate translation can effectively convey the speaker's thoughts, thereby enhancing relations between countries and bolstering interaction and mutual understanding among countries. On the contrary, if there are errors in the translation, the country's image will be damaged, and national interests will be greatly compromised.

Leaders' speeches are aimed at the global audience and represent an important way for a country's culture to

go global. Translation is a conversion activity between different languages. In essence, it is also a cross-cultural communication activity. Therefore, the purpose of translation is to promote the exchange of thoughts and enhance cultural communication. As a medium of cross-cultural communication, translation not only reflects cultural soft power but also helps to enhance such power when it done well ^[1].

In the contemporary era, when translating Chinese into foreign languages, translation shall “reposition” the global culture with a positive attitude, so that Chinese culture can truly stand among the cultures of all countries in the world ^[2]. Under this goal, translators shoulder the mission of cross-cultural communication, promote Chinese culture to go out, and ultimately realize the common prosperity of Chinese culture and all cultures in the world.

Based on this, this study attempts to analyze foreign minister’s speech at China-CELAC Forum from the perspective of interpretation text, and deeply analyze the composition mode of diplomatic discourse from three aspects: the syntactic choice of sentences, the rhetorical choice of passages, and the use of metaphor. The leader’s speech is not a simple pile of information, but a set of well-designed strategic narrative system. It builds China’s image as a responsible power through multiple discourse strategies, and clearly conveys the strategic positioning of China-LAC relations to the world.

2. Syntactic selection and effect analysis

Syntactic rhetoric refers to the rhetorical activity of choosing sentence patterns based on specific expression needs when elaborating a certain meaning, using the sentence as the grammatical unit, so as to achieve the communication purpose and expression effect ^[3]. The research corpus of this study is the speech manuscripts of Chinese leaders. As a speech manuscript, the first requirement is to enable the audience to understand and clearly hear the main idea the speaker wants to convey. Therefore, the selection of sentence pattern and syntactic rhetoric are important aspects. Good expression not only enables the audience to understand the real meaning the speaker wants to convey, but also makes the listener willing to listen, transforming from passive listening to active listening. Through the analysis of this speech manuscript (foreign minister’s speech at China-CELAC Forum), it can be found that it has the following characteristics in terms of syntactic rhetoric:

2.1. Integration of long and short sentences—concise and vivid expression

A long sentence refers to one with a large number of words and a complex structure ^[3]. From the definition, it is not difficult to find that scholars define long sentences based on the number of words and the complexity of the structure, rather than from the perspective of grammatical nature. Therefore, the grammatical nature of a long sentence can be either a simple sentence or a complex sentence. The so-called “many words” and “complex structure” in the definition mainly result from the abundance of modifying and parallel components and the complexity of the structural level. It is precisely because of these characteristics that long sentences are rich in meaning, logically rigorous, and capable of containing a large amount of discourse information ^[4]. The concept of a short sentence is the opposite of a long sentence, referring to a sentence with few words and a simple structure. Its main features are simple structure, clear meaning, conciseness, and directness. Both have their own strengths, and the characteristic presented in the corpus is the alternating of long and short sentences. Such a choice of sentence structure combines the rhetorical advantages of both long and short sentences, making the expression more vivid and clear. It avoids the shortcomings of using only short sentences, such as limited expression capacity and incomplete sentence meaning, as well as the drawbacks of using only long sentences, such as being lengthy, cumbersome, and stiff.

Example 1: **Firmly support each other's core interests.** Latin America is the common home of LAC people, not the backyard of any country. China firmly supports LAC countries in safeguarding independence, unity and self-improvement, exploring a modernization path suitable for their own national conditions, and opposing power politics and interference in internal affairs. Internal affairs concern China's national sovereignty and territorial integrity. We hope and believe that the LAC side will continue to firmly adhere to "one China policy" and support China's legitimate position.

At the beginning of Example 1, a short sentence was used to explain the main idea that China and LAC should firmly support each other's core interests. Then, a long sentence was used to express in detail how to uphold each other's core interests. China firmly supports LAC countries in safeguarding independence, solidarity, and self-improvement, and provides assistance to the best of its ability. LAC side always adheres to "One China Principle" and supports China's legitimate position on major issues. Through the analysis of long and short sentences in the speech manuscript, it is not difficult to see that the vast majority of the ways in which long and short sentences are used in combination are to first use a short sentence to point out the main idea, and then use a long sentence to elaborate in detail around the short sentence that points out the main idea earlier. This kind of expression with both detailed and simplified elements not only avoid the lengthy and complex sentences caused by too many long sentences with unclear meanings, but also overcomes the drawbacks of short sentences clustering together with insufficient details, and rigid and lifeless expressions. It makes the entire speech with clear main point both vivid, rhythmic, and appropriate in detail and conciseness.

2.2. Complete and loose sentences appear alternately—express flexibly and rhythmically

The complete sentence refers to the following: first, the structure should be the same or similar; second, the sentences have opposite levels and oblique tones, but this is not a necessary point; third, the number of characters in sentences should be equal. The overall impression of a complete sentence is uniformity and neatness, giving people a sense of rhythm when reading. In contrast, the structure of a loose sentence is not uniform, its sentence structure is flexible, and there is no limit on the number of characters. Through the definition of a complete sentence, it is not difficult to find that a complete sentence is also a rhetorical method with strong beauty in form, giving people a sense of neatness and symmetry visually and a sense of rising and falling in cadence ^[5]. The rhetorical effect of loose sentences is to give the speech with a lively and flexible beauty, and they can be used to elaborate on parts that require detailed description. The alternating use of complete and loose sentences makes the language expression contain loose feature in complete structure, with a loose form but coherent meaning. By integrating the rhetorical effects of complete and loose sentences, the entire expression not only becomes more flexible and vivid with a sense of rhythm and neatness, but also enhances the coherence of the sentence momentum ^[6].

Example 2: China and LAC are thousands of miles apart, and what connects us? It is not a geopolitical game, nor a game of major power rivalry, but a common adherence to fairness and justice, and a common pursuit of modernization. China-LAC cooperation rejects camp confrontation and advocates openness and win-win results, setting a new model for building a new type of international relations and providing new impetus for the Global South cooperation.

Example 3: This morning, the president delivered an important speech at the opening ceremony of this meeting, stressing that China is willing to work with LAC side to launch five major projects, seek common development and revitalization, and jointly build a China-LAC community with shared future.

The combination of complete and loose sentences in this way makes the entire sentence both easy to read

and flexible and vivid. In Example 2, “not a geopolitical game”, “nor a game of major power rivalry”, and “a common adherence to fairness and justice”, “a common pursuit of modernization” are respectively similar structures. This combination conveys the close and intimate relationship between China and LAC to the audience clearly. At the same time, it also endows the speech with a strong rhythm, making it powerful when read and cadenced when heard. In Example 3, “seek common development and revitalization” and “jointly build a China-LAC community with shared future” are similar structures. This combination that are paired and related in meaning makes the entire sentence coherent in momentum and profound in meaning. It not only has the neat and uniform beauty of complete sentences, but also the flexible and vivid dynamic of loose sentences. While achieving the rhetorical effect of being reasonably detailed and appropriately balanced in complexity and simplicity, it also endows the speech with a symmetrical rhythm, expressing China’s vision of jointly building a bright future and working together for development and rejuvenation with LAC.

In leaders’ speeches, the collocation of complete and loose sentences is common, which is a frequently used rhetorical method. Such collocation makes the sentences coherent, rhythmic and expressive, and plays an important role in forming the unique rhetorical style of China’s diplomatic discourse text.

3. Application and effect analysis of figure of speech

This article mainly employs the rhetorical device of parallelism. Parallelism refers to the arrangement of three or more language units, which can be phrases, sentences or paragraphs ^[7]. To further define parallelism, first, structurally, the structures of the parallel items shall be similar or identical; second, semantically, the meanings of the parallel items shall be close or related; third, in terms of tone, the tones of the parallel items shall be consistent or the same ^[3].

Example 4: In today’s world, the trend of world multipolarization and economic globalization is rolling forward. However, some great countries believe in the supremacy of power and the priority of their own countries, try to replace international rules with the law of the jungle, replace the multilateral system with unilateral hegemony, and bully other countries with tariffs as weapons. These practices violate the legitimate rights and interests of all countries in the world, including China and LAC countries, damage the rule-based multilateral trading system, and also impact the stability of the global political and economic order.

In example 4, the three “verb.+noun.+with...” parallel items appear continuously without any other language materials in the middle, which together form a continuous parallel block, emphasizing that some countries in the world are implementing hegemonism and power politics, which has seriously endangered the legitimate rights and interests of surrounding countries. On the whole, the parallel items composed of sentences has a strong sense of rhythm, which not only reflects the logical rigor and thoughtfulness of the political speech, the objectivity and fairness of the political speech, but also enhances the acceptability of the audience and the rhythmic sense of the speech itself.

Example 5: China is willing to cooperate closely with LAC side in various fields under the framework of “the Belt and Road Initiative” and Global Development Initiative to improve the level of interconnectivity and maintain the stability of the industrial and supply chains.

In this example, the three phrases “cooperate closely with LAC side in various fields”, “improve the level of interconnectivity” and “maintain the stability of the industrial and supply chains” form a group of phrase parallelism, which act as objects in the whole sentence and directly express China’s future development

arrangements. This makes the sentences cadenced, the phonological structure smooth, and the overall sense of language rhythm strengthened. It emphasizes that China and LAC side will strengthen practical cooperation in economic and trade aspects, and make it easy for the audience to receive the core information while reading it catchy.

4. Application and effect analysis of metaphor

Metaphor is not only a cognitive mechanism of human beings but also a conscious choice of discourse by the speaker, which can help build social relations and social identities ^[8]. Politicians often need to adopt certain discourse strategies when constructing national identities, and metaphor, as a diplomatic discourse strategy, can influence people's thinking, reshape people's attitudes, and even help reorganize the reality to form the conceptual structure expected by the speaker ^[9], thereby achieving the construction of national identity and strengthening the audience's identity of the discourse country ^[10]. This article intends to explore the construction of national identity by leaders in the speech at China-CELAC Forum from the perspective of metaphor analysis.

The main metaphor categories include building, journey, personification, transportation, sports, physical environment, plants, conflicts, etc.^[11] the first three categories appear most frequently in speeches. The following is a further analysis

4.1. Metaphor of building

The building domain is a very important primitive domain, which conceptualizes the abstract and complex system in our daily experience by characterizing things and events such as theory, outlook, career and relationship as things related to building in various discourses ^[3]. The forward-looking building metaphor in political discourse usually has a strong positive connotation. And politicians apply this metaphor to expound the national development strategy, express their desire for a valuable social goal, imply the development in a certain direction, and indicate that people need to work together to achieve this goal.

Example 6: LAC leaders also made important statements and formed broad consensus. This has drawn a blueprint for the long-term future of China-LAC relations and provided strategic guidance. China is willing to work with LAC side to jointly implement the relevant agreements.

Example 7: China will implement a series of measures announced by President, continue to strengthen civilized dialogue with LAC side, expand exchanges with universities, think tanks, media and local governments, continue to hold China-LAC Region People-to-People Friendship Forum and local government cooperation forums, transcend cultural barriers and conflicts through exchanges and mutual learning of civilization, and constantly consolidate the public opinion foundation for China-LAC friendship.

Example 8: The two sides actively promoted the in-depth docking of "the Belt and Road Initiative" with the development strategy of LAC side. Chancay Port, large industrial parks and other major projects were completed one after another, and new cooperation in new energy, photovoltaic, electric vehicles, digital technology, cross-border e-commerce and other fields flourished.

In the speech, the speaker projected the original domain of building into the target domain, and introduced some concepts of "blueprint", "consolidate", "complete", etc., to symbolize the development process of China-LAC relations with the architectural process and related things. On the one hand, the use of keywords such as "blueprint", "consolidate", "complete" can reflect the macro overview of the development of China-LAC

relations in the minds of the audience through people's intuitive understanding of building, and show the audience the necessity and importance of maintaining the sound relationship between the two sides, which is conducive to audience to understand China's foreign policy; On the other hand, just as the construction of buildings requires the builders to work together and build a solid foundation step by step, the development of diplomatic relations also requires all departments to work together to build a "relationship building". Reflecting the construction process such as "construction" and "building" to the dynamic process of the development of diplomatic relations is precisely to convey such a message to audiences all over the world.

In general, the speech of Chinese leaders at China-CELAC Forum is committed to conveying the concept of friendship between China and its neighbors to the world, and then shaping the national image of "relationship builder".

4.2. Metaphor of journey

In addition to building, metaphor of journey is also a metaphor often used by Chinese leaders to describe economic development ^[12].

Example 9: China-LAC science and technology partnership program, China-LAC cultural exchange year and other activities were successfully held, and the "LAC craze" in China and the "China craze" in LAC were rising simultaneously, with both sides reaching out to each other.

Example 10: China is willing to work with LAC to practice real multilateralism, adhere to extensive consultation, joint contribution, and shared benefits, lead the reform of global governance with the concept of fairness, justice, openness and inclusiveness, jointly safeguard the international system with the United Nations at the core and the international order based on international law, and continuously improve the representation and voice of developing countries.

Example 11: China firmly supports LAC countries in safeguarding independence, unity and self-improvement, exploring a modernization path suitable for their own national conditions, and opposing power politics and interference in internal affairs.

Under this metaphorical framework, the speech introduced the concepts related to the journey, such as "reaching out to each other", "work with... together", "path", and reflected the specific and familiar journey domain into the abstract and complex political domain. Among them, the "path" metaphor appears most frequently. China and western developed countries have chosen different development paths, which is a major difference between the two sides. Some developed countries use this as an excuse to give China all kinds of unfair treatment in international activities. However, it is for this reason that on some major international occasions, China has unswervingly reaffirmed Chinese political position, stressed that China adheres to the path of industrialization of scientific development and peaceful development suitable for its own national conditions, and has established an image of a great country with peace and development as its goal, cutting through the thorns and obstacles, and forging ahead bravely.

4.3. Metaphor of personification

Metaphor of personification refers to taking human themselves as the standard to measure things around them, and using it to perceive the world. Therefore, metaphor of personification has become an important tool for human beings to recognize things and express ideas ^[13].

Example 12: As developing countries and members of the Global South family, China and LAC shall work

together to safeguard our legitimate rights and interests.

In the above example sentence, when the speaker described China and LAC, in order to enhance the effect of language expression, the speaker used “family members” to refer to the status of China and LAC in the developing countries and the Global South by borrowing the human body system, expressing that the future development of China and LAC needs the support and shelter of the developing countries and the Global South.

5. Conclusion

The foreign minister’s speech at China-CELAC Forum and the corresponding interpretation practice are a vivid and profound presentation of the diplomatic discourse system of major country with Chinese characteristics. The study shows that the original text constructs a three-dimensional narrative through subtle sentence arrangement, rhetoric selection and the use of metaphor. When interpreting, the interpreter can grasp these core elements, strive to improve the comprehensibility and acceptance of the Chinese concepts in the English language environment on the premise of preserving information and strategic intention. Diplomatic interpretation is by no means a simple code switching, but a highly challenging practice of strategic communication. Its effectiveness is directly related to the global cognition and recognition of the Chinese concepts and Chinese plans. With the ever-changing international environment, it is of unprecedented urgency to improve the strategic communication ability of diplomatic interpretation. This requires us to fundamentally change our concept and incorporate interpretation into the core link of national international communication capacity-building; Always adhere to the audience orientation and deeply study the history, culture and realistic concerns of the target country, so as to integrate Chinese and foreign languages, and tell more inspiring and persuasive Chinese stories. Only in this way can diplomatic interpretation truly become a strategic bridge across the civilization gap and connecting China and the world, and lay a solid language and cognitive foundation for China to participate in global governance and promote the construction of a community with a shared future for mankind.

Note

The example sentences in this study are all extracted from the speech at China-CELAC Forum, and the bolded part in the examples is for the purpose of highlighting.

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Analysis of Occupational Health Examination Results of Radiation Workers in Yangzhou in 2025

Faqlang Li^{1*}, Feifei Qiu²

¹Yangzhou Jiangdu District Center of Disease Control and Prevention, Yangzhou 225200, China

²Yangzhou Center of Disease Control and Prevention, Yangzhou 225000, China

**Author to whom correspondence should be addressed.*

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Abstract: Objective: To assess the health status of 2,957 radiation workers who underwent occupational health examinations in Yangzhou in 2025, and to explore the health effects of low-dose ionizing radiation. Methods: A cross-sectional survey was conducted, and the health examination data were statistically analyzed. Results: Significant differences in abnormal rates were observed among different genders, ages, job types, and examination types ($P < 0.05$). The highest abnormal rate was found in electrocardiogram (41.56%), followed by liver function (16.44%) and blood pressure (16.03%). The abnormal rates of lens, blood pressure, electrocardiogram, and nails increased with age. Conclusion: Long-term exposure to low-dose ionizing radiation has adverse effects on the health of radiation workers, underscoring the necessity of strengthening occupational health protection.

Keywords: Radiation workers; Occupational health examination; Ionizing radiation; Health effects

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1. Introduction

With the widespread application of radiation technology in medical, industrial, and other fields, the number of radiation workers has been increasing year by year. To safeguard their health, the “Basic Standards for Protection Against Ionizing Radiation and for the Safety of Radiation Sources” (GB 18871-2002) stipulates that the average annual effective dose for radiation workers over five consecutive years should not exceed 20 mSv, with no single year exceeding 50 mSv ^[1]. In recent years, with enhanced awareness of radiation protection and improved protective measures, the radiation doses received by radiation workers have significantly decreased ^[2]. However, due to the unique nature of their occupation, radiation workers remain chronically exposed to low-dose ionizing radiation environments, making regular health risk assessments essential ^[3]. This study analyzes the occupational health examination results of 2,957 radiation workers in Yangzhou City in 2025, exploring the impact of different

factors on their health status to provide a basis for formulating scientific protective strategies.

2. Objects and methods

2.1. Research objects

Select radiation workers who participated in occupational health examinations in 2025, including 2,083 males and 874 females, with a gender ratio of 2.4:1 and an average age of (39.86 ± 10.96) years. Among them, there were 1,972 medical application personnel and 985 non-medical application personnel; 372 individuals were pre-employment personnel, while 2,585 were on-the-job or off-the-job personnel.

2.2. Methods

Data on general conditions, ophthalmology, electrocardiogram (ECG), dermatology, and laboratory tests (including thyroid function, blood routine, and blood biochemistry) were collected. Health examinations and result evaluations were conducted in accordance with the “Health Requirements and Monitoring Specifications for Radiation Workers” (GBZ 98-2020).

2.3. Statistical processing

Data were organized using Excel, and statistical analysis was performed using SPSS 19.0. The trend χ^2 test was used to compare abnormal rates across age strata, while the χ^2 test was used to compare abnormal rates between other groups. A statistically significant difference was considered when $P < 0.05$.

3. Results

3.1. Analysis of basic conditions of physical examination indicators

The overall abnormal rate among radiation workers was 90.13%. The top five indicators with the highest abnormal rates were electrocardiogram (41.56%), liver function (16.44%), blood pressure (16.03%), platelets (15.96%), and lens (11.84%), as shown in **Table 1**.

Table 1. Basic conditions of physical examination indicators [$n = 2,957$]

Examination item	Normal count	Abnormal count	Abnormal rate (%)
White Blood Cells	2,648	309	10.45
Red Blood Cells	2,690	267	9.03
Hemoglobin	2,628	329	11.13
Platelets	2,485	472	15.96
Lens	2,607	350	11.84
Liver Function	2,471	486	16.44
Renal Function	2,945	12	0.41
Thyroid Function	2,875	82	2.77
Blood Pressure	2,483	474	16.03
Electrocardiogram	1,728	1,229	41.56
Nails	2,741	216	7.30

3.2. Analysis of abnormal physical examination indicators by gender

There were significant differences in the abnormal rates of multiple indicators between different genders ($P < 0.05$), as detailed in **Table 2**.

Table 2. Abnormal rates of physical examination indicators by gender [n(%)]

Evaluation index	Male (n=2083)	Female (n=874)	χ^2 Value	P-value
White Blood Cells	167 (8.02)	142 (16.25)	44.562	<0.001
Red Blood Cells	145 (6.96)	122 (13.96)	36.703	<0.001
Hemoglobin	183 (8.79)	146 (16.70)	39.049	<0.001
Platelets	323 (15.51)	149 (17.05)	1.091	0.296
Lens	261 (12.53)	89 (10.18)	3.250	0.071
Liver Function	457 (21.94)	29 (3.32)	155.442	<0.001
Renal Function	417 (20.02)	19 (2.17)	155.970	<0.001
Thyroid Function	47 (2.26)	35 (4.00)	6.979	0.008
Blood Pressure	430 (20.64)	44 (5.03)	111.441	<0.001
Electrocardiogram	922 (44.26)	307 (35.13)	21.163	<0.001
Nails	188 (9.03)	28 (3.20)	30.818	<0.001

3.3. Analysis of abnormal physical examination indicators by age

As age increases, the abnormal rates of the lens, blood pressure, electrocardiogram, and nails among radiation workers show an upward trend ($P < 0.05$), as shown in **Table 3**.

Table 3. Abnormal rates of various indicators among different age groups [n(%)]

Evaluation index	18-	30-	40-	50-	60-	Trend χ^2	P-value
White Blood Cells	56 (9.57)	101 (10.39)	93 (11.79)	53 (10.60)	6 (5.41)	0.000	0.983
Red Blood Cells	51 (8.72)	80 (8.23)	79 (10.01)	41 (8.20)	16 (14.41)	1.258	0.262
Hemoglobin	62 (10.60)	107 (11.01)	85 (10.77)	56 (11.20)	19 (17.12)	1.246	0.264
Platelets	93 (15.90)	139 (14.30)	130 (16.48)	82 (16.40)	28 (25.23)	3.280	0.070
Lens	56 (9.57)	70 (7.20)	79 (10.01)	95 (19.00)	50 (45.05)	87.882	<0.001
Liver Function	96 (16.41)	180 (18.52)	127 (16.09)	68 (13.60)	15 (13.51)	3.359	0.067
Renal Function	90 (15.39)	151 (15.53)	112 (14.20)	65 (13.00)	18 (16.22)	0.947	0.331
Thyroid Function	16 (2.74)	24 (2.47)	18 (2.28)	18 (3.60)	6 (5.41)	1.857	0.173
Blood Pressure	47 (8.03)	111 (11.42)	133 (16.86)	141 (28.20)	42 (37.84)	127.413	<0.001
Electrocardiogram	260 (44.44)	356 (36.63)	307 (38.91)	233 (46.60)	73 (65.77)	10.000	0.002
Nails	3 (0.51)	20 (2.06)	63 (7.98)	97 (19.40)	33 (29.73)	239.373	<0.001

3.4. Analysis of abnormal physical examination indicators by occupational category

There were statistically significant differences in the abnormal rates of hemoglobin, liver function, renal function, thyroid function, and electrocardiogram indicators among radiation workers of different occupational categories (P

< 0.05), as shown in **Table 4**.

Table 4. Abnormal rates of various indicators among different occupational categories [n(%)]

Evaluation index	Medical	Non-medical	χ^2 Value	P-value
White Blood Cells	207 (10.50)	102 (10.36)	0.014	0.906
Red Blood Cells	176 (8.92)	91 (9.24)	0.079	0.779
Hemoglobin	200 (10.14)	129 (13.10)	5.799	0.016
Platelets	317 (16.08)	155 (15.74)	0.056	0.812
Lens	246 (12.47)	104 (10.56)	2.312	0.128
Liver Function	281 (14.25)	205 (20.81)	20.599	<0.001
Renal Function	251 (12.73)	185 (18.78)	19.149	<0.001
Thyroid Function	64 (3.25)	18 (1.83)	4.899	0.027
Blood Pressure	304 (15.42)	170 (17.26)	1.658	0.198
Electrocardiogram	779 (39.50)	450 (45.69)	10.337	0.001
Nails	141 (7.15)	75 (7.61)	0.209	0.648

3.5. Analysis of abnormal physical examination indicators by type of physical examination

There were statistically significant differences in the abnormal rates of blood pressure and nails among radiation workers undergoing different types of physical examinations ($P < 0.05$), as shown in **Table 5**.

Table 5. Abnormal rates of various indicators among different types of physical examinations [n(%)]

Evaluation index	Pre-employment	During employment	χ^2 value	P-value
White Blood Cells	46 (12.37)	263 (10.17)	1.669	0.196
Red Blood Cells	38 (10.22)	229 (8.86)	0.728	0.393
Hemoglobin	47 (12.63)	282 (10.91)	0.979	0.322
Platelets	51 (13.71)	421 (16.29)	1.609	0.205
Lens	35 (9.41)	315 (12.19)	2.403	0.121
Liver Function	53 (14.25)	433 (16.75)	1.484	0.223
Renal Function	59 (15.86)	377 (14.58)	0.421	0.516
Thyroid Function	11 (2.96)	71 (2.75)	0.053	0.817
Blood Pressure	32 (8.60)	442 (17.10)	17.441	<0.001
Electrocardiogram	163 (43.82)	1066 (41.24)	0.891	0.345
Nails	4 (1.08)	212 (8.20)	24.388	<0.001

4. Discussion

Through a cross-sectional analysis of the occupational health examination results of 2,957 radiation workers in Yangzhou City, this study found a relatively high overall abnormality rate (90.13%) in this population, with the abnormality rates of multiple indicators being significantly correlated with gender, age, job type, and on-the-job

status. This suggests that the impact of long-term low-dose ionizing radiation exposure on health is a multifactorial and gradual process, with varying risks among different subgroups, warranting in-depth exploration.

4.1. Core abnormal indicators highlight cardiovascular and metabolic burdens

In this study, the abnormality rate of electrocardiograms (41.56%) ranked highest, far exceeding other indicators, aligning with the trend of multiple recent studies focusing on the long-term effects of radiation on the cardiovascular system^[4-5]. Combined with the fact that the abnormality rate of blood pressure (16.03%) also ranked among the highest, it suggests that long-term low-dose ionizing radiation may impose a sustained burden on the cardiovascular system of radiation workers. This impact may be related to radiation-induced chronic inflammatory responses, oxidative stress, and endothelial dysfunction. Therefore, in future occupational health monitoring, in addition to traditional blood tests and lens examinations, cardiovascular function assessment should be elevated to a more central position to enable early warning and intervention.

4.2. Gender differences reveal potential female sensitivity and key protection focuses

Regarding blood system indicators (white blood cells, red blood cells, hemoglobin), the abnormality rate among female workers is significantly higher than that among male workers, which echoes the conclusion of some studies that females are more genetically susceptible to radiation damage^[6-7]. This finding holds significant practical implications: it suggests that when formulating protection strategies, male and female workers should not be regarded as a homogeneous group; instead, gender-specific risks should be considered. For instance, more targeted health education can be provided to female workers, and it can be explored whether differentiated management in terms of dose limits or frequency of medical examinations is necessary. This may represent an innovative direction worthy of in-depth exploration in the field of radiation protection in the future.

4.3. Job type differences reflect the effectiveness of protective behaviors and health management

The fact that the abnormality rate of key indicators such as liver function, renal function, and electrocardiograms among radiation workers in non-medical industries surpasses that in the medical industry is a thought-provoking discovery^[8]. It may reveal significant disparities in protective behaviors and health management awareness across different work environments. Workers in the medical industry typically possess more professional knowledge about radiation, and the protective supervision in their workplaces is also more stringent and standardized. Conversely, some non-medical industries (such as industrial radiographic testing) may suffer from weak protective awareness and relatively lagging supervision^[9-10]. Therefore, the focus of public health interventions should be expanded outward to strengthen supervision and training for non-medical radiation units, extending the “protection culture” from the medical field to all industries involving radiation.

4.4. Cumulative effects of age and length of service, and early intervention window in the radiation industry

The abnormality rates of the lens, blood pressure, electrocardiogram, and nails increase significantly with age, clearly demonstrating the superimposition of the cumulative effects of radiation exposure and the body’s natural aging process. In particular, the abnormality rate of the lens rises sharply after the age of 50, and the data from the city in 2025 (11.84%) shows a notable increase compared to that in 2015 (7.31%), sounding an alarm for protective measures. This emphasizes the necessity of providing focused monitoring for workers of advanced

age and long service duration. Meanwhile, for younger workers, it is essential to make full use of the baseline data from “pre-employment physical examinations” and establish individualized health risk warning models by tracking the dynamic changes in early indicators such as nails and blood pressure during their on-the-job period, thus achieving a transition from “group protection” to “precise monitoring” [11–12].

4.5. Research limitations

This study is a cross-sectional survey, making it difficult to confirm the causal relationship between ionizing radiation and health abnormalities. Changes in abnormal indicators may be simultaneously influenced by various confounding factors such as age, lifestyle, mental stress, and genetic background. For example, the higher abnormal rates in liver function and blood pressure indicators among males may be related to occupational exposure, but they could also be associated with prevalent gender-based lifestyle differences. Future research should incorporate personal dose monitoring data and conduct prospective cohort studies to more precisely quantify risks.

5. Conclusion and outlook

In summary, the health impacts of long-term low-dose ionizing radiation on radiation workers in Yangzhou City exhibit multi-system and differentiated characteristics. To address this challenge, the following innovative and comprehensive measures are recommended: First, in terms of monitoring strategies, transition from “universal examinations” to “precision monitoring based on risk stratification”, with a focus on workers with long tenures, females, and those in non-medical industries. Second, in terms of protection, expand from “physical protection” to “behavioral and health management”, enhancing overall health literacy among practitioners through strengthened training and mental health support. Third, strengthen data integration; future research should combine health records with personal dose data to establish a dynamic risk assessment system, thereby ensuring more scientific and effective occupational health protection for radiation workers.

Disclosure statement

The authors declare no conflict of interest.

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Second Language Motivational Self System in Adult Second Language Learning: Mediating Roles of Vision Intervention and Roadmaps

Minjie Lai*

International College, Guangzhou College of Commerce, Guangzhou 511363, Guangdong, China

**Author to whom correspondence should be addressed.*

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Abstract: This article presents a critical review of the literature on the Second Language Motivational Self System (L2MSS) and its application in adult second language (L2) learning. By analyzing the three components of the L2MSS—the ideal L2 self, the ought-to L2 self, and the L2 learning experience, it demonstrates that for adult learners, the ideal L2 self and direct learning experiences serve as the primary motivational drivers, while the ought-to L2 self exerts a comparatively weaker influence. The paper further investigates the mediating roles of vision intervention and roadmaps in translating motivation into sustained learning behavior. It argues that vision intervention is a critical mechanism for strengthening the ideal L2 self by making it vivid and attainable, while detailed roadmaps are essential for operationalizing this vision into concrete, actionable steps. The discussion culminates in pedagogical implications, suggesting that effective adult L2 instruction should integrate systematic vision-building exercises and provide structured roadmaps to bridge the gap between motivational states and actual learning effort, thereby fostering long-term engagement and proficiency.

Keywords: Second language motivational self-system; Vision intervention; Roadmaps; Adult learners

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1. Second language motivational self system

The Second Language Motivational Self System is grounded in self-discrepancy theory and possible selves^[1-2]. L2MSS comprises three key components: the ideal L2 self, ought-to L2 self, and L2 learning experience^[3-4].

The ideal L2 self is conceptualized as what the learner would ideally like to become, specifically, their future achievement as an L2 user^[3-5]. For most L2 adult learners, developing L2 ability enables them to create a new language identity based on the existing one to fulfil the needs for a positive social identity^[6-7]. In China, the ideal L2 social identities for adult learners could be of various types, for example, a supervisor to work with foreign colleagues in a transnational corporation, a speaker to give a public speech in English in an annual meeting, or a successful salesperson negotiating with foreign clients in English.

Ought-to L2 self indicates the attribute that the learner believes they should possess for meeting the social expectations which may come from family, examinations, or jobs ^[3-5]. Besides meeting others' expectations, the ought-to L2 self also plays a role in avoiding possible negative consequences, such as studying hard to avoid failing the exam ^[3]. It emphasizes that L2 learners study English to live up to others' expectations. Adults possess well-established personalities and a capacity for independent thought. Some studies suggest that external expectations exert less influence on adult learners ^[8-10]. It indicates that the ought-to L2 self may not be powerful enough to motivate adult learners. While addressing the problem of L2 adult beginners with low motivation, the ideal L2 self and L2 learning experience should be emphasized more.

L2 learning experience concerns learners' past and existing learning experiences, which could be affected by the curriculum, successful learning experience, classmates, and teachers ^[3]. The L2 learning experience is the direct experience to encourage or discourage students in language study. Notably, the L2 learning experience pays attention to evaluating current learning situations rather than guidance for future selves. L2 learning experiences are likely to be the decisive factor for adult L2 learners to continue L2 study. The level of learners' comfort in the classrooms, strong social network, visible progress in L2 learning, and self-efficacy are essential components of the L2 learning experience for adult learners to stay in the language program ^[11]. It is very crucial to take advantage of the L2 learning experience in motivating adult learners for long-term study.

2. The impact of L2MSS on intended learning behavior

From many research findings in the L2MSS framework, the ideal L2 self has been proven as the strongest force to motivate learners in L2 study since the ideal L2 self was found to have a strong positive correlation with positive L2 attitudes and motivated behaviour ^[12-14]. Furthermore, those with ideal L2 selves are more likely to succeed in language proficiency ^[10, 15]. A quantitative study (N>10,000) in China confirms that the ideal L2 self has the dominant positive impact on L2 learners regardless of age, region, or levels of language proficiency ^[5]. In summary, the ideal L2 self functions as a powerful motivator in the context of adult L2 learning.

Ought-to L2 self tends to have less impact than ideal L2 self on motivating L2 learners. The marginal relationship between ought-to L2 self and motivated behaviour has been found in research ^[13, 16-17]. Although L2 learners in Asian countries, such as China and the Republic of Korea, ought-to L2 selves probably play a more important role than ideal L2 selves in shaping learners' motivation in Western countries, as the learners in Asian countries would bear more family expectations or obligations. It is true for teen L2 learners but not for adult learners ^[18-19]. Take China's adult learners for example, their motivation is greatly driven by ideal L2 selves instead of ought-to L2 selves ^[10, 20]. Therefore, the ought-to L2 self would be paid less focus while transferring motivation to actual learning behaviour in Chinese adult L2 learners.

Regarding the L2 learning experience, the most straightforward and visible component in L2MSS plays an important role in adult L2 learners. The L2 learning experience has been highlighted as its decisive function in adult learners' attitudes towards study in different studies ^[5, 10, 21]. Indeed, studies on EFL contexts suggest that this situated motive plays a more decisive role in participating in classroom activities and long-term study and stimulating motivation, especially for low-level learners ^[5, 10, 21]. Adult L2 learners would be more likely to stop the study if the L2 learning experience seems less likely to fulfill their needs.

3. Vision intervention and actual learning behavior

The ideal L2 self and L2 learning experience would be more crucial than the ought-to L2 self in adult learners. The former two components would be more emphasized in the following discussion associated with actual learning behaviour.

The following discussion focuses on the use of vision intervention to strengthen the ideal L2 self. The vision intervention cooperating with roadmaps would be an effective tool to make the intended effort from L2 motivation into reality from the perspective of the L2 learning experience.

Vision, as the vivid mental image, is closely associated with imagery not limited to the visual sense but involves different modalities, including sight, sound, taste, touch, and smell ^[5]. In a motivational context, the vision is the future image of the L2 self, personalized by combining imagination and personal experience ^[22]. The combination of personal reality is because an effective ideal L2 self strengthened by the vision intervention should be applicable, reasonable, and coordinated with social contexts ^[3].

Notably, the vision is different from an abstract goal. It allows learners to immerse and experience their future ideal state in L2 study in the present instead of merely endpoints, which provides positive attitudes towards study ^[10]. It would be crucial to increase their engagement and joy in learning tasks.

4. Vision intervention and ideal L2 self

Within the L2 Motivational Self System framework, vision serves as a critical enhancer of the ideal L2 self—the primary motivator for adult learners. Within the L2 Motivational Self System framework, vision serves as a critical enhancer of the ideal L2 self—the primary motivator for adult learners. Empirical studies consistently demonstrate that visualization techniques significantly strengthen ideal L2 selves, whereas learners lacking vision tend to rely more on externally-driven ought-to L2 selves ^[23–25]. Since ought-to selves often fail to internalize and sustain motivation, particularly among adults, vision becomes essential for maintaining consistent engagement. Research in Chinese contexts confirms the vision's motivational efficacy ^[5]. Beyond motivation enhancement, vision offers particular value for diverse adult learners by providing a sustained future focus that transcends immediate learning experiences or social pressures, thereby fostering greater intended effort and enabling teachers to guide heterogeneous learners toward tangible outcomes ^[25].

5. Vision intervention and L2 learning experience

Vision intervention not only strengthens the ideal L2 self but also enhances engagement through the positive effects it generates. While some studies propose that the L2 learning experience (the present) contributes to forming the ideal L2 self (the future), other evidence indicates a reverse pathway ^[16, 26–28]. Specifically, by providing a vivid future self-image, vision intervention makes learners more willing to engage in tasks, transforming perceivedly boring activities into meaningful steps toward their ideal selves ^[4]. This demonstrates that the ideal L2 self can exert a backward influence, enriching the immediate learning experience ^[4]. Supporting this, Sato's study found that learners without initial vision intervention reported more frustration, whereas an experimental group receiving it showed greater engagement ^[29]. Thus, for goal-oriented adults, this pathway from future self to present experience is highly persuasive, underscoring the value of applying vision intervention at the outset of learning.

6. The framework of an effective vision

According to the L2 Motivational Self System, vision serves as a powerful imagery enhancer that motivates L2 learners to increase their learning effort. An effective vision should be developed through six foundational principles: it begins with helping learners imagine themselves as successful L2 users in domains such as career, academia, or daily life; this vision then requires strengthening through regular exposure to vivid future self-imagery^[3, 30]. To maintain motivational efficacy, the vision must be substantiated as achievable, personalized, and grounded in reality, while also being translated into concrete action through structured learning plans. Furthermore, sustaining the vision demands periodic reactivation to prevent its erosion amid competing distractions, and it should be counterbalanced by introducing a feared self to enhance motivational tension. For adult learners with diverse objectives, personalized yet realistic visions are particularly crucial. Therefore, visions should be periodically refined throughout the learning process to preserve both relevance and feasibility.

7. Roadmap: The key to actual learning behavior

A vision intervention enhances motivation, but a roadmap is crucial for translating intended effort into actual learning behavior. It operationalizes the ideal L2 self by breaking it into manageable sub-goals, creating a bridge between motivation and action. Although adult learners are often self-directed, they typically lack the expertise to construct a coherent learning path. A roadmap provides this necessary guidance, making the abstract ideal L2 self achievable.

Realizing an ideal L2 self requires sequential steps. A personalized roadmap gives direction to vision interventions, making them meaningful^[10]. Evidence indicates that learners with detailed roadmaps possess clearer short- and long-term goals than those without, increasing their confidence and self-assurance^[29]. Furthermore, a well-designed roadmap helps learners recognize the discrepancy between their actual and ideal L2 selves, ensuring that external obligations are considered alongside personal aspirations in the learning journey.

8. Implications for teaching and learning

Teachers applying the L2MSS should help learners reduce discrepancies between their actual and ideal L2 selves. The ideal L2 self is personalized, requiring vision interventions for its development. This is challenging in large classes where learners have different goals. A feasible approach is to group learners by their ideal self types and provide tailored vision interventions in separate, weekly sessions. This increases efficiency and manages teacher workload. For example, inviting successful former learners to share experiences can make ideal selves more tangible and inspiring, which is particularly valuable in EFL contexts with limited L2 community exposure.

Regarding the L2 learning experience, adult learners are often driven by specific needs and expect visible progress. Carefully selected teaching materials are crucial. While meeting all individual needs is difficult, one-on-one customized courses that focus on learners' specific interests can effectively address this diversity.

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Research on the Mechanism of the Chain Leader System in Promoting the Modernization of Local Industrial Chains

Quan Zhu¹, Songbin Wu², Zongshu Wu³

¹School of Management, Shenzhen Polytechnic University, Shenzhen 518055, Guangdong, China

²School of Economics, Shenzhen Polytechnic University, Shenzhen 518055, Guangdong, China

³School of Economics and Management, Hainan Normal University, Haikou 571158, Hainan, China

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Abstract: This paper focuses on the chain leader system, an important institutional innovation implemented by local governments in China to address internal and external shocks and promote the modernization of industrial chains. Based on a systematic review of literature related to industrial chains and the chain leader system, this paper focuses on analyzing the core mechanism of the chain leader system in promoting the modernization of local industrial chains. The research proposes that its role is mainly realized through three mechanisms: first, the coordination mechanism; second, the precise empowerment mechanism; third, the environment optimization mechanism. Based on the above mechanism analysis, this paper further puts forward policy suggestions such as improving the scientific decision-making and dynamic evaluation mechanism, promoting in-depth integration with the innovation chain and talent chain, and clarifying the boundary between the government and the market, aiming to provide theoretical reference and decision-making basis for optimizing the practice of the chain leader system and building a modern industrial system.

Keywords: Chain leader system; Industrial chain; Industrial modernization

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1. Problem proposal

The chain leader system is an important institutional innovation and a key measure for local governments to promote the modernization of industrial and supply chains and build a modern industrial system. In recent years, governments at all levels in China have paid close attention to the security of industrial and supply chains, and the chain leader system has emerged as the times require. It first originated in Changsha, Hunan Province, in 2017, and was rapidly promoted and applied by local governments after being implemented in Zhejiang Province in 2019. By the end of 2023, 31 provinces, autonomous regions, and municipalities directly under the Central

Government in mainland China had implemented the chain leader system in the whole region or part of the region. Among them, 19 provinces and cities clearly proposed to implement the chain leader system in provincial policies or planning documents, and required subordinate cities and counties to establish corresponding working systems with reference. The implementation effects and existing problems of the chain leader system are gradually emerging.

2. Literature review

2.1. Research on industrial chains

The “industrial chain” is a Chinese characteristic concept proposed by domestic scholars, and similar concepts abroad mainly include value chain and supply chain ^[1]. There was an upsurge of research on industrial chains in China between 2004 and 2010. Generally speaking, the industrial chain covers the entire process of product or service production, from raw material production to technological R&D, product design, intermediate product manufacturing, final product assembly, and even circulation, consumption, and recycling ^[2].

In recent years, the central government has paid increasing attention to the industrial and supply chains and their security issues. Terms such as industrial and supply chains and their modernization have been repeatedly mentioned in relevant central documents, and the academic community has set off a new wave of research. Scholars have conducted extensive discussions on issues such as the connotation and characteristics, practical challenges, and realization paths of the modernization of industrial and supply chains ^[3–6].

2.2. Research on the chain leader system

In recent years, with the rapid development of the chain leader system from “local experience” to “national practice”, academic research on it has gradually emerged. Existing literature mainly conducts qualitative analysis around the background, connotation, significance, and problems of the chain leader system. Scholars believe that China’s complete industrial system and industrial agglomeration are the inherent foundation for the emergence of the chain leader system, and the dual impact of the severe economic situation on industrial and supply chains is the realistic background for the rapid promotion and application of the chain leader system ^[7]. Scholars point out that the chain leader system is an institutional arrangement in which local governments select core industries, and administrative leaders serve as “chain leaders” with the goal of stabilizing, supplementing, extending, and strengthening the chain ^[8]. The essence of the chain leader system is a new industrial management method introduced by local governments to make up for market failures and maintain the normal operation of market mechanisms. It plays an important role in promoting the coordinated development of the industrial chain and innovation chain, improving the basic capacity and modernization of the industrial chain, and enhancing the position of the industrial chain in the global value chain ^[9]. In the implementation of the chain leader system, there are problems such as unclear boundaries between the government and the market, leading to the trap of “all-powerful government”, and one-sided emphasis on local chain production, leading to the rise of local protectionism. Meng Qi used provincial panel data from 2017 to 2021 to empirically test the impact of the chain leader system on the modernization of industrial chains, pointing out that the chain leader system mainly drives the modernization of industrial chains through factor agglomeration and innovation capacity improvement ^[10].

In addition, some scholars have analyzed the mechanism and path of large state-owned enterprises (SOEs) playing the role of industrial chain leaders. The research group of the Institute of Industrial Economics, Chinese Academy of Social Sciences proposed that central enterprises as industrial chain leaders can realize the industrial chain governance function of industrial chain leaders by solving the bottleneck of “chokepoint” technologies,

driving the breakthrough of basic software and hardware, coordinating the stable production and supply of the supply chain, strengthening strategic demand traction, coordinating the internationalization of the industrial chain, and filling the gap of industrial common technologies. Zhao Jing et al. found through a case study of UHV power transmission projects that state-owned enterprises can solve identity legitimacy through the “chain leader-led” mechanism, promote the process through the organizational method of the “R&D-engineering coupling” mechanism, and build cooperative network resources through “industry-university-research-application collaboration” to promote key core technology research and independent innovation ^[11].

3. The mechanism of the chain leader system in promoting the modernization of local industrial chains

3.1. Coordination mechanism: breaking the “fragmentation” dilemma and building an industrial development community

In the traditional industrial development model, there are often information barriers and goal differences between various departments and enterprises, leading to scattered resources, serious internal friction, and the formation of a “fragmentation” dilemma. The primary mechanism of the chain leader system is to integrate scattered factors into an organic industrial development community through high-level coordination and efficient coordination.

First, the chain leader system realizes the integration of governance authority. The appointment of the main leaders of cities and counties as “chain leaders” endows industrial chain governance with sufficient administrative authority and resource mobilization capacity. This can effectively break departmental barriers and realize “cross-departmental” collaboration. When the industrial chain development encounters cross-domain problems involving planning, land, environmental protection, finance, talent, etc., the chain leader can convene relevant functional departments to work on-site, conduct “one-stop” decision-making and scheduling, avoiding the institutional transaction costs for enterprises to “run back and forth” between multiple departments, and significantly improving the efficiency of public services.

Second, the chain leader system promotes the connection of market entities. The key to the modernization of the industrial chain lies in the coordinated progress of enterprises on the chain, especially leading enterprises and supporting enterprises. The chain leader plays the role of a “super liaison officer”, accurately removing “blockages” within the industrial chain by establishing industrial alliances and organizing supply and demand docking meetings. For example, helping local small and medium-sized enterprises integrate into the supply chain system of leading enterprises, or guiding leading enterprises to release orders and transfer technologies locally, thereby strengthening the “stickiness” of the industrial chain and forming an integrated development pattern of “large enterprises leading small ones and small enterprises promoting large ones” ^[12-13].

3.2. Precise empowerment mechanism: focusing on “key points” to improve industrial chain resilience and level

The chain leader system is by no means a “broad-brush” universal policy; its essence lies in “precision.” Through in-depth on-site “diagnosis”, it identifies the specific needs and weak links of the industrial chain, and conducts targeted resource injection and policy empowerment.

First, precisely “making up for weaknesses” to ensure industrial chain security. The chain leader and his special working group will conduct a panoramic scan and risk assessment of the industrial chain, accurately identifying which key links, core technologies, and core components have “chokepoint” risks or excessive

external dependence. On this basis, the chain leader system can launch mechanisms such as “unveiling the list and appointing the leader”, concentrating resources to support relevant enterprises or scientific research institutions in technological research, or targeted introduction and cultivation of specialized, refined, and innovative “little giant” enterprises in this field, realizing import substitution and independent control in key areas, and fundamentally enhancing the resilience and security of the industrial chain.

Second, precisely “strengthening advantages” to promote industrial chain upgrading. For links in the industrial chain that already have certain advantages, the function of the chain leader system is to “add flowers to the brocade” and promote them towards high-end and intelligent development ^[14–15]. For example, the chain leader can coordinate and connect with national-level innovation platforms and top industry expert resources to provide intellectual support for enterprises’ technological transformation and upgrading; set up special industrial funds to guide social capital to invest in key technological breakthroughs and advanced capacity expansion of the industrial chain; and take the lead in formulating industry standards higher than national standards to lead the quality improvement and brand building of the entire industrial chain.

Third, precisely “cultivating seedlings” to lay out the future of the industrial chain. The chain leader system has a forward-looking vision and can deploy the innovation chain around the industrial chain. By analyzing the industrial technology roadmap, the chain leader system can lay out cutting-edge fields in advance, guide the R&D directions of local universities and scientific research institutes to align with industrial needs, accelerate the local transformation of scientific and technological achievements, incubate and cultivate future industries, and inject a steady stream of new momentum into the continuous modernization of the industrial chain.

3.3. Environment optimization mechanism: Creating a “rainforest-type” ecosystem to stimulate endogenous growth drivers

The modernization of the industrial chain not only requires external promotion but also a good ecosystem that can stimulate endogenous innovation vitality. The in-depth mechanism of the chain leader system lies in its role transformation from “manager” to “service provider” and “ecosystem builder”, committed to creating a vibrant industrial ecological environment like a tropical rainforest.

In terms of the policy environment, the chain leader system promotes the transformation of policies from “supply-oriented” to “demand-oriented.” By conducting in-depth research in enterprises, the chain leader can directly hear the voices from the front line, thereby promoting the introduction of more down-to-earth and targeted personalized policies. This avoids the drawbacks of “one-size-fits-all” policies, making policy supply highly compatible with the real needs of industrial development, and forming a “drip irrigation” policy support system ^[16].

In terms of the business environment, the chain leader system itself is a “letter of trust” and “commitment letter.” It sends a strong signal to the market that the local government attaches great importance to and is committed to the development of the industrial chain for a long time, which greatly enhances entrepreneurs’ investment confidence and attracts the agglomeration of external high-end factors. A stable, transparent, and predictable business environment, like fertile soil, allows all types of entities on the industrial chain to operate with peace of mind and innovate boldly, and ultimately form a self-reinforcing and sustainable modern industrial system.

4. Policy suggestions

4.1. Improve the scientific decision-making and dynamic evaluation mechanism to enhance the operational efficiency of the chain leader system

It is recommended that local governments establish a “digital brain of the industrial chain”, use big data, artificial intelligence, and other technologies to real-time monitor the operation of the industrial chain, accurately identify breakpoints, blockages, and potential points, and provide data support for the chain leader’s decision-making. At the same time, introduce third-party institutions to conduct regular evaluations of the implementation effect of the chain leader system, establish a key performance indicator (KPI) system, such as industrial chain resilience, innovation capacity, and local supporting rate, and realize dynamic adjustment and precise policy implementation of “one chain, one policy” to avoid resource misallocation.

4.2. Promote the in-depth integration of the chain leader system with the innovation chain and talent chain to strengthen endogenous drivers

Encourage the chain leader to take the lead in establishing an innovation consortium of “government-industry-university-research-funding-application”, and set up “unveiling the list and appointing the leader” projects around key core technologies of the industrial chain. Simultaneously implement the “talent training on the chain” plan, customize talent introduction and training programs according to the industrial chain development map, realize the seamless connection between industrial chain needs and innovation resources and talent supply, and gradually shift the focus of the chain leader system from “making up for weaknesses” to “forging strengths.”

4.3. Clarify the boundary between the government and the market to build a sustainable industrial ecosystem

The key to the success of the chain leader system lies in stimulating the vitality of market entities. The government should position itself as a service provider and coordinator, focusing on breaking administrative barriers, optimizing the business environment, providing application scenarios, and protecting intellectual property rights. Focus on supporting “chain master” enterprises to play a leading role, cultivate specialized, refined, and innovative “little giant” enterprises to integrate into the global value chain, and ultimately form a sound development pattern dominated by the market and guided by the government, avoiding improper intervention of administrative means in market competition.

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A Ten-year Review and Visual Analysis of Global Artificial Intelligence Research—A Bibliometric Analysis in CiteSpace Based on Highly Cited Literature

Hongbo Lai¹, Zhang Han¹, Yiwei Zhao¹, Yunxi Zhang^{2*}

¹School of Management, University of Shanghai for Science and Technology, China

²School of Economics and Management, Shanghai University of Political Science and Law, China

**Author to whom correspondence should be addressed.*

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Abstract: Taking the highly cited literature related to artificial intelligence over the ten-year span between 2009 and 2019 from the Web of Science database as the data sample, this paper has analyzed the distribution of literature, hot topics of research, frontier research and evolution of artificial intelligence by using CiteSpace and applying dual-map overlay, co-word and co-citation analysis, among other bibliometric approaches. The research findings indicate full-fledged multidisciplinary features of artificial intelligence, but interdisciplinary integration is still at a nascent stage; most of the existing researches are focused on fundamental technologies, while applications are quite limited, with more applications of the computer vision technologies; deep learning is garnering the most interest, while a cutting-edge research theme could be the combination of quantum physics and machine learning.

Keywords: Artificial intelligence; CiteSpace; Co-citation analysis; Deep learning

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1. Introduction

Researches on artificial intelligence (AI) can date back to the 1940s and 1950s. The Dartmouth Conference held in 1956 is widely considered as the beginning of this field. A standard and consistent definition of artificial intelligence is absent. In the Webster's Dictionary, artificial intelligence is defined as "the capability of a machine to imitate intelligent human behavior"..

Over recent years, more and more government and business organizations have realized the importance of artificial intelligence. All countries around the world, especially the advanced ones, are implementing strategic realignment and targeting artificial intelligence. The United States, China, Europe and Japan, among other

countries and regions, have made some tremendous headway in artificial intelligence. Unlike the business world in which a mass fervour for artificial intelligence didn't occur until recently, the academic world's interest in artificial intelligence started much earlier. In the All Databases of the Web of Science (WoS), the literature under the subject line of artificial intelligence first appeared in 1952, began to grow in the late 1980s and has been exploding in recent years, driven by the booming industry.

In this context, there is an abundance of artificial intelligence-related studies in the academic world, and the industry and the academia are increasingly interconnected. In order to portray the whole picture of artificial intelligence, sum up previous studies, and assess the available findings, we need to carry out an elaborate review and analysis of the literature that was produced globally over the last decade and then provide forecasts of future research trends.

1.1. A Review of Global Artificial Intelligence Literature

Artificial intelligence literature published in the Web of Science database over the last 60 years as of June 2019 was retrieved, and the returned results are shown in **Figure 1**. It is apparent that the literature related to AI has kept building up since the beginning of this century, and registered explosive growth after 2015. In this boom, many scholars have made a general overview of this subject, but there are some problems. First, the amount of literature has expanded at an exponential rate, making it difficult to review the literature on a subjective and qualitative basis in a chronological order or by topic^[1]. Second, in these massive literature, some scholars pull out different main lines and choose to conduct reviews or researches from a certain perspective or focus on a specific field, including neuroscience study^[2], deep learning^[3], and economics^[4]. These reviews have academic depth, but fail to present the whole picture of AI related research. Third, most reviews are more about a subjective analysis and collation of the literature, including the authors' personal opinions. As a result, the reviews are subjective, and cannot objectively reflect the facts on which the analysis and study should be based.

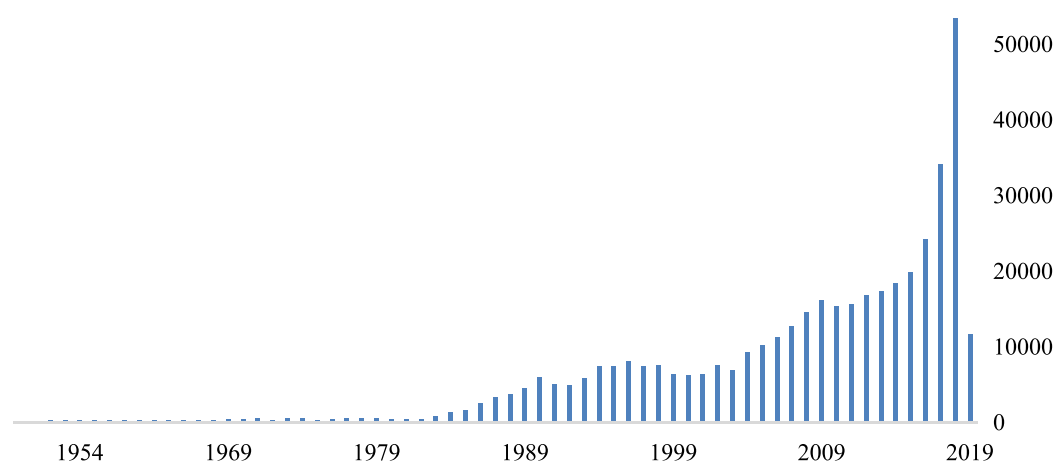


Figure 1. Annual distribution statistics of artificial intelligence literature (as of June 2019)

The bibliometric approach based on mapping knowledge domain not only solves the problem of subjectiveness in the existing literature, allowing the scholars to intuitively investigate and analyze some fields, but also avoids the problem to a great extent where traditional reviews are too subjective because of pure data and its visual expression. This approach itself is an early application of artificial intelligence, so many scholars naturally

use it as a tool for bibliometric and analytical research on the AI literature. Some scholars have analyzed the status quo from different angles, such as studies based on relevant authors, institutions, countries ^[5-8], as well as those based on the literature of AAAI (American Association for artificial Intelligence) Conference ^[9]. A number of tools of mapping knowledge domain are applied to bibliometric studies, including TDA ^[10], SciMAT ^[11], CiteSpace ^[12]. Among them, CiteSpace, developed by Professor Chen Chaomei, is one of the most widely used ones ^[13], owing to its unique features and excellent performance. Lv Wenjing et al. ^[12] used this program to analyze the knowledge map of artificial intelligence literature in CNKI(China National Knowledge Infrastructure) and CSSCI(Chinese Social Sciences Citation Index) databases, and to visually analyze the distribution from various levels and angles, but they did not analyze the co-citation network of this field. Co-words and co-citation network analysis can extract the topic words that are used frequently, and dig out the relationship among the literature, which helps us get a deeper understanding of the research field. Therefore, the method of mapping knowledge domain is used to further analyze the co-word network and co-citation network in the field of artificial intelligence.

Based on the foregoing work, this paper will use CiteSpace as a bibliometric tool to conduct scientific measurement and visualization of the literature of artificial intelligence. The “co-word network”, “co-citation network” and the seldom used “dual-map overlay” functions are applied to identify the inherent connections in the artificial intelligence discipline and to analyze the hotspots and frontiers in this field, and also to shed light on the evolution and trends of popular sub-fields. We hope to provide more valuable reference from the academic perspective in this boom of artificial intelligence, and contribute to the construction and development of AI at a deeper level.

2. Materials and Methodology

To make sure the sample data feeding into the visual analysis in this paper represents a subjective and comprehensive picture of the status quo of artificial intelligence, this paper selects the WoS Core Collection as data sources. It contains the vast majority of high-level international academic achievements, including journal articles, conference proceedings and research reports. And it is a database widely recognized as a global reservoir of knowledge. By drawing upon the search terms used in the “*China AI Development Report*” released by the Science and Technology Policy Research Center of Tsinghua University in July 2018 and combining experts’ opinions, we use the following search words: *artificial intelligence, machine learning, recognition image, computer vision, facial recognition, speech recognition, natural language processing, semantic search, semantic web, text analytics, virtual assistant, visual search, predictive analytics, intelligent system*. The OR logic is adopted among the search words to conduct topic search. At the same time, the search is confined to ESI highly cited literature. This retrieval method not only ensures completeness of the data but also helps sift out noisy data and minimize its effect on the analysis results. As the highly cited literature search applies only to the literature published after 2009, the retrieval interval is set to 2009 to 2019.

By following the said search strategy, the literature search was completed on June 19, 2019. A total of 2,178 entries were returned, including 1,746 articles, 432 reviews, 31 conference proceedings and 14 monographs. After these were imported into CiteSpace and duplicate entries were eliminated, 2,171 entries were left, constituting the data sample for the study.

3. Results and Discussion

3.1. Discipline Distribution

Firstly, the function for analyzing the retrieval results in WoS is used to make a preliminary analysis of the subject distribution of the literature in the retrieval results. In the WoS database, the literature is classified into one or more disciplines depending on what it involves. Discipline distribution is a macro-analysis which can reflect the scope it involves, the foundation it requires and the direction it applies. In order to better reflect the disciplines, we classified the disciplines as per the WoS categories which are more detailed than research areas. The results are partially shown in **Table 1**. In general, the research field of artificial intelligence shows multidisciplinary characteristics.

Table 1. Discipline Distribution of Artificial Intelligence Research (TOP 21)

WoS Categories	Record Count	%
Computer Science Artificial Intelligence	538	24.702
Engineering Electrical Electronic	527	24.197
Computer Science Information Systems	149	6.841
Automation Control Systems	125	5.739
Computer Science Interdisciplinary Applications	123	5.647
Multidisciplinary Sciences	123	5.647
Neurosciences	122	5.601
Energy Fuels	100	4.591
Remote Sensing	94	4.316
Imaging Science Photographic Technology	91	4.178
Chemistry Multidisciplinary	89	4.086
Computer Science Theory Methods	85	3.903
Telecommunications	85	3.903
Biochemistry Molecular Biology	58	2.663
Computer Science Software Engineering	56	2.571
Geosciences Multidisciplinary	56	2.571
Engineering Civil	55	2.525
Materials Science Multidisciplinary	55	2.525
Computer Science Hardware Architecture	52	2.388
Environmental Sciences	52	2.388
Green Sustainable Science Technology	52	2.388

As shown in Table 1, most of the disciplines are conventionally perceived as “hard” subjects. Among them, computer science is the most prominent: this category represents a more than 42% share cumulatively. Artificial intelligence is a discipline derived from computer science. Though its development to date embodies the integration and diversification of disciplines, its fundamental nature is computer science. Electrical and electronics under the engineering discipline has a share almost equal to that of artificial intelligence under the computer

science discipline. This suggests artificial intelligence technologies have been realized largely in physical reality, such as various electronic devices, robots as a typical example, which apply AI technologies. Multidisciplinary science and neuroscience come out on top in the table and stand out among all computer system and engineering disciplines, indicating an unfolding multidisciplinary trend in artificial intelligence.

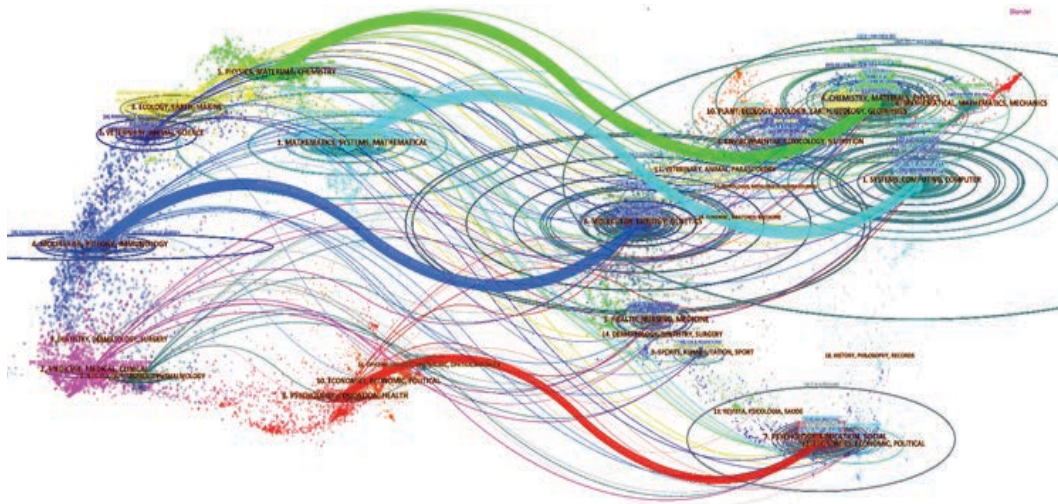


Figure 1 is the dual-map overlay of the journal discipline obtained by CiteSpace following some refinements and adjustments. In this figure, CiteSpace classifies numerous journals into clusters and names the clusters. The most important disciplines are shown on both sides of the map. The journals of cited literature are distributed on the right, regarded as the research foundation of artificial intelligence. The journals of citing literature are distributed on the left, as the application field of artificial intelligence. The ellipse on each cluster formed by the journals represents the number of papers and authors in the journal: the longer the horizontal axis of the ellipse, the more authors; the longer the vertical axis, the more papers.

through other methods like deep learning, and thereby to drive the advancement of physics and chemistry, cornerstones of modern sciences. Digging into social sciences is a dominant tendency of research in the latest developments of AI over the last decade. It can be seen on the map that the curve of psychology and education ranks the fourth in the strength of citation. This also shows the multidisciplinary nature of artificial intelligence and is expected to become more salient in the future.

Table 2. Journal citation relationships in the research of artificial intelligence
(in descending order of strength of citation relationship)

Citing Discipline	Cited Discipline
mathematics, systems, mathematical	systems, computing, computer
molecular, biology, immunology	molecular, biology, genetics
physics, materials, chemistry	chemistry, materials, physics
psychology, education, health	psychology, education, social

Note: The names of disciplines are clustered by CiteSpace according to the journal by LLR algorithm.

The two ends of the four significant citation curves are all connected to the same disciplines. This indicates the research foundation and application of AI studies are still concentrated in the same or akin disciplines (compared to Chen Chaomei's research on the scientific map, which clearly reveals that some disciplines of application have more than one foundation^[15]), and the characteristics of interdisciplinary citations are yet to show up. Perhaps in the future, on the basis of the apparent multi-disciplinary trends, more interdisciplinary citations will emerge, and the characteristics and trends of interdisciplinary integration will become manifest.

Compared to the left side, it is evident that the ellipse of cited literature on the right is more concentrated in several disciplines, including computer science, biomedicine, physical and chemical materials. The top four of most cited journals are IEEE Transactions on Pattern Analysis and Machine Intelligence, Science, Nature and Lecture Notes in Computer Science.

3.2. Hotspots

Comparatively speaking, discipline analysis is from a macro perspective, while research hotspots and evolution analysis based on keywords and references stand for a micro perspective. Compared with co-citation analysis, the results presented by subject-term co-word analysis are simpler, more intuitive and easier to interpret; while co-citation analysis requires specific literature searches. Therefore, the co-word analysis of subject terms can be carried out first, followed by the analysis of literature co-citation.

In CiteSpace, terminologies are extracted and generated from the titles, keywords, abstracts and supplementary keywords of the literature. Therefore, this paper uses terminologies in the co-word analysis, which can better reflect the topics of the literature. Node type is selected as Term. See **Table 3** below.

Table 3. Co-word analysis of artificial intelligence research (Top 10 by frequency)

Frequency	Terminologies	Centrality
168	machine learning	0.04
101	deep learning	0.06
96	computer vision	0.03
95	support vector machine	0.05
84	neural network	0.06
75	artificial intelligence	0.03
73	learning algorithm	0.03
57	convolutional neural network	0.01
56	learning technique	0.04
52	the-art method	0.08

Table 3 outlines the results of co-word network. Many terminologies, such as artificial intelligence, deep learning and machine learning, are widely known by and accessible to the masses in their everyday life. Machine learning is the primary approach to realizing AI. It has long been the core of AI and a hot topic in related fields. Firstly introduced as a concept originating in artificial neural network in 2006, deep learning is now the most popular among machine learning methods. Convolutional network, another high-frequency word, is a typical algorithm in deep learning. To be more precise, deep learning is a special type of machine learning. As it way outperforms most traditional machine learning methods, it is often studied separately.

Algorithms account for the vast majority of the top 10 subject words by frequency. Algorithms form the most crucial foundation of AI, or even function as the “soul” thereof. While computer vision is a universal technique and a basic application, it still represents, in our view, the rise of research on the application of AI. Apparently, AI research is still concentrated on the level of foundational technologies, which deep learning has garnered the greatest interest in recent years. The research on its applications is also booming, and the hottest field is computer vision. Compared with foundational technologies, however, its applications are underanalyzed.

3.3. Frontier and Evolution

In CiteSpace, research frontier refers to emerging theoretical researches and emergence of new topics, which is composed of the citation collection of co-citation references. Cluster naming in the co-citation network is determined by the terms extracted from the cited literature and can be regarded as the research frontier^[16]. We use the co-citation network of the literature to further analyze the research frontier of artificial intelligence and its evolution trends since 2009. Meanwhile, the setting retrieves the top 50 most cited papers every year. As the retrieval of keywords contains keywords provided by the authors, plus additional keywords supplemented by WoS according to a given algorithm, there may be some deviation in the representation of the literature. Since the titles are carefully chosen by the authors to be pertinent to the contents, we choose to name the cluster by the title. After comparisons, the more representative and comprehensible naming results of the LSI algorithm are selected. The node type is selected as tree ring history. The size of the tree ring reflects the times the literature is cited, and the rings represent citations of the literature in different years. The minimum spanning tree pruning algorithm

is selected to ensure that the co-citation network presented is not too cluttered without changing the network structure. Meanwhile, it is set to retrieve the top 50 most cited papers every year. Remaining clusters after the elimination of smaller clusters are shown in **Figure 3**. The Modularity index of clustering reaches 0.9, indicating a salient clustering structure of the co-citation network. The average silhouette value is low due to the presence of plenty of small-to-medium-sized clusters in the network. Therefore, the rationality of the clustering results can be established. The number of entries in each cluster is less than the total of 2,171 entries in the sample, indicating the existence of many subdivisions under the study of artificial intelligence.

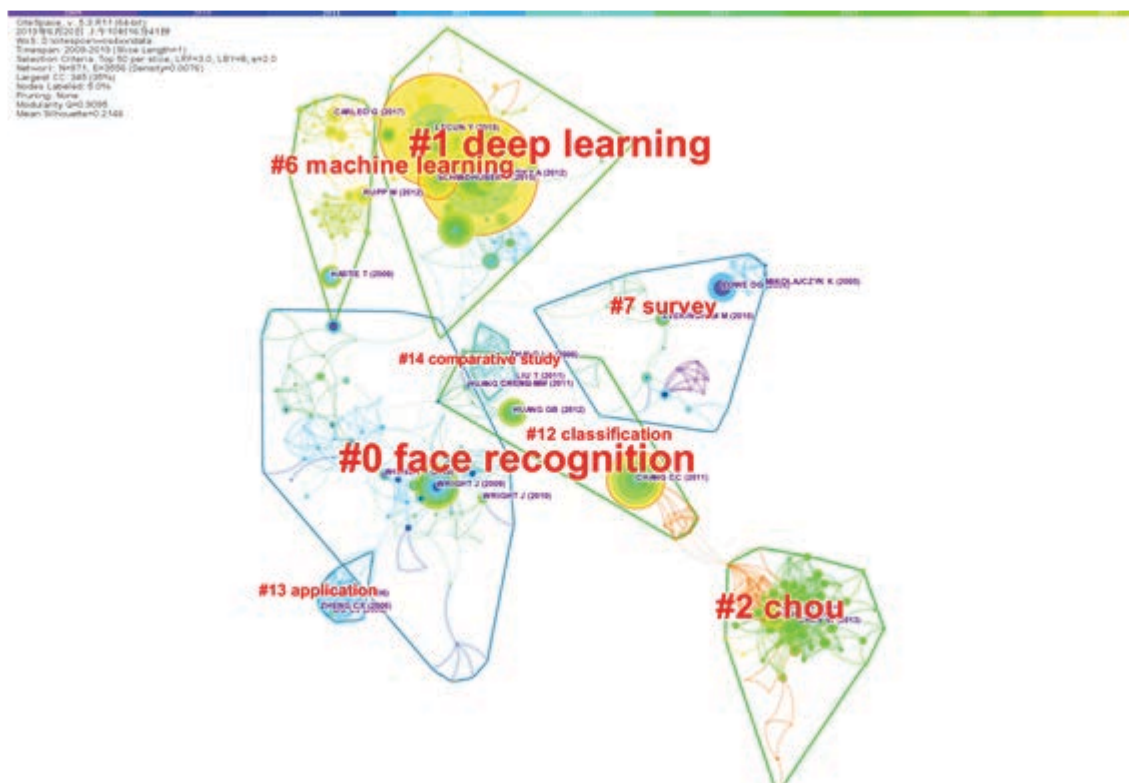


Figure 3. Co-citation network of artificial intelligence research

The results of analysis suggest face recognition, deep learning, Chou 's PseAAC and machine learning are the four largest clusters in terms of size. Next, there are classification, application and so on. Their cluster names denote the frontier research topics in the field over the time span of 2009-2019, and share some similarities with the hotspots identified based on the co-word of subject words in the previous section. In order to probe into these frontier research topics in more depth, the authors have produced a timeline view of the co-citation network based on the clustered co-citation network, as shown in **Figure 4** and **Table 4**.

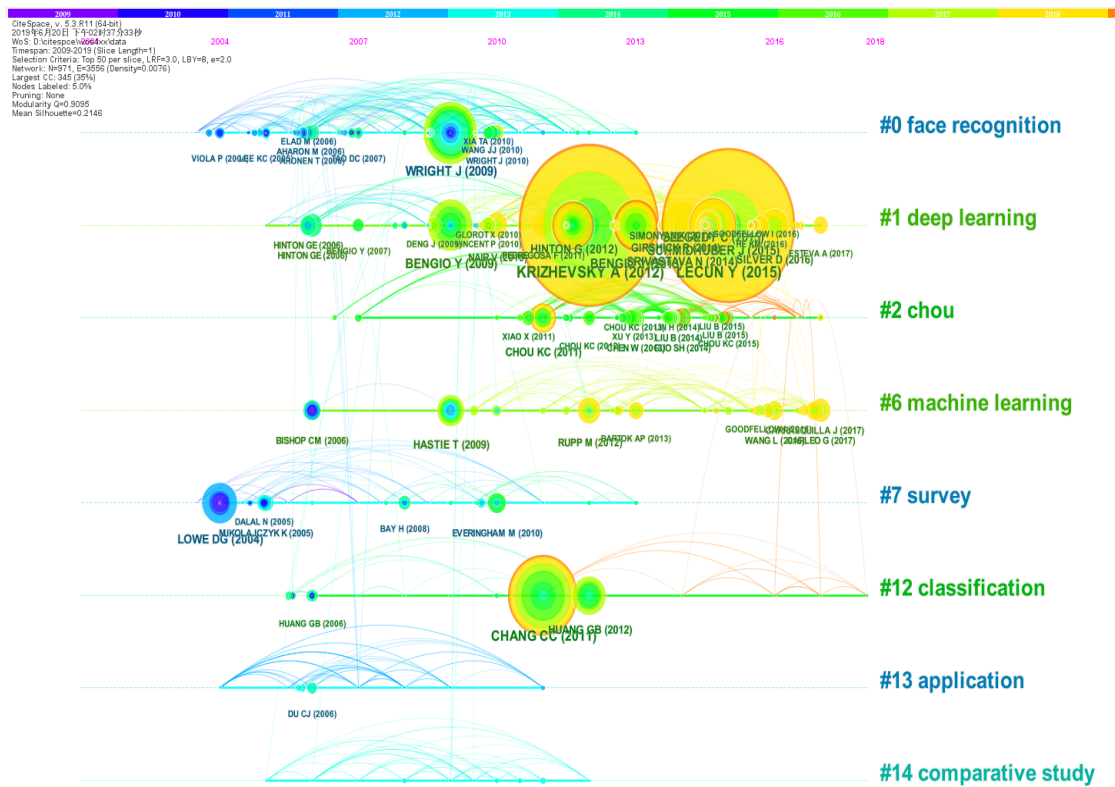


Figure 4. Timeline view of the co-citation network (partial)

Table 4. Details of main clusters

ClusterID	Label	Size	Silhouette	Begin	End	Last	Mean Year
0	face recognition	84	0.941	2004	2013	10	2008
1	deep learning	80	0.949	2005	2017	13	2012
2	chou	62	0.976	2007	2017	11	2014
6	machine learning	33	0.977	2006	2017	12	2014

The frontier represented by the largest #0 cluster is face recognition, which contains 84 co-citation entries and is an application of computer vision. One of the most important articles is authored by John Wright et al. and published in IEEE Transactions on Pattern Analysis and Machine Intelligence in 2009^[17]. This article is pioneering in incorporating sparse representation into face recognition, resulting in a giant step forward compared with the performance of existing face recognition methods: the recognition rate is much higher than that of traditional approaches, with superior effectiveness and stability.

The co-citation literature in this cluster is distributed between 2004 to 2013, and the median year is 2008, indicating quite early time of the literature cited in this field. The timeline view shows clearly that the study of face recognition started very early and can be roughly divided into two periods. During the period from 2004 to 2007, the distribution of cited literature was relatively stable, and no works of cardinal significance appeared. After the publication of the article by John Wright et al. in 2009, which became a hit in this field, the literature distribution became stable again. Over these years, there were little research achievements worthy of mentioning, and the citation time of the article stopped at the year of 2017 or so. Face recognition is a frontier research that started

early and evolved at a steady pace, but its development seemingly has stagnated over the recent years.

The frontier represented by cluster 1 is deep learning, which contains 80 cited works. Second in size, it contains plenty of masterpieces. In 2006, Geoffrey Hinton, the founder of deep learning, published two iconic articles on Neural Computation^[18] and Science^[19]. The one published in Science is widely recognized as a milestone in the history of deep learning, sparking off a deep learning boom in both the academic and business worlds^[20]. In 2012, Hinton co-authored with the research teams at Microsoft, IBM and Google^[21] an article on deep neural networks in speech recognition, published in the IEEE Signal Processing journal and hailed as the forerunner of deep learning in this direction. Yoshua and Bengio published two enlightening works in 2009^[22] and 2013^[23]. The former summarizes the motives and principles of learning algorithms in the deep learning framework and provides theoretical guidance for related studies. The latter is an overview of representation learning. Yann LeCun, together with Hinton and Bengio, known as the “troika” of deep learning, published a review about deep learning on Nature^[2] in 2015. Along with an introduction of CNN, RNN, distributed feature representation and different applications thereof, they projected the future of deep learning.

Among other important works, Hinton’s student Krizhevsky et al. applied deep learning to picture recognition in ILSVRC 2012^[24] and beat the second-place SVM to win the crown, proving the capability of deep learning. Jürgen Schmidhuber presented a review of neural networks and deep learning in chronological order^[25]. Christian Szegedy proposed a new deep convolutional neural network in the 2014 ILSVRC^[26].

The co-citation literature in this frontier field is distributed between 2005 and 2017, and the median year is 2012. With the publication of two papers by Hinton in 2006 widely acknowledged as the starting point, deep learning was further developed by Bengio et al. In 2012, Hinton’s team won the crown in ILSVRC-2012, which helped draw attention to the deep convolutional neural network and initiated a new phase of explosive development of deep learning. After that, some important works were published, and were widely cited in the last couple of years. Therefore, this paper concludes that deep learning is the most cutting-edge research field as a branch of AI, and relevant studies will continue at a high speed.

The label of cluster #2 is Chou, which refers to the pseudo-amino acid discrete model framework proposed by Chou. It may be deemed to represent the subdivision of protein structure prediction, and it is the only one named after biomedical terminology among all major clusters. It accords with the analysis of disciplines in the previous section of this paper. The core piece in this cluster is a review published by Kuo-Chen Chou in 2011^[27] in the Journal of Theoretical Biology, which comprehensively describes the steps of protein structure prediction. Another important paper has developed a set of genomic prediction methods for human, drosophila and nematodes^[28]. Most of the authors in this cluster are ethnic Chinese, indicating this group of people have made some achievements in this field.

The co-citation literature in this field is distributed between 2007 and 2017, and the median year of publication is 2014. With the review published by Chou in 2011 as the watershed, co-citation was almost zero before that, and some influential works appeared after that. However, the citation duration of these works is short, and mostly concentrated in one or two years after their publication, indicating limited impact of these works.

The label of cluster # 6 is machine learning, which has long been a hot topic and the centerpiece of AI, and is the key method to realize AI. Given the long history of research in this field, its co-citation timeline view herein appears to be quite stable. The most important work in this field, authored by Trevor Hastie, provides statistical viewpoints on machine learning, inter alia. The Boosting method in this book is frequently cited^[29]. Another consequential book by Christopher M. Bishop is a classic textbook in the field of machine learning^[30], and has a

preference for the Bayesian model. But it has been seldom cited in recent years as it was published long time ago (2006).

Obviously, in this cluster many works were published in top physics journals, including *Science*, *Nature Physics* and *Physical Review*. The same holds true in the discipline analysis. That suggests the combination of machine learning and physics. Juan Carrasquilla created a simple statistical physical model with supervised learning in 2016, demonstrating for the first time that machine learning can be applied to solve problems in physics^[31]. After that, Lei Wang^[32], Giuseppe Carleo^[33] and other scholars did more work, mostly concentrated on quantum physics.

The citation in this field is distributed between 2006 and 2017, and the median year of publication is 2014, indicating that the literature cited in this field has come out of late and been replaced quite fast. From the perspective of timeline, the development of this field is quite flat. A couple of highly cited works came forth about every three years, but a span of explosive development as seen in deep learning did not occur. Around 2016, the combination of machine learning and physics began to take shape, and a series of important works came out. There are three main topics in this direction: the application of machine learning to physics, the interpretation of physical thoughts to machine learning, and quantum machine learning. We think these herald a new direction that has the potential to revolutionize physics, quantum physics and machine learning in particular.

By summing up the foregoing analysis of four clusters, we find that some reviews or some referential books are of cardinal significance, and these works are often written by the most accomplished and distinguished experts and scholars in this discipline. Some examples are the review of deep learning by LeCun, Hinto and Bengio^[2], the interpretation of the steps of protein structure prediction by Chou^[27] and the most classic machine learning textbook by Bishop^[30]. The citation of these works by all highly cited works indicates the research in artificial intelligence attaches great importance to foundational studies. At the same time, we notice that many important cited works are the results of efforts on solving practical problems. The most obvious case is deep learning. The papers of Krizhevsky^[24] and Szegedy^[26] are both the results of their participation in the ILSVRC competition, and Wright^[17] introduced sparse representation in order to reduce excessive data and noise in the process of image recognition.

4. Conclusion

4.1. Main Conclusions

This paper elaborates on and analyzes the status quo, hotspots, frontiers and trends of artificial intelligence research using CiteSpace based on the sample data of highly cited references from 2009 to 2019. The findings are summarized as follows.

- 1) Our research indicates full-fledged multidisciplinary features of artificial intelligence, but interdisciplinary integration is still at a nascent stage. This paper analyzes the fields involved in artificial intelligence research from the level of discipline by using the function of dual-map overlay. Research on AI is widely distributed in computer, biomedicine, physics, chemistry, social sciences and their related disciplines, a sign of its multidisciplinary nature. However, the citation curve does not tangibly reveal an interdisciplinary citation relationship, which indicates the integration of the disciplines under study is yet to take shape. In general, artificial intelligence, unlike traditional classical sciences, is not an independent discipline and is yet to develop a set of scientific principles of its own.

It is more like a craft or an experimental approach. Therefore, multidisciplinary and interdisciplinary integration is its inherent nature, and will reveal itself more and more in the future.

- 2) Research on artificial intelligence focus on foundational technologies, while application research is limited in quantity and focus on computer vision. In this paper, the hotspots of AI are analyzed through the terminology-based co-word network. Terms of foundational technologies, most being algorithms, dominate the list of top ten words by frequency, led by deep learning. Computer vision is a basic application, and face recognition is a typical application thereof. We think it heralds the beginning of application research, although generally speaking, artificial intelligence applications are underanalyzed.
- 3) Deep learning is currently the most popular and frontier research, and the combination of quantum physics and machine learning may be the most exciting one. We have generated a co-citation network of the sample literature and clustered it, followed by a detailed analysis of the important literature in the subdivisions under study, represented by four largest clusters. The aim is to study the frontier direction and its evolution process. The study of deep learning contains a number of papers which were highly cited and continue to be cited. Combining the results of co-word analysis, we may conclude that deep learning is the most popular research frontier. Some papers addressing the combination of physics, especially quantum physics and machine learning, came forth in the field of machine learning in 2016. The combination of these two fields may be the most current direction and is likely to be further combined with deep learning. We also notice in the analysis that artificial intelligence attaches importance to basic research, and its key theoretical research findings have derived from the process of solving practical problems.

4.2. Inspirations and Deficiencies

As a non-conventional and non-independent discipline, artificial intelligence will spread and penetrate into more fields like water flowing into everything in the future. It is set to promote the integration of more disciplines, and drive the advancement of disciplines. Meanwhile, continued efforts on basic research will enable AI to meet social needs better, giving a boost to application research. A trend of “AI+” in the academic world like in the industry will ensue.

Deep learning is a hotspot and frontier as expected, but the combination of quantum physics and machine learning is not. We find it interesting that AI may continue to penetrate other basic sciences and bring about substantial changes, as already foreshadowed in the discipline analysis section. We may expect artificial intelligence, mainly machine learning/deep learning, to bring about game-changing reforms as an “invention of invention methods”^[34]. At the same time, this paper is intended to contribute to the development and construction of relevant disciplines, and facilitate the higher-level development of AI in broader aspects such as economy, institution and policy.

In order to improve data quality and ease the burden of data processing, the sample literature in this paper has been obtained by running a search using some keywords and picking out those highly-cited ESI papers. Some important works may have been excluded from the analysis because they do not meet the criteria. In addition, it is impossible for this paper to cover a longer timeline for all sorts of reasons, and thus the research and analysis of the earlier period of artificial intelligence is not available.

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Research on Foreign Discourse Quality of Enterprise Websites in Liaoning Province, China

Tianxin Li*, Yilin Wu

School of Foreign Studies, Shenyang University of Technology, Shenyang 110870, Liaoning, China

**Author to whom correspondence should be addressed.*

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Abstract: Under the background of the promotion of the “Belt and Road” Initiative and the deepening of the “going out” strategy of enterprises in China, the foreign discourse of enterprise websites has become the key carrier of international image communication and market expansion. This study takes 8 well-known enterprises in Liaoning Province of China as samples, covering manufacturing, service and high-tech industries, and constructs a three-level evaluation index system of “Corporate Image Discourse — Public Relations Discourse — Internationalization Discourse”. The quality of foreign discourse of 8 enterprise websites is comprehensively evaluated by means of stratified sampling, content analysis, technical testing and questionnaire survey. The study found that the overall performance of the foreign discourse quality of the websites of large enterprises and high-tech enterprises in Liaoning is good, but there are also some problems such as differentiation in the presentation of corporate image, lack of depth of public relations operation, the general weakness of international adaptability and promotion ability. The results provide an empirical reference for enterprises to optimize the website’s foreign discourse system and enhance their international competitiveness.

Keywords: Liaoning enterprise; Enterprise website; Foreign discourse; Quality evaluation; International communication

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1. Introduction

The enterprise website is the core display window of the brand image, and it is also an important bridge connecting the enterprise and the international market. It can not only help enterprises to establish brand image and enhance popularity, but also maintain existing customer relationships and tap potential business opportunities through timely release of product information, optimization of service processes, and ultimately enhance market competitiveness. In the process of “going out”, high-quality foreign discourse can effectively convey brand value, expand international influence, and enhance the voice of Chinese enterprises in the global market^[1].

Enterprise’s foreign discourse refers to the language symbol system used by enterprises to transmit information to the international market and target customers (Breeze, 2015)^[2]. As the core platform with the

functions of information dissemination, promotion and legalization (Breeze, 2015)^[2], the enterprise website's discourse covers multiple symbols such as text, images and videos, which is highly consistent with the website's communication objectives (Davis, 1989^[3]; Bruce, 1998^[4]). Blue Book of Language Service for Chinese Enterprise Globalization (2016) clearly pointed out that foreign-related economic and cultural activities under the "Belt and Road" Initiative need to be based on language exchange, and there is an urgent need for all-round and multi-level language services^[5]. Translation and language services, as important supports, directly affect the effectiveness of corporate external communication.

On the one hand, this study focuses on the actual operation of language in the enterprise scene, analyzes the role of discourse in the construction and image of enterprise identity; on the other hand, it discusses the interaction between discourse and macro factors such as business activities, cultural background and social practice. The research can provide practical reference for the domestic and foreign production and operation, overseas market development and brand value promotion of Liaoning enterprises, and help Liaoning enterprises to better integrate into the international market.

2. Research objects and methods

2.1. Research objects

In order to ensure the representativeness and universality of the research, this study adopts the stratified sampling method, and selects well-known enterprises in different industries in Liaoning as the research objects, covering manufacturing, service industry, high-tech industry and other fields, specifically including Genertec Shenyang Machine Tool Co., Ltd., Dalian Shipbuilding Industry Co., Ltd., Ansteel Group Co., Ltd., Neusoft Co., Ltd., Dalian Bingshan Group Co., Ltd., Liaoning Cheng Da Biotechnology Co., Ltd., Shenyang Blower Works Group Co., Ltd. and Dalian Wanda Group Co., Ltd., focusing on the analysis of the foreign discourse quality of their websites.

2.2. Evaluation model and index

This study integrates the existing research results to construct an evaluation system: drawing on the five evaluation criteria of comprehensiveness, timeliness, objectivity, authority and accuracy proposed by Jim Kapoun (1998)^[6], referring to the three-dimensional first-level index framework of "Corporate Image -- Public Relations -- Internationalization" in Li Chen (2018)^[7], and combining 12 second-level indexes and 19 third-level indexes of Wang LiFei (2022)^[8] to form a three-level evaluation indexes (see **Table 1** for details).

Table 1. Evaluation index system of foreign discourse quality of enterprise websites

Level 1 Index	Level 2 Index	Level 3 Index
Enterprise Image Discourse	Company History	General Introduction
		Annual Event
	Business Philosophy	Enterprise Purpose
		Enterprise Management Strategy
	Organizational Structure	Senior Management
		Organizational Structure

Table 1 (Continued)

Level 1 Index	Level 2 Index	Level 3 Index
Public Relations Discourse	Text Media	Enterprise News
		Important Speech
	Multimedia	Audio/Video
	Communication Channel	Message Board/Forum
		Contact Information
	Financial Disclosure	Annual Report
Internationalization Discourse	International Image Publicity	No Enterprise Logo
		Enterprise Logo in English and Chinese
	International Customer Service	Number of Website Languages
		Overseas Recruitment Column
	International Marketing	Internationalization Column
	Convenience for Overseas Use	Search Box / Navigation Index
	Website International Promotion	News Update Speed

2.3. Data Collection Methods

Using a multi-method data collection strategy to ensure the reliability and validity of the study:

- (1) Website content analysis: systematically evaluate the language quality, information integrity, content update frequency and column settings of the website;
- (2) Technical performance testing: the use of professional website testing tools, testing website loading speed, compatibility, stability and security measures;
- (3) Questionnaire survey: collect user experience feedback for international users, focusing on evaluation dimensions such as ease of use, information practicality, and cross-cultural adaptability;
- (4) Data quality control: cross-validation of all kinds of data collected, elimination of invalid information, to ensure the objectivity of the analysis results.

3. Result analysis

According to discourse performance in the three core indexes of Corporate Image, Public Relations and Internationalization, the foreign language websites of the 8 Liaoning-related enterprises are scored item by item (out of 10 points), and the scores are combined with the comprehensive judgment of the integrity, functionality and overseas suitability of the actual content of the websites. The specific results are shown in **Table 2**.

Table 2. Foreign Discourse Performance of Enterprise Websites in Liaoning Province, China

Name of Enterprise	Discourse Performance			Comprehensive Evaluation
	Enterprise Image	Public Relations	Internationalization	
Genertec Shenyang Machine Tool Co., Ltd.	6 points	5 points	5 points	General
Dalian Shipbuilding Industry Co., Ltd.	6 points	5 points	5 points	General
Ansteel Group Co., Ltd.	8 points	7 points	7 points	Excellent
Neusoft Co., Ltd.	9 points	8 points	8 points	Excellent
Dalian Bingshan Group Co., Ltd.	7 points	6 points	6 points	Good
Liaoning Cheng Da Biotechnology Co., Ltd.	6 points	6 points	6 points	Good
Shenyang Blower Works Group Co., Ltd.	5 points	4 points	4 points	General
Dalian Wanda Group Co., Ltd.	8 points	8 points	8 points	Excellent

The specific scoring reasons for each enterprise are as follows:

(1) Genertec Shenyang Machine Tool Co., Ltd. (foreign language website associated with www.smtcl.com)

Discourse performance of Corporate Image (6 points): Its foreign language section can briefly sort out the development process and core business, and clearly define the main business orientation of machine tool manufacturing. However, the elaboration of the business philosophy of the enterprise is relatively general. The organizational structure only reflects the core production department, lacks the display of related structures such as overseas subsidiaries, and the information integrity is general.

Discourse performance of Public Relations (5 points): Text media mainly introduces product parameters, with very little multimedia content and only a few product pictures; Communication channels only reserve basic email and telephone, and there is no online consultation portal; Financial information is not disclosed separately to foreign users, and can only be indirectly deduced from Chinese financial reports. Public interaction and information transparency are insufficient.

Discourse performance of Internationalization (5 points): Only simple display of product export scope, no targeted international customer customization service section; The website is suitable for overseas browsers, but there is no multilingual switching. International promotion only relies on simple display of industry exhibition information and lacks active overseas communication design.

(2) Dalian Shipbuilding Industry Co., Ltd. (foreign language website relying on www.dsic.cn foreign language plate)

Discourse performance of Corporate Image (6 points): Foreign language websites can find out the development context of the main shipbuilding industry of the enterprise, covering the historical records of major shipbuilding projects. The business philosophy revolves around “marine equipment manufacturing”, but the organizational structure only presents the core production plant area, the introduction of research and development, overseas business and other departments is missing, and the overall expression is relatively brief.

Discourse performance of Public Relations (5 points): The text media focuses on the introduction of ship products and project results, and the multimedia only has a small number of pictures of the ship construction site; The communication channel is single, only fixed telephone is provided; There is no financial disclosure section

specifically for overseas, and the public has limited access to information.

Discourse performance of Internationalization (5 points): It can list some overseas ship order cases, reflecting the international business layout, but there is no exclusive service channel for international customers; The loading speed of the website is suitable for overseas networks, but there are no international marketing activities and promotion sections, and the penetration of overseas markets is weak.

(3) Ansteel Group Co., Ltd. (foreign language website en.ansteel.cn)

Discourse performance of Corporate Image (8 points): The foreign language website has completely combed the process from the establishment of the factory to becoming an international steel giant, clearly conveying the business philosophy of “green steel and high-quality development”. The organizational structure covers production, research and development, overseas branches and other sectors, with clear logic, enabling overseas users to fully understand the enterprise system.

Discourse performance of Public relations (7 points): rich text media, covering industry trends, technological breakthroughs and other content, equipped with high-definition pictures of production lines and products; Communication channels include contact information of overseas offices; Regular disclosure of foreign language summaries of consolidated financial statements, but lack of video and other multiple forms of communication.

Discourse performance of Internationalization (7 points): It focuses on the promotion of global steel supply capacity and overseas base construction, with international customer docking section; The website supports overseas visit optimization, international promotion combined with industry international summit and other activities, but multilingual only supports English, which is not suitable for users in non-English-speaking countries.

(4) Neusoft Co., Ltd. (foreign language website associated <https://bpo.neusoft.com>)

Discourse performance of Corporate Image (9 points): The foreign language website takes “software and solution provider” as its core positioning, combs in detail the development process from “Dongda Alpine” to international enterprises, highlights “technological innovation” in its business philosophy, clearly divides software research and development, medical technology and other business sectors in its organizational structure, including overseas subsidiary structure, and has a three-dimensional image.

Discourse performance of Public Relations (8 points): Text media covers technical White Papers, industry cases, etc.; Multimedia has product demonstration videos and online press conference playback; Communication channels set up exclusive mailboxes and online message boards for overseas customers; Regular disclosure of financial data related to international business is highly transparent, and only the efficiency of interactive response is not clearly marked.

Discourse performance of Internationalization (8 points): Customized solutions for different regional markets, international customer service has a dedicated docking team; The website supports multilingual switching and overseas network acceleration, and is promoted through global industry exhibitions and technical forums. Only some emerging markets are slightly weaker in promotion.

(5) Dalian Bingshan Group Co., Ltd. (foreign language website en.bingshan.com)

Discourse performance of Corporate Image (7 points): The foreign language website clearly introduces the history originated from Dalian Refrigeration Factory in 1930, clearly defines the core positioning of refrigeration equipment manufacturing, mentions the enterprise structure of diversified investment, and includes information such as joint ventures. However, the international expression of business philosophy is relatively brief and lacks in-depth explanation.

Discourse performance of Public Relations (6 points): Text media covers product and overseas project

introduction, with a small number of production line videos; Communication channels provide overseas sales calls; Financial information only discloses the overall revenue profile, without subdividing the financial data of overseas business, and the multimedia form is relatively single.

Discourse performance of Internationalization (6 points): Project cases in more than 60 countries and regions are shown, with basic international business docking portals; The website is suitable for overseas visits, but there is no multilingual switching. International promotion relies on passive display of project cases and insufficient active marketing.

(6) Liaoning Cheng Da Biotechnology Co., Ltd. (Foreign Language Website Associated with www.cdbio.cn Foreign Language Section)

Discourse performance of Corporate Image (6 points): It focuses on the safety and effectiveness of biological vaccines and biological agents, in line with the core demands of the international biomedical industry. Without a clear division of key departments such as research and development, quality control and overseas sales, it is difficult for overseas partners to connect with the core team.

Discourse performance of Public Relations (6 points): Text media focuses on the research and development background and application value of core biological products, professional norms. Lack of multimedia forms, no research and development laboratories, production lines and other real content; single communication channel, no medical compliance consulting portal for overseas customers; no public financial data, it is difficult for overseas investors and partners to assess the strength of enterprises.

Discourse performance of Internationalization (6 points): International customer service does not involve key information such as overseas registration and certification of products, and the core needs of pharmaceutical customers are not met. Lack of international promotion, not related to overseas pharmaceutical exhibitions, clinical trial cooperation and other content.

(7) Shenyang Blower Works Group Co., Ltd. (Foreign Website Associated with www.shangu.com.cn Foreign Section)

Discourse performance of Corporate Image (5 points): The foreign language section only simply marks the core business of fan manufacturing, and the development process only mentions the breakthrough of key products. The business philosophy and organizational structure are hardly explained to foreign language users, which can only enable users to initially know the main business of the enterprise, and the information is seriously insufficient.

Discourse performance of Public Relations (4 points): The text content is mainly product catalog, without multimedia supporting content; The communication channel is only domestic switchboard telephone, and there is no overseas docking method. There is no foreign financial information disclosure, and public communication and information disclosure are almost blank.

Discourse performance of Internationalization (4 points): It only mentions export qualification in product introduction, no international customer service; The website can be accessed overseas, but there is no adaptation optimization, no international promotion related content, and the international adaptability is very poor.

(8) Dalian Wanda Group Co., Ltd. (foreign language website support www.wanda-group.com)

Discourse performance of Corporate Image (8 points): Foreign official website fully presents the development process, corporate culture and management philosophy through the “everything” column, clearly shows the organizational structure of the four major industrial groups, highlights the emerging formats such as film and television, sports, etc., introduces the global layout in detail, and has a clear and three-dimensional corporate image.

Discourse performance of Public Relations (8 points): Text, panoramic photos, videos and other forms are rich, and new columns spread enterprise information in multiple forms; Communication channels cover overseas branch telephones and mailboxes, with service navigation bars; Financial information discloses international business revenue overview. It has strong interaction and information transmission capabilities.

Discourse performance of Internationalization (8 points): It focuses on global format publicity, with international customer docking channels; The website supports overseas visits and forwarding dissemination, and new columns help overseas cultural dissemination. International promotion is carried out in combination with global projects. However, there is still room for improvement in service coverage in some niche markets.

4. Conclusions and recommendations

Combined with the results of the discourse quality evaluation of eight foreign language websites of Liaoning enterprises in three dimensions: Corporate Image discourse performance, Public Relations discourse performance and Internationalization discourse performance, the following conclusions are drawn:

4.1. Advantages

- (1) The image display of heavy industry enterprises is solid. The foreign language websites of heavy industry enterprises such as Ansteel Group Co., Ltd., Dalian Shipbuilding Industry Co., Ltd. and Shenyang Blower Works Group Co., Ltd. have obvious advantages in the expression of corporate image discourse. Most of these websites can clearly sort out the long development history of the enterprise, systematically elaborate the business philosophy around technological innovation and quality control, and introduce the organizational structure to meet the needs of industrial production and global project cooperation, so that overseas partners can quickly understand the core strength of the enterprise. For example, Ansteel Group's foreign language website presents in detail its development from basic steel industry to diversified formats, which meets the information needs of international industrial customers for the background of partners.
- (2) Head enterprises are better in public relations and internationalization. For Neusoft Co., Ltd., Dalian Wanda Group Co., Ltd. and other technology or service-oriented head enterprises, public relations and internationalization construction is relatively mature in their foreign language websites. As a science and technology enterprise, Neusoft's foreign language website has professional and timely text media content, matched with multimedia materials such as product demonstration videos, and also has exclusive consultation channels for overseas customers. Dalian Wanda Group focuses on the global layout of cultural tourism and commercial projects in international image publicity, which can meet the information demands of overseas investors and partners and has a certain awareness of international marketing.
- (3) Internationalization is clearly expressed for the core businesses. Most foreign language websites of enterprises can focus on the core business for international discourse output. For example, the foreign language website of Liaoning Cheng Da Biotechnology Co., Ltd. focuses on publicizing the international certification and overseas supply of biological products such as vaccines. Dalian Bingshan Group Co., Ltd., on the other hand, focuses on core products such as refrigeration equipment, and displays its solutions suitable for different overseas scenarios to help overseas customers quickly connect with their core businesses.

4.2. Disadvantages

- (1) There are disadvantages of differentiation in the presentation of Corporate Image. The introduction of the organizational structure on the foreign language websites of some traditional manufacturing enterprises is too general, only referring to the core departments, and does not reflect the configuration of overseas branches or cross-border collaboration teams; The enterprise history of some emerging business sectors is briefly sorted out, and the expression of business philosophy is in Chinese literal translation. For example, the simple translation of “keep improving” lacks interpretation in line with the international context, which is easy to be misunderstood by overseas users.
- (2) The operation form of Public Relations is single and insufficient in depth. Most foreign language websites of enterprises rely too much on text media, and multimedia content such as real product shooting and production process is scarce, and the application of new communication forms such as short video and live broadcast is very few. In terms of communication channels, with the exception of a few leading enterprises, Genertec Shenyang Machine Tool Co., Ltd., Liaoning Cheng Da Biotechnology Co., Ltd. and other enterprises only leave email or fixed telephone, lacking efficient communication tools such as instant chat and AI customer service. In terms of financial disclosure, only large groups such as Dalian Wanda Group Co., Ltd. have relatively standardized English financial reports, while most other enterprises have not disclosed key financial data to the public, which is difficult to meet the information needs of overseas investors.
- (3) International adaptability and promotion ability are generally weak. First, there is a lack of coverage in small languages, and all foreign language websites of enterprises are mainly English, which is not aimed at the market layout of small languages in Southeast Asia and Europe, and cannot match the mother tongue browsing habits of some overseas customers; Second, the international customer service is lagging behind, the after-sales response mechanism is not perfect, and there is no service channel suitable for multiple time zones. Third, the website promotion is insufficient, most enterprises do not optimize for overseas mainstream search engines such as Google, and rarely conduct website drainage through overseas industry platforms and social media. Fourth, the convenience of overseas use is poor, and some websites have problems such as slow loading speed, poor adaptation of mobile terminals, and currency units not automatically switched to target market currencies.

4.3. Suggestions for improvement

- (1) Optimize the international expression of corporate image discourse. For heavy industrial enterprises with a long history, the visualization section of “Historical Milestone” can be added, and the time axis can be used to match the cases of overseas major projects to connect the development process of the enterprise. The expression of business philosophy needs to be adjusted in combination with the culture of the target market^[9]. A professional foreign language writing team and a Translation Quality Assessment Model^[10] can be employed to avoid Chinese literal translation, translate slogans such as “Quality First” into expressions in line with the international business context such as “Committed to consistent quality assurance”. In the organizational structure part, the functions and contact information of overseas branches and cross-border project departments are clearly marked to enhance the docking efficiency of overseas cooperation.
- (2) Enrich the presentation and interaction of public relations discourse. On the one hand, supplement high-

quality multimedia content, such as Ansteel Group Co., Ltd. can add intelligent workshop video for steel production, Neusoft Co., Ltd. can add short films of overseas application scenes of software products, and Liaoning Cheng Da Biotechnology Co., Ltd. can produce animation of vaccine research and development process. On the other hand, broaden communication channels, deploy LiveChat and WhatsApp floating buttons for automatic time zone switching, reduce the required items in inquiry forms to less than 5 items, and enhance customers' communication willingness. In addition, financial disclosure needs to be standardized. Listed companies should regularly publish multilingual financial summaries, and non-listed companies can disclose key data such as core business revenue and overseas market share to enhance overseas trust.

- (3) Fully upgrade the adaptability and promotion of internationalization discourse. First, promote multilingual adaptation, give priority to increasing mainstream trade languages such as Spanish and German, and add exclusive language sections for key overseas markets; Second, optimize overseas use experience, use CDN to accelerate and compress picture formats to improve loading speed and realize automatic switching of currency and measurement units. Third, strengthen international promotion, embed keywords from overseas search engines and cooperate with international websites and social media to drain them. Fourth, improve international customer service, build a AI customer service system based on the industry knowledge base, respond to consultation 24 hours a day, sort out the information of overseas after-sales outlets, and clearly mark the maintenance and technical support process.

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Pushing Open Another Door: A Preliminary Exploration of the Modernist View of Truth

Hao Dong*

Aviation University of Air Force, Changchun 130022, Jilin, China

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Abstract: The view of reality has always been a controversial topic, whether it is the classicist school or the realist school, there is a relatively complete definition of the view of reality. However, the modernist view of truth is different, it pursues not only the truth in real life, but also requires a more nuanced description of the truth in the depths of the soul, so it may be closer to the essence of truth. Through the discussion of the modernist view of truth, this paper aims to reveal that the definition of truth itself is actually a long process of continuous development and change.

Keywords: Modernism; View of reality; Realism

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1. Introduction

In the 20th century, various literary genres rose and fell, separated and merged, and merged to form a literary tide. In this wave, modernist literature undoubtedly plays a pivotal role. It stands out for its many genres, wide influence, and opposition to traditional literature. The modernist view of reality also provides people with a new perspective and opens a door to the cognitive world.

2. Concept of Modernism and its view of Reality

Since we want to explore the true view of modernism, we might as well clarify such a concept, what is modernism? There are different opinions about the definition of modernism. Modernist literature refers to the general term for various literary trends that have emerged in the West since the 20th century and have rejected traditional literature and innovated in terms of literary and artistic content and form. Its main trends and genres are: late symbolism, futurism, expressionism, stream of consciousness, existentialism, surrealism, absurdist drama, new fiction, black humor, etc. The common characteristics of modernist literature are that it emphasizes writing about the subjective world, attaches importance to psychological truth, and believes that art is expression and creation, not imitation and reflection. Pay attention to form, believing that content is form, and form is content. In terms of creative content, it focuses on expressing crisis awareness, self-pursuit and alienation. Commonly used artistic

techniques are symbolism, grotesqueness, free association, inner monologue, etc. Modernist literature occupies an important position in Western literature in the 20th century, exposing and expressing various shortcomings and insurmountable contradictions in modern society, opening up new themes for literary creation, expanding the scope of literary expression, and creating some new writing techniques.

Through the above understanding of modernism, it is not difficult to find that the modernist view of truth is actually a subversion of the traditional literary view of reality, and the modernist school opens the way for its own creation by criticizing and crusading the realism that preceded it. In realism, reality exists in various phenomena of reality; Modernists believe that reality exists in the inner consciousness of individuals. Modernist writers oppose the imitation and reproduction of reality by realism, believing that this creative method can only lead to simply copying life and listing life phenomena, and it is difficult to achieve "higher reality". The surrealist writer Breton said in the Surrealist Manifesto: "From St. Thomas to Anatole Francis, borrowing from positivist realism, is in my opinion completely opposed to any spiritual and ethical development, and I hate it because it is made up of mediocrity, hatred and vulgar complacency." Russian futurist writers also declared in their manifesto that they would "throw Pushkin, Dostoevsky, Tolstoy, etc., out of the steamer of modern life." And "we look from the towering skyscrapers to see how small they are!" ..."

Looking back at history, we can clearly see that realist writers advocate truth and never doubt that they may obtain truth to the greatest extent. However, this truth can only be the truth in the consciousness of the literary subject, and therefore it can only be the individual truth and the imaginary truth. Truth is just the wishful thinking of writers, even if a writer like Balzac who can grasp the truth of social history as a whole is still an individual, he can only observe history and society from an individual perspective. Maupassant has long pointed out that everyone has their own reality in their body and mind, and human senses are very different, so there are as many people as there are realities. The definition of truth in various schools of modernism in the 20th century is far from realism. In Proust's "Remembrance of the Passing Years", reality is a certain connection between the feeling and memory surrounding the subject; Virginia Woolf regarded the atomic facts in people's hearts as real; The French New Novel School directly subverted the principle of the wholeness of truth, believing that truth is a concept that has never been completed and is always in change, and every innovation of the artist is to recreate a kind of reality; Surrealists believe that the subconscious, dreams, hallucinations, and instincts are the source of artistic creation, and in order to pursue psychological truth, they advocate unconscious writing, believing that there can be no artistic considerations and the pursuit of beauty when writing, and that any rational factor must be rejected, and everything presented or experienced in the original recorded illusions or dreams is regarded as real. They even advocated hypnosis, allowing writers to be hypnotized in a dark room, making them dream and record them by others, and thinking that this was the best creation. In this way, the undoubted objectivity and authenticity of classical realism are disintegrated by complex and even conflicting subjective realities, and become chaotic psychological fragments.

In fact, almost all literary changes, as far as the inside is concerned, are changes related to the concept of truth. After the old picture of reality collapses and is shattered, the new generation faces a new real situation, which requires a new artistic way to convey this new reality, and change occurs. The reality of Kafka's beetle, the reality of Proust's memory in his new view of time and space, the reality of Borges' labyrinth, and the reality of Rober-Grier's objects, etc., are all mutated or broken truths. The real pictures that arise from them just appropriately express the different spiritual situations of modern people. In this way, the changes brought about by modernism are nothing more than changes in reality and the means of conveying this truth. The basic

characteristics of modernism are more fully displayed, that is, it no longer emphasizes the true reproduction of objects, but emphasizes the expression of subjectivity, the expression of subjective instincts and subconscious, and the pursuit of psychological truth. It focuses on the writer's self-feeling, insists on exploring the inner heart of people, and expresses mental images and touch feelings. Modernist writers believe that objective reality is nothing more than the appearance of people, and subjective reality is the essence; Only by breaking through objective reality to express subjective reality is the "highest truth". Therefore, we should start from the subject's feelings and feelings to describe reality, so that art can depict the spirit and express the truth of the soul. The truth of art does not lie in its similarity to the objective world, but in the degree of individual awareness of the unique feelings of the world that it expresses. The reality of things is replaced by the reality of people, which is where the modernist view of reality lies.

3. Discussion on the Reality and its modern explanation

This leads to two levels of truth: one is the truth seen by the writer, that is, the material truth; One is the reality experienced by the writer, that is, the psychological truth. Those works that describe material reality are full of materialism, and the basis behind them is positivism. For a person who has lived through the great journey of twentieth-century literature, eye-centered positivism certainly does not excite him anymore, because there are studies that show that the human eye cannot accept the information it sees without prejudice, it always selectively selects the material. The main feature of twentieth-century literature is the extreme development of imagination, which brings the writer the freedom of mind that greatly compensates for the limitations of the eyes. The transcendent imagination allows the writer's experience to go deep into the interior of the era. What the realist writer sees is only a phenomenon (and only a small part of it), it is only responsible for the writer's own experience, memory, traditional artistic habits, but most likely not for the zeitgeist that has moved forward. This is why we admire Balzac's greatness on the one hand, but on the other hand, we can no longer observe the current era in Balzac's way. Each era has its own different way of presenting the truth, and there are also different essences about the truth, and if a writer wants to get close to this truth, he must use his mind obviously greater than his eyes. Most of the modernist writers of the twentieth century did not hesitate to betray tradition and carry out very novel or even exaggerated practices in form or thought, in fact, in order to better get closer to the changed reality. Therefore, there is no truth that the writer sees, only the truth that the writer experiences. Further, why is reality still shocked when reality has been deformed, distorted, and even unrecognizable in the writer's pen? This shows that the standard of truth in art is not to refer to the external logic of daily life, but to what extent it reveals the essence of the human spirit. We can't read much about the characteristics of reality from the appearance of Kafka's novels, but the reality he expresses is profound and representative, so we still feel shocked when we read it now, which once again shows that psychological reality is more insightful, more infectious, and better able to reflect and grasp the essence of society and people than material reality.

4.The Philosophical Foundations of the Modernist Concept of Reality

4.1. The Subversion of the Myth of Rationality by Irrationalism

Nietzsche's proclamation that "God is dead" fundamentally shook the foundations of Western rationalism, providing the philosophical premise for the birth of the modernist concept of reality. Schopenhauer's philosophy of the will and Bergson's theory of life impulse further shifted the literary focus from the rational world to irrational life instincts. Kafka's *The Metamorphosis* begins with the irrational event of "Gregor Samsa turning

into a giant insect,” profoundly revealing the fragile nature of modern rational order. Once the protagonist loses his instrumental value as a “breadwinner,” the seemingly strong emotional bonds in family relationships quickly disintegrate, with familial warmth replaced by naked disgust and abandonment. This plot development directly addresses Nietzsche’s critique of “rational alienation”—in highly industrialized societies, human relationships are reduced to purely instrumental connections, and the illusory facade of civilization constructed by rationality collapses when individuals lose their utility.

T.S. Eliot’s *The Waste Land* opens with the declaration that “April is the cruellest month,” a complete reversal of traditional aesthetic values that embodies the deep deconstruction of existing value systems by irrationalism. On the “wasteland” where “God is dead,” spring, a symbol of vitality and hope, no longer brings comfort but becomes a source of pain “mixing memory and desire.” This reinterpretation of natural imagery marks the establishment of a radically different standard of truth in modernist literature.

4.2. Psychoanalysis and the Exploration of the Unconscious

Freud’s psychoanalytic theory opened a new path for modernist literature to explore the psychological reality of the human mind. The discovery of the unconscious greatly expanded the domain of literary representation, making the complexity and contradictions of the inner world the core concern of modernist writers. In *In Search of Lost Time*, Proust vividly demonstrates how the taste memory triggered by the “madeleine” breaks the boundaries of time and space, freely moving between past and present. The use of this “stream of consciousness” technique is essentially a literary practice of Freud’s “determinism of the unconscious,” showing that beneath the surface of rational consciousness, the undercurrents of desire, trauma, and memory dominate human mental activity.

Faulkner in *The Sound and the Fury* takes the depiction of the unconscious to an even more extreme level. Through the chaotic monologue of the idiot Benjy, Quentin’s pre-suicidal hallucinations, and Jason’s paranoid delusions, the novel constructs a fragmented and complex psychological landscape, directly confirming Freud’s theory of the “id, ego, and superego.” This multi-layered portrayal of the inner world allows modernist literature to achieve unprecedented depth in exploring psychological reality.

4.3. Existentialism and the Perception of the Absurd

Existentialist philosophy provided modernist literature with a new perspective to examine the human condition. Camus’ philosophy of the absurd and Sartre’s theory of radical freedom prompted writers to shift their focus from the external world to the essence of individual existence. Beckett’s *Waiting for Godot* portrays the absurdity of modern existence through the hopeless waiting of two tramps. The characters’ waiting for “Godot” has no clear object or purpose, and the cyclical promise that “Godot will come tomorrow” mirrors the futile search for ultimate meaning in modern life. When traditional meaning-givers—religion, reason, and science—have all failed, the act of waiting itself becomes the most powerful proof of the absurd.

This sense of absurdity does not lead to complete nihilism. As Camus pointed out, the clear awareness of the absurd becomes the starting point for human resistance. By directly confronting and representing the absurd, modernist literature seeks to rediscover the value and possibilities of existence in the ruins of collapsed meaning.

5. Theoretical Criticism of the Modernist Conception of Reality

The academic community has offered diverse interpretations and critiques of modernist views on reality:

Epistemological Perspective: Some scholars have explored the concept of truth in modernist painting from an epistemological standpoint, arguing that modernist painting broadly refers to all works created in ways distinct from traditional methods, holding an exceptionally significant position in the development of Western 20th-century art.

Philosophy of Authenticity: Jin Guantao proposed the concept of “philosophy of authenticity” in **The Vanishing Real: Intellectual Dilemmas of Modern Society**. He argued that authenticity originally served as three interconnected bridges spanning the empirical world and the symbolic world, but today our inner world lacks the keystone to support these bridges.

The Diversity of Aesthetic Realism: In discussions surrounding Western modernist literature and art, the issue of the authenticity of artistic works arises. Indeed, no Western modernist artist considers their work to be unreal, nor is there any Western modernist literary or artistic movement that does not claim to embody truth.

Cross-disciplinary Comparative Study: Scholars have compared the history of cinema and art history from the 1980s, revealing that the concept of truth exhibits both commonality and variability. Commonality manifests as the pursuit of truth “from technique to concept,” while variability is demonstrated by the often cross-cultural validation of the notion of truth.

6.The Influence and Significance of Modernist Realism

The modernist view of reality has exerted a profound influence on literary and artistic creation as well as theoretical criticism since the 20th century. **Expanding the Boundaries of Reality:** The modernist conception of reality breaks away from the traditional realist pursuit of objective truth, extending the notion of reality to include subjective experiences, psychological states, and formal innovations, thereby vastly enriching the possibilities of artistic expression. It reflects the dilemmas of modernity: by portraying alienation, absurdity, and irrationality, the modernist view of truth profoundly reveals the spiritual predicaments of modern society and human existence, serving as a crucial perspective for understanding the crisis of modernity. It fostered the innovation of artistic forms: the modernist view of reality gave rise to various artistic movements and creative techniques such as stream of consciousness, surrealism, and expressionism, driving the comprehensive innovation of literature and art in the 20th century. **Inspired postmodern thought:** The modernist perspective on truth, which questioned and deconstructed the traditional concept of truth, laid the foundation for postmodernism’s critique of “grand narratives,” serving as a crucial precursor to postmodern intellectual trends.

However, one thing worth noting is that the concept of truth is becoming more and more blurred now, and many modern writers are actually analyzing the truth while expressing the truth. For classical writers, it is to tell the truth, but for modern writers, truth is no longer a clear fact that is easy to explain. Especially because modern people are increasingly losing confidence in understanding the world and themselves, real karma has become one of the problems that plague writers. Careful people may notice that the literature of the twentieth century strengthened the element of fantasy, and sometimes writers deliberately blurred the line between truth and illusion, because modern people have lost the courage and ability to affirm the truth, because the result of the lack of rationality, morality, and value is to make people lose their trust, aphasia, and loss, and then make people live in a situation of psychedelic chaos.

Rollo May, a contemporary American thinker, once said: “My personal belief has always been to seek inner truth. This may also express the voice of modernist writers. It is precisely because they are not satisfied with the

real experience they have that they begin to search for inner truth in this increasingly shallow age, with the aim of getting closer to the spiritual core of this era. We might as well say that modernism opened the door to the world of psychic cognition, and on the way to explore, it seemed that a voice came from afar: “Come in!” Give you the truth!

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An Analysis of Paths to Enhancing the Sustained Participation Willingness of Primary Militia Based on Multi-Theory Integration

Jingyuan Chen*

College of Systems Engineering, National University of Defense Technology, Changsha 410000, Hunan, China

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Abstract: Primary militia are a crucial component of China's armed forces, and the stability and combat effectiveness of their contingent directly affect the effectiveness of national defense mobilization. However, under the conditions of a market economy and prolonged peace, the characteristics of annual reorganization and high personnel mobility pose challenges to the sustained participation willingness of primary militia. Based on social exchange theory, psychological contract theory, and self-determination theory in organizational behavior, this paper proposes specific measures to enhance the sustained participation willingness of primary militia from four dimensions: optimizing institutional guarantees, innovating management models, strengthening spiritual incentives, and constructing a supportive environment. The research aims to provide reference for strengthening the construction of militia contingents in the new era.

Keywords: Primary militia; Sustained participation willingness; Organizational behavior; Countermeasures

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1. Introduction

Militia are a mass armed organization led by the Communist Party of China that does not separate from production. They are part of the armed forces of the People's Republic of China and serve as assistants and reserve forces of the Chinese People's Liberation Army^[1]. As the backbone of the militia organization, the level of primary militia's sustained participation willingness directly impacts the stability of the militia contingent and the quality of militia training. Therefore, enhancing their sustained participation willingness is conducive to strengthening the construction of primary militia contingents and improving the efficiency and quality of national defense mobilization.

1.1. Research Background

As a key component of China's armed forces, the generation and maintenance of primary militia's combat effectiveness are directly related to the effectiveness of national defense mobilization. Currently, primary militia

organizations implement a dynamic management model of “annual reorganization.” While this mechanism ensures the vitality of the contingent, it also poses severe challenges to the long-term retention of core backbones. At present, the low sustained participation willingness of primary militia in some regions cannot be ignored—their enthusiasm for participating in training and performing tasks is insufficient, and problems such as difficulty in gathering personnel, implementing scheduled time, and carrying out activities are prominent. Against the backdrop of deepening market economy development and prolonged peace, how to effectively address the tension between personal development, family responsibilities, and national defense obligations, and stimulate the sustained participation enthusiasm of primary militia, has become an important issue urgently needing to be resolved in militia construction in the new era.

1.2. Research Significance

At the theoretical level, this study applies social exchange theory, psychological contract theory, and self-determination theory from organizational behavior to the special group of primary militia, expanding the explanatory boundaries of these theories and providing a new perspective for understanding the sustained participation behavior of members of quasi-military organizations. At the practical level, exploring effective paths to enhance sustained participation willingness can provide theoretical basis and action reference for optimizing militia work policies and innovating management models, which has positive practical significance for consolidating the foundation of national defense reserve force construction.

1.3. Research Content

This paper aims to systematically explore specific measures to enhance the sustained participation willingness of primary militia. First, on the basis of defining core concepts and elaborating theoretical foundations, it analyzes the current status and challenges of primary militia’s participation willingness. Then, the core part of the paper focuses on constructing countermeasures, systematically proposing a set of interconnected and synergistic enhancement paths from four dimensions: improving institutional guarantees, innovating training management, strengthening spiritual incentives, and building a supportive environment.

1.4. Research Methods

This study mainly adopts literature research and theoretical analysis methods. By systematically sorting out academic literature and policy documents related to organizational commitment and militia management at home and abroad, combined with social exchange theory, psychological contract theory, and self-determination theory, in-depth theoretical deduction and analysis are conducted to construct the logical framework and countermeasure system of this paper.

2. Related Concepts and Theoretical Foundations

2.1. Core Concepts

2.1.1. Primary Militia

According to the provisions of the “Regulations on Militia Work of the People’s Republic of China,” primary militia refer to the backbone forces selected from the Chinese militia organization based on political, physical, and professional conditions. Compared with ordinary militia, primary militia implement the team-building standards of “organizational implementation, political implementation, and military implementation.” Their core feature

lies in being “both soldiers and civilians”: they engage in their own occupations in daily life, participate in regular military training, and shoulder the important missions of being the first to be mobilized for military service, supporting the front line, and defending the rear in wartime or emergency situations. The key to understanding primary militia lies in grasping the duality of their identity, the legality of their obligations, and the particularity of their management.

2.1.2. Sustained Participation Willingness of Primary Militia

The sustained participation willingness of primary militia refers to the stable psychological tendency and behavioral intention of individuals who meet the recruitment criteria of primary militia and have joined the militia organization. Based on recognizing the core responsibilities of primary militia—“serving in peacetime, responding to emergencies in times of crisis, and engaging in warfare in wartime”—and the institutional premise of “annual reorganization” of primary militia, they voluntarily continue to participate in organizational tasks such as militia training, combat readiness duty, and emergency rescue in the future period, and take the initiative to maintain their membership and participation enthusiasm. From the perspective of the stability of the primary militia contingent, a high level of sustained participation willingness is the cornerstone of contingent stability. When primary militia have a strong willingness to participate, the personnel turnover rate will decrease, and the organizational structure and personnel allocation of the contingent can remain relatively stable. This is conducive to forming a tacit cooperative relationship within the contingent, accumulating work experience, and improving overall combat effectiveness.

2.2. Research Theories

This study mainly relies on the following three theories, which explain the psychological mechanisms affecting the relationship between individuals and organizations from different perspectives.

2.2.1. Social Exchange Theory

Social exchange theory holds that all human social activities can be regarded as exchange behaviors, and exchange relationships are formed on the basis of mutual benefit. That is, when one party provides help or support to the other, the other party has the obligation to repay, but the repayment behavior cannot be predicted, so this exchange relationship is uncertain and risky^[2]. Only based on trust can it further develop into a long-term exchange relationship. The core of embedding this theory into the governance practice of primary militia is to enhance their consciousness of sustained participation, and the key is to build a “social exchange agreement” with both stability and fairness. Primary militia invest time, bear task risks, and fulfill their responsibilities for the organization; the organization needs to provide corresponding returns and guarantees through standardized mechanisms. When primary militia perceive the fairness of this exchange, their consciousness of sustained participation will be significantly enhanced.

2.2.2. Psychological Contract Theory

The psychological contract has narrow and broad senses. In the broad sense, the psychological contract refers to the sum of a series of unwritten expectations existing between each member of the organization and between members and leaders. It includes two levels: individual-level expectations and organizational-level expectations. In the narrow sense, the psychological contract refers to the belief system of employees’ individual responsibilities

and obligations between themselves and the organization in the context of employment relations. It is a two-way relationship based on employees' subjective cognition, emphasizing employees' individual perception of the responsibilities the organization should bear and the responsibilities they themselves should assume^[3]. The psychological contract reflects a series of subtle and implicit psychological expectations held by the organization and employees towards each other. While expecting the other party to meet certain expectations, they hope the other party will behave in a way they desire. Applied to the group of primary militia, the content of the psychological contract includes in-depth expectations such as organizational care, skill training, social recognition, and sense of honor and belonging. If organizational management practices fail to meet the psychological expectations of primary militia, there is a risk of psychological contract breach leading to negative emotions and further reducing participation willingness. Therefore, understanding and proactively managing the psychological contract of primary militia is of great significance for maintaining their participation willingness.

2.2.3. Self-Determination Theory

Self-determination theory is a cognitive theory proposed by Deci and Ryan in the 1980s to explain human intrinsic motivation. It holds a metatheoretical belief in positive human nature and insists that everyone has internal resources to promote development and change. The theory believes that people will have a tendency towards self-integration, improvement, and learning with the support of society and the external environment, and the relationship between individuals and the environment is an organic interaction^[4]. Applying this theory to primary militia means that their participation willingness can come from experiencing autonomy, competence, and relatedness in the organization, transforming their participation behavior from "being required to participate" to "wanting to participate."

2.3. Analytical Framework of This Study

Based on the core concepts and related theoretical foundations defined earlier, this study proposes a systematic countermeasure path to enhance the sustained participation willingness of primary militia by constructing an analytical framework: taking social exchange theory as the core support to form the countermeasure of "improving institutional guarantees," implementing the organization's relevant responsibilities in the "explicit contract" by building a fair and credible system of salary, welfare supply, and rights protection, meeting the most basic exchange demands of primary militia and laying a solid material and safety foundation for their sustained participation; establishing specific measures of "building a supportive environment" under the guidance of psychological contract theory, focusing on fulfilling the mutually default "implicit contract," deepening military-civilian cooperation, strengthening family care, and enhancing social recognition to respond to the primary militia's demands for social emotions such as respect and belonging, and consolidating the emotional connection with the organization; relying on self-determination theory to set corresponding "innovative training management models" and "strengthened spiritual incentive mechanisms," optimizing training content and implementation forms to meet individual needs for ability development, implementing participatory management to meet the demand for autonomous choice, building an honor system and fostering organizational culture to respond to the need for relatedness, activating the intrinsic motivation of primary militia from the source, and forming an inherent and sustainable participation willingness. The three theories complement each other and jointly focus on the core goal of enhancing the sustained participation willingness of primary militia. The following will elaborate on specific implementation methods in detail from four dimensions based on this analytical framework.

3. Countermeasures to Enhance the Sustained Participation Willingness of Primary Militia

3.1. Improve the Institutional Guarantee System and Lay the Material Foundation for Sustained Participation

Institutional guarantee is a fundamental condition for stimulating and maintaining the sustained participation willingness of primary militia. A sound institutional system can not only solve the worries of militia but also enhance the credibility and attractiveness of the organization through clear expectations and stable returns.

3.1.1. Establish a Scientific and Reasonable Salary and Welfare System

Relevant military and local departments should improve the social insurance system for primary militia, and in accordance with regulations, guarantee accident insurance and medical insurance for primary militia during training and task execution. On the basis of maintaining the original standards of wages, bonuses, and other welfare benefits of primary militia during training and task execution, explore the establishment of a subsidy system for primary militia and clarify the on-duty subsidy standards. Implement a differentiated subsidy payment standard for primary militia based on differences in professional positions, skill levels, and task types, in line with the core principle of “distribution according to work and rewarding excellence.”

3.1.2. Improve the Comprehensive Rights Protection Mechanism

Establish a coordination mechanism for protecting the rights and interests of primary militia to provide professional legal support for militia; smooth the green channel for protecting the rights and interests of militia, and give priority to accepting and quickly handling cases involving the rights and interests of militia. Focus on the career development rights and interests of primary militia. Incorporate militia service experience into the personal professional credit system as an important reference for employment, entrepreneurship, loans, and other important social activities. For primary militia who start their own businesses, provide supportive policies such as entrepreneurial guaranteed loans and tax reductions and exemptions, transforming the militia identity from a “political honor” into visible “social capital.”

3.1.3. Optimize the Pension and Preferential Treatment Policy System

For primary militia who are injured, disabled, or sacrificed during training, exercises, or task execution, as well as their families, a sound pension and preferential treatment policy system should be established. In accordance with relevant national regulations, timely and fully issue pension funds, and establish a mechanism for increasing pension standards in line with the level of economic and social development. At the same time, pay attention to humanistic care, establish a regular visit and condolence system, and promptly understand and solve the actual difficulties in the lives of disabled militia and the families of martyrs.

3.2. Innovate Training and Management Models and Enhance the Intrinsic Attractiveness of Sustained Participation

The quality and effect of training and management are directly related to the participation experience and sense of gain of primary militia. Innovating training and management models is a core link in enhancing the sustained participation willingness of primary militia.

3.2.1 Promote the Reform of Training Content and Methods

The practicality and combat effectiveness of training content are important factors affecting the participation motivation of primary militia. Efforts should be made to promote the innovation of training content, closely follow actual combat needs and the reality of militia, and increase the proportion of practical skill training such as emergency rescue, disaster prevention and reduction, and UAV operation. In terms of training methods, on the basis of training in accordance with regulations, modern training methods such as simulated confrontation and artificial intelligence should be actively introduced to improve the technological content and actual combat atmosphere of training. Break the traditional model of “you speak and I listen, you teach and I practice,” and vigorously promote discussion-based, case-based, and experiential teaching methods to enhance the interactivity and participation of training.

3.2.2. Implement Participatory and Active Management

In the management of primary militia, full respect should be given to the subject status of militia, a militia representative conference system should be established to regularly listen to the opinions and suggestions of militia on management work, and enhance their sense of autonomy. Establish a mentor system of “veterans leading new recruits,” allowing experienced militia to take on the role of trainers, which not only recognizes their abilities but also strengthens the sense of belonging within the team. Establish a talent pool of militia, focus on training outstanding militia, and provide opportunities for promotion to militia cadres or recommendation to more important positions.

3.2.3. Improve the Assessment, Evaluation, and Incentive Mechanism

Establish a scientific assessment and evaluation system, taking the performance of militia in training, mastery of skills, and quality of task completion as core evaluation indicators to correctly guide the behavioral direction of primary militia. In terms of the incentive mechanism, a point-based management system can be implemented, quantifying participation, training results, and task performance into points, which serve as important bases for selecting excellent individuals and promoting militia cadres. Government departments can appropriately set up a special reward fund for primary militia, and give additional performance rewards to those who perform outstandingly in major exercises, training, flood control, disaster relief, and other tasks.

3.3. Strengthen Spiritual Incentives and Organizational Identity and Consolidate the Ideological Foundation for Sustained Participation

Spiritual incentives and organizational identity are high-level needs beyond material incentives^[5], and have special significance for the group of primary militia with a dedication color. Strengthening spiritual incentives and enhancing organizational identity are powerful spiritual motivations for improving the sustained participation willingness of primary militia.

3.3.1. Construct a Multi-Level Honorary Commendation System

A four-level honorary system for primary militia covering the national, provincial, municipal, and county levels can be established to form a hierarchical and comprehensive commendation pattern. In addition to the annual summary and commendation, an immediate commendation mechanism can also be established to give circular praise, medals, and other rewards to those who perform outstandingly in daily training and community services. Actively coordinate local media to publicize the advanced deeds of excellent militia, and set up a column “Militia

Style” in newspapers, television, the Internet, and other media. Through grand ceremonies and extensive publicity, enhance the professional pride and sense of honor of militia.

3.3.2. Deepen Organizational Culture Construction and Identity

Efforts should be made to strengthen the organizational culture construction of primary militia and create a distinctive militia cultural brand. By regularly organizing militia days, military camp open days, and other activities, enhance the sense of belonging and identity of militia to the organization. Continuously strengthen the construction of militia’s identity through forms such as enlistment oaths and regular organizational life. Carry out education on “excellent traditions of militia” to cultivate their sense of historical mission and responsibility. Organize thematic education activities in conjunction with major festivals and anniversaries to integrate the red gene into the blood of militia.

3.3.3. Strengthen the Guidance of Mission and Value

Adopt methods such as theoretical lectures, situation analysis, and case teaching to help militia recognize the current security challenges, and enhance their sense of crisis and mission. Pay attention to linking macro national security with the specific responsibilities of militia, making them realize the direct connection between their own work and national security and social stability. Through continuous value guidance, enable primary militia to integrate the realization of personal values into the cause of national defense, forming an internal and lasting participation motivation.

3.4. Build a Social Support Network and Create a Good Atmosphere for Sustained Participation

Individual behavioral choices are deeply influenced by the social environment^[6]. Building an extensive social support network and creating a social atmosphere of “honor to be a militia” are important external conditions for enhancing the sustained participation willingness of primary militia.

3.4.1. Strengthen Military-Civilian Coordination and Policy Connection

Promote the inclusion of primary militia work into the performance appraisal system of local Party and government leaders to enhance the attention paid by local governments to militia work. At the policy level, strengthen the connection and matching of military and local policies. Clarify the responsibilities and obligations of enterprises and institutions in supporting militia work to ensure that the salary and treatment, promotion, and other aspects of militia are not affected during their participation in training and task execution. Provide policy incentives such as tax reductions and exemptions and priority in projects for enterprises and institutions that actively support militia work, forming a positive interaction mechanism.

3.4.2. Expand Family Support and Community Participation

A care mechanism for militia families should be established to regularly carry out visits and condolence activities, and establish militia family service centers as appropriate to provide help for family members in employment training, child care during tasks, and other aspects. Organize the selection of “excellent militia family members” to enhance the sense of honor and support of family members. Organize militia to participate in community security patrols, civilized city creation, voluntary services, and other activities to enhance their social identity and sense of existence. Community militia workstations can be established in conjunction with village and community militia

companies to serve as a bridge between militia and the community.

3.4.3. Cultivate a Social Culture of Respecting the Military and Valuing Martial Spirit

Strengthen national defense education for all people, and integrate the concept of integrated military-civilian development into the national education system. Take the opportunity of National Defense Education Day and National Defense Education Month to organize various forms of publicity and education activities to improve the social awareness of militia work. Guide the media to actively publicize the status and role of militia and their advanced deeds, showing the good image of militia in the new era. Through continuous cultural cultivation, form a good social atmosphere of caring for national defense and supporting militia in the whole society, providing a profound social foundation for militia work.

4. Conclusion

Enhancing the sustained participation willingness of primary militia is a systematic project that requires joint efforts and comprehensive measures. The countermeasure system constructed in this paper from four dimensions—institutional guarantees, training management, spiritual incentives, and social support—takes into account the special requirements of primary militia as “soldiers” and their ordinary needs as “civilians,” reflecting the unity of rights and obligations, incentives and constraints, and material and spirit. Enhancing the sustained participation willingness of primary militia requires continuous exploration and innovation. Only by adhering to systematic thinking and taking multiple measures can we effectively stimulate the intrinsic motivation of primary militia, making them a reliable reserve force that “serves in peacetime, responds to emergencies in times of crisis, and engages in warfare in wartime,” and providing solid guarantees for consolidating national defense and maintaining social stability.

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Analysis of the Relationship between Mobilization Uncertainty and Flexibility Based on the “Effective Response Dimension” Framework

Meichao Chen¹, Yong Xue^{1*}, Chengdong Zhang²

¹Aerospace Engineering University, Beijing 101416, China

²Unit 32006, Beijing 100080, China

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Abstract: Modern social mobilization systems are becoming increasingly complex, leading to significant uncertainty in the mobilization process. This paper introduces the concept of “Effective Response Dimension” to quantify the complexity of mobilization systems, namely the number of key decision-making nodes in the mobilization system (truncation dimension, k_t) and the order of collaboration among mobilization departments (superposition dimension, k_s). Utilizing flexibility’s ability to quickly adapt to changes and modularly reorganize resources, this study reduces the effective response dimension or provides compensation, conducts more comprehensive simulation assumptions for resource allocation, process regulation, and social collaborative mobilization, suppresses the growth of uncertainty, and generates more accurate mobilization decisions.

Keywords: Mobilization; Effective Response Dimension; Uncertainty; Flexibility

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1. Introduction

Mobilization refers to responding to sudden events that disrupt social order during social development, such as natural disasters, financial crises, and supply chain disruptions. National mobilization systems are increasingly large and complex. Liu Jia ^[1] argues that mobilization-based governance has become one of the necessary means for the whole society to jointly respond to sudden public crises. Wu Chunxiao ^[2] points out that the resources that government governance needs to mobilize include three aspects: human resources, organizational resources, and material resources. Yong Linyi ^[3] notes that the formation of resource mobilization capacity relies on the collaborative support of multiple conditions. Traditional mobilization models have evolved into comprehensive supply chain mobilization involving universal participation, gradually forming a comprehensive mobilization system with cross-field, cross-departmental, and even transnational coordination. A refined mobilization simulation

process can form an ideal mobilization plan. However, in the actual implementation of mobilization, the reliability of mobilization actions lacks reference data from social practice for verification. In the absence of a standard scope, overly idealized mobilization processes increase complexity and uncertainty risks, making it difficult to effectively control mobilization effects.

2. Analysis of Uncertainty Factors in Mobilization Actions

Mobilization refers to a series of activities in which the state, in response to the needs of the overall development strategy, mobilizes resources from various social fields into an emergency state, unifies the will of the whole people, transforms social potential into comprehensive strength, and coordinates the allocation of resources required for the development strategy. Usually, it constitutes a complete social mobilization process from mobilization preparation to mobilization implementation and then to demobilization. In this overall mobilization process, the uncertainty factors arising in the mobilization preparation stage, mobilization implementation stage, and mobilization demobilization stage are mainly analyzed.

2.1. Main Uncertainty Factors in the Mobilization Preparation Stage

Insufficient planning and anticipation capabilities to address deep uncertainty: Adequate social mobilization preparation lies in the prediction and planning of uncertainty. How to respond to uncertainty is a common challenge faced by mobilization planning in countries around the world. The state not only needs to overcome the risks brought by uncertainty but also balance risks and cost expenditures to avoid resource waste or social unrest caused by excessive planning. However, in general, there is a lack of sufficient planning and anticipation capabilities to cope with deep uncertainty.

Failure to break through the limited scope of traditional mobilization: At present, China's social development is in an upward stage with a stable development trend and few fluctuations. The thinking for formulating mobilization plans cannot break away from traditional mobilization scenarios and models, fails to fully combine specific scenarios for uncertainty analysis of varying degrees, and cannot fully guarantee and represent expected change needs. In a stable development period, traditional mobilization preparations can play a certain backup role, but in the future under special development trends, especially unprecedented changes dominated by the rapid development of emerging technologies, the problem of lacking the ability to break through traditional mobilization will become more prominent.

2.2. Main Uncertainty Factors in the Mobilization Implementation Stage

Short-term and long-term mobilization needs are constrained by mobilization plan budgets: In the process of mobilization implementation, most of the budget expenditures for both short-term and long-term mobilization needs are irretrievable. Due to the difficulty in identifying changes in long-term development strategy needs, mobilization tends to invest most of the budget in short-term demand adjustments and social operations under long-term development planning schemes. Although budget expenditures are scientific, continuous, and developmental, from the perspective of the overall development strategy, the lack of long-term planning means uncertainty in future development.

Rigid mobilization procedures lead to strong delay in development: The existing mobilization system and structural framework have long-standing certainty and continuity. However, it is precisely this fixed procedure and model that are more vulnerable to targeted attacks and destruction, becoming a fatal weakness. An overly

certain mobilization system has inert links, weak update capabilities, and hinders the overall process, resulting in a lack of flexibility and adaptability in the system. It cannot confront flexible and variable systems, leading to fatal consequences.

2.3. Main Uncertainty Factors in the Mobilization Demobilization Stage

Lack of sound institutional guarantees: The temporary nature of mobilization may lead to such actions being carried out in certain areas without institutional guarantees, resulting in problems such as disorderly division of powers and responsibilities, difficulty in fund settlement, and easily leading to unfinished tasks, shirking of responsibilities, or resource misallocation, which affects the subsequent promotion of mobilization.

Lack of effective feedback mechanisms: In the demobilization process, there is a lack of timely collection of actual demands, operational difficulties, and relevant suggestions during the implementation process, leading to the lack of dynamic evaluation of demobilization effects and summary of review experience. The lack of a closed loop generates uncertainty.

3. The “Effective Response Dimension” Analysis Framework

The mobilization system introduces the “Effective Response Dimension” analysis framework to quantify the mobilization process through “effective dimensions”, measure the connection between the complexity and uncertainty of each mobilization node, help formulate flexible measures according to the application background and purpose, adjust the mobilization process, and ensure the relative stability of the mobilization process lacking practical experience data.

3.1. Core Connotation

It reflects system complexity through the truncation dimension k_t and superposition dimension k_s , providing a quantitative and structured tool for the operation and evaluation of mobilization systems and other similar complex management systems. The truncation dimension k_t is the number of key elements in the system. Minor changes in key elements will significantly affect the core output of the system, such as the completion time of mobilization tasks and the quantity and quality of mobilized materials, reflecting how many non-negligible driving factors exist in the system and the complexity of these driving factors. The superposition dimension k_s is the highest order of collaborative effects that must be considered to explain most of the system’s behaviors, reflecting the complex, non-linear interactions between various departments and units as well as the connection complexity of the system.

3.2. Core Idea

It reflects that the essential complexity of a system is determined by its “effective response dimension” rather than the actual number of component structures; whether the uncertainty of the system can be effectively controlled depends on the allocation of the “effective response dimension” by flexibility, and the effectiveness of flexible measures is reflected through quantitative analysis.

3.3. Main Objectives

The application of this concept is consistent with the reality of insufficient experience in mobilization actions. In the absence of sufficient data verification, it judges whether an increasingly complex mobilization system has become more accurate or merely more uncertain and difficult to control. By quantitatively evaluating the actual

complexity of the mobilization system, tracing the source of output uncertainty, and using flexible means for regulation, the stable operation of the mobilization system is achieved.

3.4. Mathematical Principles of Complexity and Uncertainty

In mathematical models, the number of parameters and their connection modes are the main factors affecting the complexity of mathematical models^[4]. For models lacking verification data, such as those for trend prediction, exploring the potential impact of emerging technologies, and predicting potential risks in the natural environment, by focusing on the number of model components and their connection modes, we can establish the correlation between model complexity and uncertainty based on statistical principles with the help of the Analysis of Variance (ANOVA) decomposition framework and the concept of effective dimension^[4]. In the ANOVA decomposition framework, parameters are regarded as random variables, and their uncertainty is described by probability distributions—these distributions reflect the statistical errors, natural variations, inherent randomness, and subjective judgments of parameters.

Given the form $y = f(x)$, $x = (x_1, x_2, \dots, x_i, \dots, x_k) \in R^k$, where y is a scalar output and $x_1, x_2, \dots, x_i, \dots, x_k$ are k independent parameters, the proportion of variance transmitted by each parameter to y is calculated, namely the first-order effect S_i , the interaction between parameter pairs (second-order effect $S_{\{i,j\}}$), the interaction between parameter triples (third-order effect $S_{\{i,j,l\}}$), and so on up to the k -th order interaction.

For a model with only three parameters, its variance decomposition formula is $S_1 + S_2 + S_3 + S_{\{1,2\}} + S_{\{1,3\}} + S_{\{2,3\}} + S_{\{1,2,3\}} = 1$. This variance decomposition method is applicable to functions $f(x)$ that are square-integrable within the domain, and its theoretical basis is derived from Sobol's functional decomposition theory—which decomposes $f(x)$ into the sum of 1-dimensional, 2-dimensional, and up to k -dimensional subfunctions.

In multi-dimensional or computationally intensive models, it is often difficult to estimate interactions up to the k -th order. The calculation of the total-order effect T_i can be considered to capture the proportion of variance transmitted to y by the first-order effect of x_i and its interactions up to the k -th order. Taking x_1 in a three-parameter model as an example, its total-order effect can be expressed as $T_1 = S_1 + S_{\{1,2\}} + S_{\{1,3\}} + S_{\{1,2,3\}}$, and the same applies to x_2 and x_3 . Based on this, we now introduce the concept of effective dimension.

3.4.1. Effective Dimension in the Superposition Sense (ks)

Let $\lambda = \{1, 2, \dots, k\}$. For any subset $u \subseteq \lambda$, let $|u|$ denote its cardinality. In the “superposition sense”, the effective dimension of the model f is defined as the smallest integer ks that satisfies the following condition:

$$\sum_{0 < |u| \leq ks} S_u \geq p \quad (1)$$

where $0 < p < 1$. The preset threshold p is artificially set, and here we assume $p = 0.99$. Taking a three-parameter model as an example, we calculate up to which order of interaction effects can capture most of the variation P in the model output. That is, the sum of Sobol indices from the first order to the ks -th order accounts for p (99%) of the total variance. All its variance components are:

First-order effects: S_1, S_2, S_3 (impact of individual parameters)

Second-order interaction effects: $S_{\{1,2\}}, S_{\{2,3\}}, S_{\{1,3\}}$ (interaction impact between two parameters)

Third-order interaction effect: $S_{\{1,2,3\}}$ (joint interaction impact of three parameters)

The cumulative calculation is performed step by step from the first order to the third order until the cumulative sum meets or exceeds P , indicating that this order is the effective dimension of the model.

If the sum of first-order, second-order, and third-order effects still does not meet or exceed P , it means that a

large amount of variation is hidden in interactions of the fourth order and above. Due to the high computational difficulty, the model can be directly determined as a complex model.

[Figure: Operational Flowchart of Effective Dimension in the Superposition Sense]

Start Effective Dimension Analysis → Estimate Sobol indices through Monte Carlo and other numerical methods → Obtain specific numerical estimation results of Sobol indices → Calculate the sum of first-order effects ($S_1 + S_2 + \dots + S_k$) → Is the sum of first-order effects $\geq p$? → Yes: Determine effective dimension $k_s = 1$; No: Calculate the sum of first-order + second-order effects ($\sum S_i + \sum S_{\{i,j\}}$) → Is the sum of first-order + second-order effects $\geq p$? → Yes: Determine effective dimension $k_s = 2$; No: Calculate the sum of first-order + second-order + third-order effects ($\sum S_i + \sum S_{i,j} + \sum S_{i,j,l}$) → Is the sum of first-order + second-order + third-order effects $\geq p$? → Yes: Determine effective dimension $k_s = 3$; No: Determine effective dimension $k_s \geq 4$ → Output the final effective dimension.

3.4.2. Effective Dimension in the Truncation Sense (k_t)

Now consider the total-order index vector $T = \{T_1, T_2, \dots, T_k\}$. In the truncation sense, the effective dimension of the model f is defined as the smallest integer k_t that satisfies the following condition:

$$k_t = |C| = \{T_i \in T \mid T_i > q\} \quad (2)$$

where $|C|$ denotes the cardinality of the subset C , which is composed of elements T_i in T that satisfy $T_i > q$. This study assumes $q = 0.05$ as the screening threshold, which is a commonly used critical value in sensitivity analysis to distinguish “influential parameters” from “non-influential parameters”—that is, the dividing line between parameters that can transmit uncertainty to y and those that cannot. Models with a higher effective dimension in the truncation sense often contain a large number of influential parameters, thus presenting a larger k_t value.

Generally speaking, the hierarchical relationship $k \gg k_t \gg k_s$ will appear in the model, which stems from the low-order effect dominance characteristic and Pareto principle generally existing in mathematical models. The model actually exists in the space defined by k_t and k_s , rather than the space nominally defined by k —when the model contains a considerable number of non-influential parameters, the k value may be artificially inflated. The space defined by k_t and k_s cannot be simplified without changing the model behavior, and has irreducible complexity. Therefore, more complex models usually present higher effective dimensions in terms of k_t and k_s , and this growth will exacerbate output uncertainty. The larger the k_s dimension, the smaller the sum of first-order indices S_i . With the gradual increase of influential parameters, these high-order effects are activated. This is because the output variance of more complex models is increasingly driven by high-order effects.

4. Analysis of the Relationship between Flexibility and Uncertainty and Countermeasure Suggestions

In the information age, the random uncertainty of mobilization is mainly constrained by complex factors such as elements, structure, function, and operation. Complex conditions lead to increased uncertainty, while flexibility can effectively respond to uncertainty.

4.1. Complexity and Uncertainty of the Mobilization System

Although the mobilization process is specifically divided into three major steps: mobilization preparation, mobilization implementation, and demobilization, with corresponding institutional measures, the more detailed the expansion of action nodes in the actual mobilization process, the more likely it is to be carried out without standardization and normalization. This is because it is impossible to determine whether the added nodes can improve the efficiency of mobilization actions. We take the gradual complexity of emergency material supply chain mobilization as an example to illustrate the above relationship.

Model A: A simple central warehousing-direct distribution model. Its uncertainty mainly comes from transportation time and demand forecasting, with low k_t and k_s values.

Model B: On the basis of Model A, multiple regional distribution centers are added. The scheduling level and inventory capacity of multiple centers become new key parameters, increasing the system's k_t value. The k_s value may also increase due to the coordination needs between centers, leading to increased uncertainty.

Model C: On the basis of Model B, real-time path optimization algorithms and complex multi-modal transportation are introduced. Adding state parameters of transportation modes, as well as the coordination of transportation mode switching, information flow, and physical flow, achieves a high-order system with significantly improved k_t and k_s values. The output uncertainty reaches the highest level.

Flexibility Intervention: Implement flexible regulation in Model C, establish a sharing mechanism for transportation resources to reduce dependence on specific transportation tools, thereby reducing k_t ; deploy dynamically modular transportation units that can be flexibly reorganized to quickly adapt even under high-order path planning and compensate for high k_s . After flexible transformation, the output uncertainty of Model C will be significantly lower than that of the rigidly designed Model C, and may approach Model B after continuous optimization.

Therefore, it is suggested to regard the specific node parameters of the mobilization system, such as resource stock, response time, coordination efficiency, and their information interaction, collaboration links, and collaboration relationship models, as key input factors of system complexity. By focusing on the number of system nodes and their connection and collaboration relationships, Sobol's functional decomposition and variance analysis are used to link system complexity with uncertainty.

4.2. Flexibility as a Regulator of Uncertainty

Flexibility refers to the ability of a system to quickly respond to and effectively adapt to uncertain changes in the environment ^[5]. Within the framework of effective dimension, flexibility regulates uncertainty through two main ways:

Flexibility reduces k_t : Modular and standardized resource units and general processes can reduce the number of key parameters required in specific scenarios. On the premise of achieving goals, the set of key parameters should be simplified as much as possible.

Flexibility optimizes k_s : Authorized decision-making, flattened structures, and information sharing mechanisms can decompose high-order, unpredictable global interactions (high k_s) into multiple low-order, more controllable local interactions (low k_s). This is equivalent to introducing a "decoupling mechanism" in the system design, reducing the overall model management interaction complexity.

Therefore, it is suggested to use flexibility as a regulator. A mobilization system with high flexibility does not mean that the system is redundant, complicated, or simple. Instead, it actively or passively switches itself to an

operation mode with lower “effective dimension”, more certainty, and more controllability when facing uncertainty through effective and orderly regulation of uncertainty, so as to maintain the certainty of the mobilization system.

4.3. Focus on the Application of Flexibility in Each Node of Mobilization

The relationship between flexibility and uncertainty lies in its recognition of the inherent connection between complexity and uncertainty, and complex system management is carried out based on this. Its ultimate goal is not to pursue absolute certainty, but to use flexibility to establish reliable response capabilities in an uncertain mobilization environment. By improving the structure, rules, and decision-making power of the system, we can actively shape and optimize its “effective response dimension”.

Apply the evaluation of complex effective dimensions and the principle of flexible regulation to the planning and process upgrading of the mobilization system. It can help decision-makers better judge whether the new nodes increase uncontrollable interactions (increase k_s) or endow the system with dimension reduction capabilities.

Mobilization Preparation Stage: By simulating different architectural schemes, select the scheme with lower (k_t , k_s) values while meeting functional requirements.

Mobilization Implementation Stage: After each new function or department is added, recalculate (k_t , k_s). If the growth of dimensions is much greater than the performance gain, the necessity of this upgrade should be questioned, or flexible design should be enhanced simultaneously.

Demobilization Evaluation Stage: Compare the (k_t , k_s) values of different mobilization schemes or different institutions to evaluate their inherent complexity and potential risks.

Therefore, it is suggested to innovate the mobilization mechanism, establish a regular assessment mechanism for the effective response dimension in all links of the operation of the mobilization system, identify the “critical point” where k_s rises sharply in the system, focus supervision priorities and resources before the critical point, and formulate more robust and executable safety standards to ensure that the complexity of the system matches the uncertainty of its environment, thereby building a flexible mobilization system that remains stable in changes.

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Empowering the Integration of Scientific Journals and New Media through AIGC: Model Innovation and Practical Pathways

Yanyan Huang¹, Mingzhi Pan¹, Mingpei Liang¹, Linkui Wang¹, Dandan Xie^{2*}

¹Editorial Department of Youjiang Medical Journal, Affiliated Hospital of Youjiang Medical University for Nationalities, Baise 533000, Guangxi, China

²Guangxi International Business Vocational College, Nanning 233007, Guangxi, China

**Author to whom correspondence should be addressed.*

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Abstract: The rapid development of Artificial Intelligence-Generated Content (AIGC) technology is profoundly transforming the publishing ecosystem of scientific journals. Based on the Diffusion of Innovations theory, this paper systematically explores the application models and innovative pathways of AIGC technology in the integration process of scientific journals and new media. The study finds that AIGC not only reconstructs the content production workflow of scientific journals but also drives fundamental changes in communication models. By analyzing typical domestic and international cases, this paper proposes a three-stage practical framework of “technology adaptation–process reengineering–ecosystem reconstruction,” providing actionable implementation plans for the digital transformation of scientific journals. The research also highlights that in advancing AIGC applications, special attention must be paid to ethical norms, quality control, and talent development as critical issues.

Keywords: AIGC; Scientific journals; Media convergence; Intelligent publishing; Digital transformation

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1. Introduction

Currently, scientific journals are facing significant opportunities and challenges in digital transformation. According to the *Blue Book of China's Scientific Journals (2023)* released by the China Association for Science and Technology, the integration of new media in China's scientific journals remains at an early stage, with less than 20% of journals achieving fully digitalized publishing processes^[1]. Against this backdrop, the breakthrough progress in Artificial Intelligence-Generated Content (AIGC) technology provides new technical support and developmental pathways for the transformation and upgrading of scientific journals.

AIGC technology refers to the use of artificial intelligence algorithms to automatically generate text, images, audio, video, and other forms of content. In recent years, with the rapid development of large-scale pre-trained

language models, AIGC has been increasingly widely applied in content creation^[2]. In the field of scientific publishing, AIGC has begun to permeate various stages, including topic selection, content creation, peer review, editorial processing, and dissemination. For example, Elsevier's "Article Assistant" can automatically generate literature review frameworks^[3], while Springer Nature uses AI tools for preliminary manuscript screening^[4]. These innovative practices are reshaping the publishing workflows of scientific journals.

However, current research on the application of AIGC in scientific journals exhibits notable gaps. On the one hand, existing studies mostly focus on case analyses at the technical application level, lacking the construction of systematic theoretical frameworks^[5]. On the other hand, there is no systematic research on how AIGC can promote the deep integration of scientific journals and new media or the potential risks and challenges in this process. Against this backdrop, this paper aims to explore the intrinsic mechanisms of AIGC in empowering the integration of scientific journals and new media, propose practical pathways, and provide theoretical references and practical guidance for advancing the intelligent transformation of scientific journals.

2. AIGC-Driven Innovation in Content Production Models

AIGC technology is profoundly changing the traditional content production models of scientific journals. In the topic selection stage, intelligent analysis systems based on natural language processing technology can track global research trends in real time and automatically identify research hotspots and cutting-edge directions^[6]. For example, IEEE's "AI Topic Spotter" system analyzes citation networks and keyword co-occurrence relationships in millions of academic papers to accurately predict emerging research fields in the next 3–5 years, providing data support for journal topic selection.

In the content creation stage, AIGC technology significantly improves the efficiency of scientific writing. Many journals have begun experimenting with AI-assisted writing tools, which can generate draft frameworks or even complete sections of manuscripts based on keywords and outlines provided by authors^[7]. The practice of *Chinese Journal of Lasers* shows that after adopting an AI polishing system, the language compliance rate of submitted articles increased by over 40%, greatly reducing the workload of language editing for the editorial team. Notably, AI-assisted writing is not intended to replace researchers' creative work but to help scholars focus more on refining and demonstrating core innovative points.

In the peer review stage, AIGC technology also demonstrates great potential. Since 2022, Nature Publishing Group has piloted an AI pre-review system that can automatically detect methodological flaws and logical gaps in papers^[8]. Statistics show that AI pre-review can reduce the average time for manuscript processing by 30% while significantly improving review quality. Additionally, AI systems can intelligently recommend suitable peer reviewers based on paper content, addressing the issue of low reviewer matching in traditional models.

3. AIGC-Empowered Transformation of Communication Models

AIGC technology is reshaping the communication ecosystem of scientific journals. In terms of communication channels, intelligent recommendation algorithms enable precise matching of content with readers. Wiley's "Personalized Discovery" system analyzes users' reading history, download records, and search behavior to build personalized knowledge recommendation models^[9]. Practical data show that this system increases article click-through rates by 35% and average reading time by 28%. Such AI-based personalized communication effectively addresses the "one-size-fits-all" dilemma of traditional journals.

In terms of communication formats, AIGC-supported multimodal communication has become a new trend. Many leading journals have begun transforming academic papers into more accessible formats such as visual abstracts, animated videos, and podcasts. For example, Cell Press's "AI Video Abstract" service automatically converts key findings of papers into 3-minute video summaries, significantly improving public understanding and dissemination efficiency of research outcomes^[10]. *Science* magazine has developed an «AI Q&A» feature that allows readers to interact with paper content through natural language, an innovative interactive reading experience that has received positive feedback from 92% of users.

In terms of communication impact evaluation, AIGC technology has also brought revolutionary changes. Traditional journal impact evaluation primarily relies on citation metrics, while AI technology enables multidimensional real-time monitoring of communication effects. New evaluation tools like Altmetric track the dissemination trajectories of papers across scenarios such as news media, social networks, and policy documents, constructing a more comprehensive impact evaluation system. CNKI's newly launched "AI Communication Analysis" feature automatically generates dissemination path maps and audience profiles for each paper, providing data support for optimizing journal communication strategies.

4. Practical Pathways for AIGC Application

Advancing the deep application of AIGC in scientific journals requires systematic implementation pathways. In the technology adaptation stage, journal publishers should establish a scientific AI technology evaluation system covering multiple dimensions such as technological maturity, cost-effectiveness, and data security. For example, for natural language processing technology, the ability to handle professional terminology should be a key focus; for image generation technology, the accuracy of scientific visual expression needs evaluation. Practice shows that blindly pursuing technological advancement often backfires, and selecting the most suitable technological solution for a journal's actual needs is crucial.

In the process reengineering stage, traditional publishing workflows must be reconstructed. A typical intelligent publishing workflow should include AI-assisted submission, intelligent pre-review, expert review, AI polishing, automated typesetting, and multi-channel publication. In this process, establishing human-machine collaboration mechanisms is particularly important. For instance, clear boundaries for AI involvement can be set, specifying which tasks can be fully automated and which require human review. The practice of *Chinese Science Bulletin* demonstrates that controlling AI-generated content to within 30% while implementing strict manual review mechanisms can effectively ensure publishing quality.

In the ecosystem reconstruction stage, scientific journals must transcend their traditional role as content providers and transition into knowledge service ecosystems. This includes building intelligent scholar communities, developing AI-based research assistance tools, and offering personalized knowledge recommendation services. For example, Elsevier's "Scopus AI" platform not only provides literature search services but also automatically recommends potential collaborators, experimental methods, and target journals based on users' research interests. Such comprehensive knowledge service ecosystems significantly enhance user engagement and market competitiveness.

5. Implementation Recommendations and Risk Mitigation

Advancing AIGC applications requires supportive policies. In talent development, efforts should be made to

cultivate interdisciplinary professionals in “AI + publishing.” Universities are advised to incorporate AI-related content into publishing curricula, while publishing organizations should conduct regular AI training. For instance, the China Redactological Society has made “AIGC Applications in Publishing” a compulsory course in continuing education—a practice worthy of promotion.

In standard development, there is an urgent need to establish industry norms for AIGC applications, covering technical standards, ethical guidelines, and quality control systems. The Committee on Publication Ethics (COPE) recently released *Guidelines for AI-Generated Content in Research Publications*, stipulating that any content created or modified using AIGC tools must be explicitly declared in the article. China should accelerate the formulation of national standards to provide normative guidance for the industry.

In risk mitigation, robust control mechanisms must be established. First, regarding data security risks, journal publishers should select technology providers that comply with national cybersecurity requirements and implement strict data management systems. Second, academic ethics risks must be addressed, particularly to prevent academic misconduct facilitated by AI tools. For example, certain “AI paper-writing” tools pose serious threats to academic integrity. The publishing industry should collaborate with technology providers and research institutions to combat such violations.

6. Conclusion

This study systematically explores the innovative models and implementation pathways of AIGC technology in empowering the integration of scientific journals and new media. The research demonstrates that AIGC can not only enhance content production efficiency but also create entirely new knowledge service models. However, AIGC applications also face multiple challenges, including technological maturity, ethical norms, and talent reserves. Future research should further examine the impact of AIGC on academic evaluation systems and the differential effects across disciplines. Overall, the deep integration of AIGC and scientific journals has become an irreversible trend, and journals that proactively embrace this transformation will gain a competitive edge in the future.

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Integrating Party Building with Core Tasks: A “Point-Line-Surface-Body” Synergistic Framework for University Grassroots Party Branches

Feifei Li¹, Xin Li^{2*}

¹School of Management, Beijing Union University, Beijing 100101, China

²School of Journalism & Communication, Hebei Institute of Communications, Shijiazhuang 051430, Hebei, China

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Abstract: Under the background of the new era, the in-depth integration of party building and business work in grassroots party organizations of colleges and universities is an important proposition to implement the fundamental task of fostering morality and cultivating people and promote the high-quality development of higher education. Taking grassroots party branches of colleges and universities as the research object, this paper addresses practical problems such as “superficial integration” and “insufficient mechanism coordination” between party building and business. Based on the “Point-Line-Surface-Body” collaborative innovation framework, it constructs a four-dimensional integration model of “Point—Precise connection with curriculum ideological and political education, Line—Branch-led geese formation effect, Surface—Professional construction community, Body—Department collaborative ecology”, exploring the practical path of in-depth integration of party building and business. It provides practical reference for solving the dilemma of “two skins” between party building and business in colleges and universities.

Keywords: Point-Line-Surface-Body; Integration of party building and business; Practical path; Collaborative innovation

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1. Introduction

As an important part of the party’s organizational system, grassroots party branches in colleges and universities shoulder the important responsibility of guiding ideology, promoting careers, and serving teachers and students. General Secretary Xi Jinping clearly proposed in the report to the 20th National Congress of the Communist Party of China that “we must adhere to the distinct orientation of focusing on grassroots and build grassroots party organizations into strong fighting fortresses for effectively realizing the party’s leadership”. This important discourse provides a fundamental follow for the integrated development of grassroots party building and business in colleges and universities in the new era.

With the in-depth advancement of the connotative development of higher education, grassroots party branches in colleges and universities, as the frontline positions for the integration of party building and business, have transformed their functional positioning from traditional political leadership to a composite function of “guidance-service-innovation”. However, the phenomenon of “two skins” between party building and business is still prominent in practice: on the one hand, some grassroots party organizations narrow party building down to theoretical learning and routine work, failing to effectively integrate it into core businesses such as teaching and scientific research; on the other hand, professional construction and talent training lack systematic design led by party building, resulting in inefficient resource allocation and fragmented goal coordination. How to solve the integration dilemma through mechanism innovation has become a key proposition for colleges and universities to implement the fundamental task of “fostering morality and cultivating people” and achieve high-quality development ^[1].

Based on this, this paper takes the Party Branch of the Financial Management Department of a university as the research object, constructs a four-dimensional integration collaborative innovation framework of “Point-Line-Surface-Body”, and explores the in-depth integration path and practice of party building with teaching, scientific research, social services and other business work. On the one hand, it makes up for the lack of attention to micro-paths in existing research; on the other hand, it provides a feasible working model and reference for grassroots party branches in colleges and universities, further promoting colleges and universities to lead the high-quality development of careers with high-quality party building.

2. Research Status of the Integration of Party Building and Business in Colleges and Universities

2.1. Theoretical Construction Research

Scholars have analyzed the inherent theoretical logic of the integration of party building and business from different perspectives. Yang Chunwei & Chang Liang (2025) proposed the “One Integration, Two High-Quality Developments” theoretical framework, emphasizing that high-quality party building needs to lead high-quality development through a three-level linkage mechanism of “consolidating the foundation-functional upgrading-reform and innovation” ^[2]; Chen Diming (2024) further guided by systematic thinking, advocating the construction of an integration closed loop through the collaborative role of political construction, organizational system, platform carriers and service overall situation ^[3]. At the same time, the application of interdisciplinary theories has injected new perspectives into the research. Shen Ziyu (2023) regarded party building and business as a “symbiosis” from an ecological perspective, proposing that the dynamic balance of three elements—organization, personnel and environment—is the key to in-depth integration ^[4]; Sun Zhanjiu & Ding Liang (2023) proposed a “four-dimensional integration” model of direction, organization, mechanism and culture in the context of first-class discipline construction, emphasizing the resonance between party building goals and discipline development goals ^[5]. In addition, Chu Qingsong & Ma Chunyang (2025) compared the characteristics of different positions and refined a three-in-one driving mechanism of “system standardization, leadership responsibility, and team building”, providing theoretical support for integration practice ^[6].

2.2. Practical Path Research

Research on the practical path of integrating party building and business focuses on mechanism design and case extraction, forming a diverse pattern of “common strategies + characteristic exploration”. Xiao Yang & Lü Wenhao (2024) proposed the concept of “dual integration and mutual promotion”, constructing a full-cycle collaborative

mechanism for joint planning, deployment, implementation and inspection of party building and business ^[7]; Jiang Xuejun (2024) advocated solving integration resistance through the improvement of the system system, optimization of the cadre team and innovation of assessment and evaluation ^[8]; Ye Lin et al. (2024) proposed a dual integration and mutual promotion path by building a “big party building” pattern, adopting “micro-governance” methods and creating a “multi-leadership” model in combination with the existing problems in the dual promotion and integration of party building and business ^[9]; Lu Youjun et al. (2024) proposed a “six prominence” strategy for grassroots departments to strengthen the business-driven effect of party building leadership ^[10]. For specific groups, Gu Xiaoxia et al. (2024) proposed that teacher party branches need to innovate working methods through the “Party Building + N” model ^[11]; Peng Qiangang (2023) focused on university administrative departments, advocating the promotion of in-depth integration of party building and business through four-dimensional linkage of “ideology, organization, action and mechanism” ^[12].

2.3. Evaluation System Research

Scientific evaluation of the integration effect of party building and business work is an important direction for in-depth research. Under the new situation, the in-depth integration of party building and business work in colleges and universities needs to establish a sound management and evaluation mechanism ^[13]. Qiu Rongpeng et al. (2023) constructed a quality evaluation system including 4 first-level indicators (system guarantee, collaborative innovation, key work, empowerment and authorization) and 17 second-level indicators, providing tool support for quantitative evaluation ^[14]; Yang Chunwei & Chang Liang (2025) proposed in the “One Integration, Two High-Quality Developments” framework that performance appraisal should take into account both party building contribution and business development to avoid one-sided evaluation indicators ^[2].

2.4. Literature Review

Through sorting out existing literature, it can be found that although research results on the integration of party building and business in colleges and universities are gradually enriched, there are still some problems and deficiencies. On the one hand, although many studies have proposed innovative practical paths and mechanisms, how to ensure the effective implementation of various measures in the specific operation process is still an urgent problem to be solved; on the other hand, some studies lack analysis on the differentiation of the integration of party building and business in different types of colleges and universities and different disciplinary fields, failing to fully reflect the diversity of higher education and not yet forming an adaptive theoretical model.

3. Construction of the In-Depth Integration Path of “Point-Line-Surface-Body”

3.1. Precise Connection with Curriculum Ideological and Political Education to Consolidate the Integration Base Point

3.1.1. Construction of Professional Characteristic Ideological and Political Resource Library

Combined with the characteristics of the financial management major, focusing on the disciplinary ideological and political education of “entrepreneurial spirit” and the professional ideological and political education goal of “proficient in finance, honest, responsible and innovative”, a three-level ideological and political resource system is developed. (1) Basic element layer: Compile the Compilation of Ideological and Political Construction Achievements of Financial Management Major, form an ideological and political element map of core professional courses, and extract ideological and political mapping points; (2) Case application layer: Develop

localized teaching cases around themes such as family and country feelings and professional ethics, covering core professional courses, focusing on the value guidance of talent training; (3) Teaching design layer: Party building leads teaching and research on curriculum ideological and political education, implement dual-target lesson plans, requiring lesson plans to reflect both knowledge transmission and value guidance.

3.1.2. Mechanism for Cultivating Teachers' Dual Capabilities Integration

Implement a three-dimensional capability improvement mechanism of “training-guidance-competition”. (1) Carry out “Party Building + Professional” themed workshops to systematically train methods for designing curriculum ideological and political education, connection points between party regulations and financial regulations, and national policy-guided research topics; (2) Implement a paired tackling plan, where party building mentors guide young teachers to formulate curriculum ideological and political education plans and jointly build model courses for curriculum ideological and political education; (3) Organize curriculum ideological and political teaching design competitions led by the department party branch, incorporating the achievement of ideological and political goals and students' value recognition into the scoring system, cultivating excellent teachers and teams for curriculum ideological and political education, and realizing the synchronous enhancement of teaching and party building capabilities.

3.2. Branch-Led Geese Formation to Extend the Integration Axis

3.2.1. Construction of Geese Formation Echelon Led by Famous Teachers

With the party branch as the core, build a goose formation-style high-quality education team led by three types of famous teachers: Beijing Municipal Teaching Masters, Beijing Municipal Curriculum Ideological and Political Teaching Masters, and Beijing Municipal Young Teaching Masters, implementing the “three guidance plans” of guiding teaching, scientific research and services. Establish party groups for teaching reform, scientific research tackling, and social services, respectively connecting key tasks of professional construction, and invite party member executives of enterprises and alumni party member representatives to participate in the revision of professional talent training programs and cooperation in industry-university-research projects.

3.2.2. Two-Way Empowerment Traction Driving Mechanism

Establish a two-way transformation system between party building goals and business goals, clarifying the leading responsibility of the party branch in key businesses. Decompose business goals such as professional construction and talent training into the annual key task list of the party branch, carry out “Party Building + Business” themed party days every month, and conduct exchanges and discussions around the theme of party building empowering high-quality professional development; at the same time, integrate core business goals such as teaching evaluation and scientific research project approval into the assessment indicators of party building leading career development.

3.3. Professional Construction Community to Expand the Integration Interface

3.3.1. System Reconstruction for Goal Coordination

Reconstruct the professional construction system framework to realize the organic unity of party building standards and business norms. In the talent training program, include the practical course of financial and accounting professional ethics cases as a compulsory course in the professional practice link, and hold a professional ethics case competition as one of the assessment methods for this course; rely on the joint construction activities of the party branch with external units to expand industry-university-research cooperation, which is used as one of the

indicators for professional evaluation; encourage teachers to carry out research projects combining party building and scientific research, guide students to participate in red competitions and social practice activities, which are used as bonus items in the year-end assessment.

3.3.2. Platform Construction for Resource Integration

Create a resource sharing platform for the integration of party building and profession, realizing the interconnection of three types of resources: courses, teachers and practice. Continuously build and share the curriculum ideological and political resource library, integrating professional course ideological and political cases, micro-party class videos, virtual simulation training projects and other resources; establish a “double-qualified” teacher workstation, invite enterprise executives to participate in curriculum construction, encourage professional teachers to participate in enterprise practice, and cooperate with each other to develop teaching resources; jointly build practice bases with the university’s financial department, accounting firms, tax bureaus, banks and other units, organizing teachers and students to participate in voluntary services such as policy promotion and financial business consulting.

3.4. Department Collaborative Ecology to Construct the Integration System

3.4.1. Party Building-Linked Governance System

Construct a three-level linkage system of college general party branch-department party branch-professional teaching and research section. Add special topics on business integration to the meetings of the college general party branch to review decisions on party building leading career development; link the party building assessment of the branch with the business assessment of the teaching and research section, issue party building deployments and business arrangements simultaneously to ensure the coordinated advancement of specific tasks, and conduct integration quality evaluation every semester.

3.4.2. Dynamic Feedback Continuous Improvement Mechanism

Construct a dynamic improvement mechanism for the integration path based on the PDCA cycle. At the planning stage, formulate an annual task list for the integration of party building and business, quantifying indicators such as the coverage rate of curriculum ideological and political education and the leading rate of party member projects; at the implementation stage, regularly hold party building-business joint meetings to coordinate and solve cross-departmental cooperation issues; at the inspection stage, conduct teacher and student satisfaction surveys every semester; at the improvement stage, establish a three-item list of “problems-measures-responsibilities” to iteratively optimize the integration path.

4. Conclusion

“One integration and two high-quality developments” is the core strategy for the development of colleges and universities in the new era. The collaborative innovation framework of “Point-Line-Surface-Body” follows the action logic of goal co-construction, resource symbiosis and value co-creation, providing a practical path for the construction and business integration development of grassroots party branches in colleges and universities. In future research, we will further explore the empowerment mechanism of digital technology on the integration path, providing continuous theoretical support and practical reference for the resonance between party building and career development in colleges and universities in the new era.

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Optimization of AI-Enhanced Project-Based Practical Teaching Path for Applied English Major in Vocational Colleges

Wei Bi*

School of Foreign Language, (ASEAN International School), Kunming Metallurgy College, Kunming 650000, China

**Author to whom correspondence should be addressed.*

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Abstract: This paper conducts research on the project-based practical teaching of Applied English major in higher vocational colleges based on AI enhancement. During the research process, the application of AI in constructing task scenarios, teaching evaluation, and AI-based evaluation was elaborated in detail, revealing the problems currently faced in practice, such as the lack of data, the increase in teachers' workload, and the rigidity of project evaluation standards. In response to these phenomena, a comprehensive project practice process mechanism with data as the main direction is presented. Establish a normative system for AI-based educational design; Adopt multi-disciplinary project evaluation schemes with AI elements and other solutions. It is expected to provide operational ideas and references for the optimization of practical teaching in the Applied English project in higher vocational education.

Keywords: AI enhancement; Project-based practical teaching; Applied English major in higher vocational education

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1. Introduction

With the application of artificial intelligence technology in higher vocational education, the ways of “teaching” and “learning” in the Applied English major of higher vocational colleges are undergoing profound changes quietly. Project-based practical teaching can connect with real working scenarios and promote the comprehensive application and development of language skills as well as the cultivation of professional abilities. However, the deep integration with AI technology has not yet solved some practical problems. Firstly, the goals are disconnected from the application of technology. The task settings of the project are not fully based on data, and teachers also face dual pressures of knowledge and time during the process of developing the intelligent platform. Secondly, most of its related research merely introduces technical functions or single-case studies, and systematic exploration is still insufficient. This paper takes the Applied English major in higher vocational colleges as the experimental object, analyzes the AI-enhanced intervention mechanism from the perspective of practical difficulties, and proposes operational path optimization ideas.

2. The role of AI Enhancement in the practical teaching of Applied English major projects in higher vocational colleges

By enhancing the project-based practical teaching of the Applied English major in higher vocational colleges through artificial intelligence technology, the information data of the teaching and learning activities both inside and outside the field no longer rely on the experience of teachers and students. By using learning analysis and tracking of learning process data, the weaknesses in students' language application process can be identified, assisting teachers in designing targeted project situation arrangements and implementing precise task assignments^[1]. Automatic assessment tools provide multi-faceted feedback on students' oral expression, writing creation, and teamwork activities, which helps reduce teachers' marking burden and enhance the objectivity and fairness of marking. The situational conversations, simulated work scenarios, and data promotion of AI technology broaden the stage for students to practice hands-on operations and further enhance their learning and mastery of communication skills in professional contexts. The data generated from these project practice processes will continuously accumulate and be clearly presented, providing basis information for optimizing the selection of learning materials, adjusting the difficulty of tasks, monitoring the quality of courses, and improving talent cultivation plans, promoting the regular and refined management of practical teaching in applied English majors in higher vocational colleges.

3. The practical predicament of artificial intelligence-enhanced project-based practical teaching in the Applied English major of higher vocational colleges

3.1. The practical process lacks data support

In the process of promoting the project-based practical teaching of artificial intelligence enhancement for the applied English major in higher vocational colleges, the basic practical data foundation is relatively weak. Most of the teaching content remains at the level of post-class feelings and experience descriptions. There is no corresponding tracking process for the learning behavior, the execution effect of tasks, and the changes in language ability. Some teachers do not have a deep understanding of the content of the learning and analysis. At the beginning of the project design, they did not fully utilize the previous relevant materials for quantitative diagnosis. During the execution process, they did not apply effective process data collection tools. In the evaluation stage, there were no data samples for horizontal comparison. Due to reasons such as inconsistent data collection standards and non-standard indicators, this leads to significant differences in the standards of one course and one class from another. Some students may also have errors in their online diaries, offline records, and personal self-reports, resulting in "fragmented data". Some teachers are unable to accurately understand the data content presented in the system reports or identify outliers. Additionally, some students are reluctant to fill in complete data out of fear of personal privacy leakage or the complexity of filling it out, resulting in the loss of important behavioral data. As a result, the function of AI diagnosis is difficult to be maximized, and the quality monitoring of practical teaching is also hard to carry out.

3.2. The pressure on teachers' practical teaching has increased

When introducing AI-based project-based teaching into English courses in higher vocational colleges, the practical teaching pressure on teachers has gradually increased. Firstly, to achieve effective project design, it is necessary to comprehensively consider language goals, professional scenarios and technical compatibility, which greatly increases the previewing time. Moreover, daily teaching, project implementation and platform maintenance

interact with each other, making the teaching process tight and prone to causing anxiety due to excessive work tension. Secondly, teachers' digital literacy is insufficient. They invest less practical effort in the selection of digital resources, the setting of parameters, and the interpretation of model outputs. Due to a lack of technical understanding, the responsiveness of the technical system is not ideal. When teachers encounter AI misjudgments or platform issues, their anxiety intensifies. Thirdly, after the introduction of AI, the school's evaluation mechanism takes the usage, innovation and presentation results of AI as the assessment criteria. As a result, teachers not only have to undertake research, management and competition guidance tasks, but also must keep the usage of technology traceable, leading to fragmented work. Fourth, the classroom organization form after the introduction of AI requires real-time monitoring of changes in platform data, the situation of students' activities, and the completion of tasks. This puts forward higher requirements for classroom control and personalized guidance, thus reducing the opportunities for self-reflection and improvement, and thus forming a practical pressure loop. The fifth issue is that the growth of the internal support system within the school has been sluggish. The boundaries of responsibilities for technical supply and educational management are unclear. There are numerous tasks related to the maintenance of technical equipment and data support. Junior teachers are burdened with a large amount of human and material resources. Many teachers are played as "subject experts", "technicians", or "project leaders" in different fields. The continuous exhaustion has led to an increasing risk of job burnout and resignation.

3.3. The evaluation methods for project-based practical teaching are monotonous

In the promotion of artificial intelligence-enhanced project-based practical teaching for applied English majors in higher vocational colleges, the evaluation methods still tend to focus on final written tests and single achievement presentations, while neglecting the task process and the value of learning data. Most courses lack evaluation criteria in aspects such as language proficiency, professional skills, collaboration ability, and problem-solving ability. In contrast, artificial intelligence mainly focuses on grading assignments and oral presentations, with the same evaluation indicators as traditional ones, and thus fails to reflect students' all-round performance. Evaluators have insufficient understanding of continuous evaluation. The observation records in classroom teaching and online logs are disconnected. There are no unified standards for on-the-job tutoring in enterprises and guidance in schools, which makes the evaluation results messy and loose. Coupled with the error rate of human voice recognition and the misjudgment rate of vocabulary in artificial intelligence tests, the test results are not genuine and trustworthy. Moreover, the feedback cycle for evaluation is long, which makes it impossible for students to understand their own strengths and weaknesses. When evaluating teachers' analyze reports, they are unable to adjust teaching plans and projects in combination with the reports due to the lack of technical support.

4. The optimization path of project-based practical teaching based on AI Enhancement for the Applied English major in Higher Vocational colleges

4.1. Establish a data-driven, project-based practice full-process system

In the project-based practical teaching link, due to the relatively weak data foundation, it is necessary to build a "data-driven" full-process system covering the early diagnosis, process monitoring and result evaluation of the project. The main body of teaching management relies on the learning analysis framework to clearly define key indicators such as learning engagement, language performance and professional ability, and pre-sets quantifiable observation points in the curriculum standards and project task books^[2]. The learning engagement index can be defined:

$$SI = \frac{(w_1 * T + w_2 * F + w_3 * Q)}{(w_1 + w_2 + w_3)} \quad (1)$$

Here, T represents the on-time submission rate of tasks, F represents the frequency of learning interaction, Q represents the proportion of high-quality speeches, and w1, w2, and w3 are the corresponding weight coefficients. Build a capability improvement index based on the test scores before and after the project:

$$\Delta P = \frac{(P_{\text{post}} - P_{\text{pre}})}{P_{\text{pre}}} \quad (2)$$

Among them, Ppre and Ppost are respectively recorded as the pre-test and post-test scores. The difference in the average scores between the project group and the reference group in the control experiment can be determined by the difference effect index:

$$E_g = P_g - P_{\text{ref}} \quad (3)$$

Pg and Pref respectively represent the average scores of the project group and the reference group. By collecting information such as task completion time, interaction quantity, and oral training path through learning platforms, mobile apps, and classroom sensors, as well as teacher observation records and student self-reports, a project progress process database that can be tracked is formed, providing support for subsequent model research and educational strategy research.

For instance, when a certain vocational college was conducting overseas cross-border e-commerce project teaching, it adopted the “big data + task archive” model to establish a network profile based on the results of the freshmen’s entrance examination, oral proficiency test and learning method survey, in order to complete the arrangement of group and project tasks. Among the 120 student samples, the task completion rate was approximately 93%. The average score Ppre in the pre-test of the project was 72.4 points, and the average score Ppost in the post-test was 91.2 points. These scores can be obtained by substituting them into the formula:

$$\Delta P \approx \frac{(91.2 - 72.4)}{72.4} \approx 0.26 \quad (4)$$

After setting up reference classes in the same period, the Pg value of the project’s later performance was recorded to be approximately 90.3 points, while the Pref of the control group was close to 78.1 points, with a difference Eg of approximately 12.2 points. Record the participation level and performance of each stage such as negotiation simulation, product promotional video arrangement, and cross-cultural communication dialogue activities in the document, and use them as the benchmark for horizontal comparison. The core indicator comparison is shown in **Table 1**.

Table 1. Comparison Table of Key Indicators before and after the project and between groups Indicator notation value

Indicator	Mark	Numerical value
The number of student samples	N	120
Task completion rate (%)	—	93.0
The average score of the pre-test	Ppre	72.4
Post-test average score	Ppost	91.2
Capacity Enhancement Index	ΔP	0.26
The average score of the project team in the post-test	Pg	90.3
The average score of the post-test of the reference group	Pref	78.1
Difference effect index	Eg	12.2

4.2. Improve the guidance mechanism for teachers' instructional design based on AI

In the process of promoting AI-enhanced practical project-based teaching for English majors in higher vocational colleges, an AI-based teacher teaching design guidance system can be constructed, and quantitative load and intelligent recommendation assistance methods can be adopted to alleviate practical pressure^[3]. The teacher practice load index can be set:

$$TPFI = \frac{(a \cdot T_{\text{prep}} + b \cdot T_{\text{maint}} + c \cdot T_{\text{support}})}{(a + b + c)} \quad (5)$$

Among them, TPFI represents the comprehensive lesson preparation load index, T_{prep} represents the lesson preparation duration, T_{maint} represents the technical debugging time, T_{support} represents the platform maintenance duration, and a , b , and c are the weight coefficients of the three types of time in different course scenarios. By continuously recording various time data and calculating the TPFI value, the teaching management entity can quantitatively grasp the work intensity in the project course design stage, providing a basis for the subsequent allocation of teaching support resources and mechanism optimization.

For instance, a certain vocational college conducted an experiment on the application of AI in teaching design guidance for English majors, selecting 24 teachers to participate and comparing the practical data before and after one semester. The results show that the average weekly project lesson preparation time per person has dropped from 6.2 hours to 4.1 hours, the number of class interruptions due to improper platform Settings has decreased from an average of 3.0 times per semester to 1.1 times, and the number of teachers who self-assess themselves as being in a “high-pressure state” has decreased from 12 to 5. The key indicators of the pilot courses are shown in **Figure 1**.

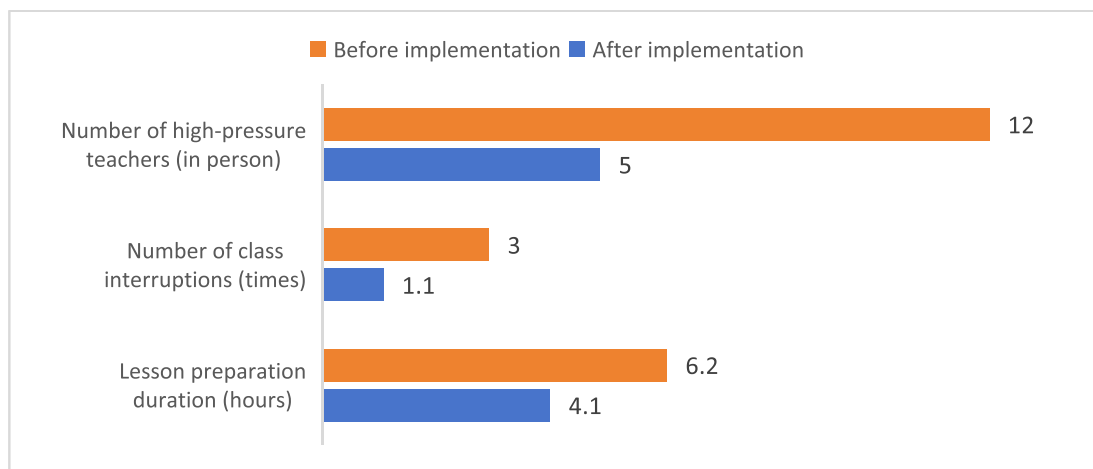


Figure 1. Key indicator Chart of the pilot course

As can be seen from **Figure 2**, with the support of the AI instructional design guidance framework, a series of issues such as teachers' course preparation, network operation management, and emotional stress have all been alleviated. Instructional design becomes more systematic and readable, and there is no need to be separately responsible for technical adjustments and data management, which is conducive to avoiding role conflicts and freeing up more time for thinking and improvement.

4.3. Implement a multi-disciplinary project evaluation system embedded with artificial intelligence

In view of the current single evaluation method of project-based teaching, a multi-disciplinary project evaluation system based on artificial intelligence technology can be designed, integrating elements such as language ability, professional quality, digital literacy and teamwork into a unified framework. A hierarchical scoring structure is constructed based on professional teaching objectives and job responsibilities. During the task design process, collectible data indicators, typical sample displays, and weighting factors are determined. A combined assessment and evaluation scheme of process evaluation and result evaluation is constructed through AI voice testing, text analysis, data analysis, and process recording, and a comprehensive evaluation index is set^[4].

$$CI = \frac{(w_1 * L + w_2 * V + w_3 * D + w_4 * C)}{(w_1 + w_2 + w_3 + w_4)} \quad (6)$$

Here, L represents the language proficiency score, V represents the professional quality score, D represents the digital literacy score, C represents the teamwork score, and W1, W2, W3, and W4 are the corresponding weight coefficients. At the same time, an evaluation data mapping mechanism is established to convert students' performance in different projects and semesters into comparable indicators. The difference structure and progress trajectory are presented through visual boards, providing structured evidence for course iteration and path optimization. Hierarchical diagnosis is carried out based on the CI index distribution.

For instance, taking a small-scale assessment activity carried out in the evaluation section of the “English Communication + Business Decision-making + Data Presentation” part of an interdisciplinary integrated task in a certain vocational college as an example, three groups of students, totaling ninety students, received data on ability index values in four aspects: Group A's language proficiency score is L=85 points, professional quality score is V=82 points, digital literacy score is D=79 points, and teamwork score is C=88 points, corresponding to CI≈83.5. Group B: L=78 points, V=80 points, D=75 points, C=82 points, CI≈78.8; Group C: L=90 points, V=88 points, D=92 points, C=95 points, CI≈91.3. As shown in Figure 2.

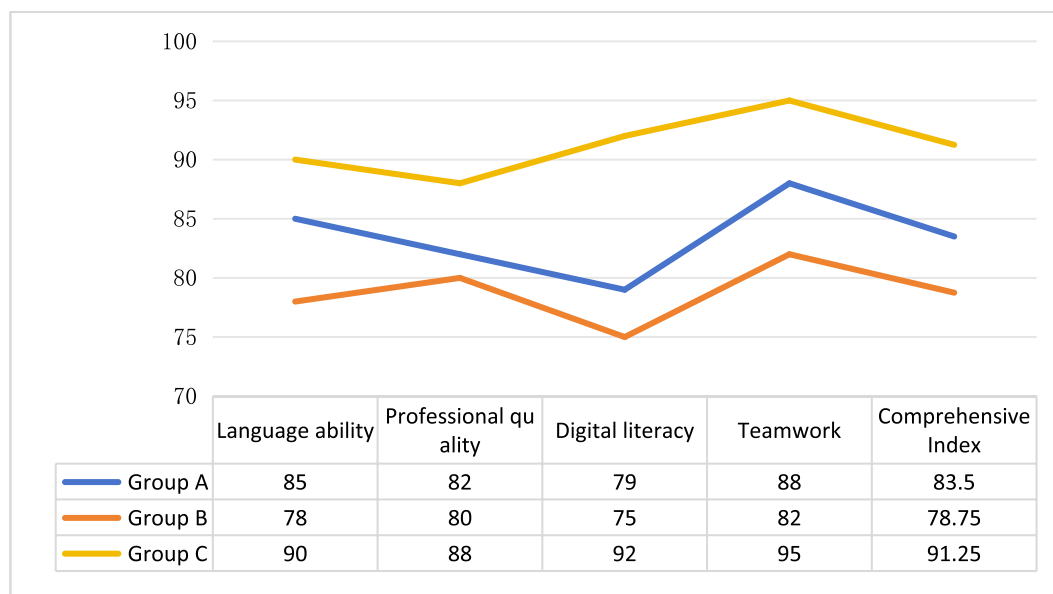


Figure 2. shows the data graph of student project ability assessment

It can be found that the differences among the three groups in the dimensions of language ability and digital

literacy are relatively small, while the differences in the dimension of teamwork are more prominent. The teaching team conducts a comprehensive assessment of language performance, professional judgment, digital application and cooperation ability based on the above-mentioned CI index and sub-item scores. At the same time, it combines the scoring data of enterprise mentors on the feasibility of the plan and industry logic to construct a cross-subject joint evaluation result. By comparing the differences among the three groups in terms of data utilization depth, language transfer ability and task strategy through learning and analysis models, this serves as the basis for optimizing the difficulty of later projects, the way of scene design, and personalized services for students, ensuring the formation of stable educational behaviors in the teaching process of vocational education.

5. Conclusion

This paper takes Applied English in higher vocational colleges as the research object. Through the learning, summary and reflection of the existing practical projects integrated with AI technology, problems such as the lack of sufficient data support for practical projects, increased burden on teachers, and single project evaluation have emerged. It indicates that relying solely on the original empirical learning methods and structured teaching in the classroom form cannot guarantee good learning outcomes. Propose the theory of an integrated project practice system driven by big data, and put forward the improvement method of teaching design using AI technology. Construct an AI evaluation model oriented to AI that combines multiple disciplines, and form a relatively complete solution^[5]. Theoretically speaking, it can expand the understanding of “AI+ project-based practice” in higher vocational education and teaching, and provide a reliable tool for deeper exploration of quality development that enhances technological capabilities. From a practical perspective, it can serve as an effective reference for the construction of the teaching content system, the building of the teaching staff, and teaching management in higher vocational education. Subsequently, longitudinal tracking and empirical tests can be carried out in different institutions and course scenarios to further examine the applicable boundaries and effect differences of the path.

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A Study Concerning the Generalization Effects of Perspective Differences among Adolescent Middle School Students

Haoyan Mei*

Shanghai Shibei Senior High School, 20071 Shanghai, China

**Author to whom correspondence should be addressed.*

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Abstract: Conflicts arising from divergent perspectives are common in adolescence, a stage marked by the ongoing formation of beliefs. This study surveyed 103 adolescents to investigate the generalization effects of perspective differences. The findings show that value-based differences among middle school students mainly appear in attitudes toward financial issues and emotional factors, while differences in understanding objective facts are concentrated in beliefs about the malleability of intelligence and the importance of effort. Variations in personal preferences are reflected in favored sports teams and the choice of celebrating birthdays by the lunar or solar calendar. Gender did not produce significant differences across values, factual understanding, or preferences, whereas age differences were evident: high school students exhibited greater conceptual divergence than middle school students across all dimensions. Perspective consistency among middle school students produced a moderate positive generalization effect, where agreement on values, preferences, and factual understanding corresponded to higher levels of relational harmony, personal and regional idealization, and familial idealization. In contrast, perspective divergences elicited a moderate negative generalization effect. Only differences in preferences and factual understanding were associated with relational conflict, personal criticism, regional bias, and familial bias, while value discrepancies did not trigger negative effects. Based on these results, the study provides recommendations to help middle school students manage conceptual differences more effectively in future interactions.

Keywords: Adolescents; Middle school students; Perspective differences; Generalization effect

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1. Introduction

During the middle school years, adolescents experience rapid physical and psychological changes alongside shifts in social roles and relationships. A prominent phenomenon in this stage is the divergence of perspectives among peers, often reflected in disagreements, conflicting interests, and value-based differences. When poorly managed,

these discrepancies may escalate into interpersonal disputes or even physical confrontation. Such incidents are not uncommon; for instance, a conflict over differing opinions at the Affiliated Experimental Middle School of the Sichuan Academy of Sciences escalated from argument to violence and ultimately resulted in a student's suicide. These conflicts may further lead to clique formation, adversely influencing mental health, academic outcomes, and social development. Against this backdrop, the present study investigates how middle school students articulate and navigate perspective differences, examines group disparities and their consequences, and aims to identify effective strategies to support harmonious peer interactions.

Existing research primarily centers on conceptual development, peer influence, conflict mechanisms, and intervention strategies. Mu Xiaoyong^[3] outlined the developmental stages of conceptual thinking—oscillation—progression, plateau, and mutation—emphasizing that increasingly abstract concepts require longer periods for maturation. Li Shiyuan^[2] found that peer tutoring may harm adolescents' emotional well-being and academic achievement due to emotional contagion and behavioral imitation, and that decisions to join or withdraw from tutoring do not substantially mitigate these risks. Xie Yongxiang (2023) reported that collective prosocial behavior strengthens adolescents' prosocial tendencies through school belonging, whereas class-level deviance predicts adolescent deviance, with weaker mediation from school alienation. Tang Xuelian^[5] highlighted the dual impact of peer groups: positive groups promote moral growth and belonging, whereas negative groups narrow moral cognition and foster moral rigidity through weakened moral emotion and will. Nie Chaoju^[4] noted that adolescents, driven by emerging self-awareness yet constrained by limited cognitive and social experience, are prone to conceptual disagreements and conflict. Karimova^[7] found that supportive collective psychological climates enhance peer affinity, promoting compromise and cooperative strategies in conflict resolution. Research on peer bullying further enriches this understanding; Marwick and Boyd^[8] proposed that “dramatization” serves as a self-protective strategy enabling adolescents to distance themselves from adult-defined notions of bullying while maintaining agency and dignity.

Although current research on adolescent issues provides theoretical guidance for behavioral interventions, it predominantly emphasizes peer influence, cognitive development during adolescence, and potential conflicts, while largely neglecting the phenomenon of conceptual opposition among adolescents themselves. This study seeks to investigate this phenomenon in depth, with the objective of elucidating the mechanisms driving the generalization effect of conceptual opposition, thereby contributing to more effective strategies for supporting and guiding adolescent mental health.

2. Research Process

2.1. Research Methods

2.1.1. Design of Research Methods

Regarding research design, this study primarily utilizes a questionnaire survey approach, organized around three principal dimensions:

- (1) The expression of opposing viewpoints among adolescents.
- (2) The group-based variations in these opposing viewpoints within the adolescent population.
- (3) The consequences arising from such opposing viewpoints among adolescents.

The questionnaire was developed accordingly, and data were gathered through online distribution via the Wenjuanxing platform. The research findings were subsequently obtained through systematic analysis of the

collected data.

2.1.2. Statistical Data Analysis Methods

The statistical analysis of the data was conducted primarily using Excel and SPSS software. Excel was utilized for data analysis, preprocessing, and visual representations following the data exported from the Wenjuanxing platform. SPSS was employed for conducting statistical tests pertinent to the research questions, including descriptive statistics, independent samples t-tests, and regression analysis. Specifically, descriptive statistics were applied to address Question 1, which examined the manifestations of view differences among middle school students. Independent samples t-tests were used to analyze Question 2, focusing on group differences in view differences among middle school students. For Question 3 about the generalization effects of view differences among middle school students, both descriptive statistics and regression analysis were employed.

2.2. Research Procedures

2.2.1. Data Collection Procedures

This study primarily employed a self-designed questionnaire for data collection. First, questions regarding demographic variables such as gender, age, and educational background were designed to clearly describe the sample characteristics. Secondly, subsidiary questions were formulated to investigate the manifestation of divergent perspectives among middle school students, variations across different groups, and the effects of generalization. The questionnaire was constructed based on established authoritative surveys and utilized a five-point Likert scale to evaluate the participants' subjective perceptions, with response options spanning from 1 ("Strongly Disagree") to 5 ("Strongly Agree"). An illustrative item from the questionnaire was: "You have significant personal preference conflicts with the classmate/friend whose views differ most from yours."

2.2.2. Data Collection Procedure

The study subjects were middle school students, and sufficient samples were obtained through self-distribution. The researcher first entered the compiled survey questionnaire into the Wenshuangxing platform, creating an electronic questionnaire for distribution. The sampling process utilized a snowball sampling technique. Specifically, the researcher disseminated the Wenshuangxing survey link within social media networks and middle/high school class groups, directly forwarded it to close acquaintances from middle school, and subsequently relied on these initial contacts to facilitate further distribution, thereby acquiring additional participants.

2.3. Sample Characteristics

This study collected 103 valid samples, as shown in Table 1. Among the valid samples, the number of female participants ($n = 36$, 34.95%) was lower than that of male participants ($n = 67$, 65.05%). Regarding age, the majority of respondents were between 14 and 16 years old ($n = 65$, 63.11%), followed by those aged 17 to 19 years ($n = 38$, 36.89%). In terms of educational background, most participants were enrolled in high school ($n = 97$, 94.17%), which was substantially higher than the proportion attending junior high school ($n = 6$, 5.83%). This predominance of high school students can likely be attributed to the dissemination of the survey primarily involved close friends and secondary contacts who were also predominantly high school students, thereby contributing to the majority representation of high school respondents.

Table 1. Sample Characteristics

Variable	Category	Frequency	Percentage
Gender	Male	67	65.05%
	Female	36	34.95%
Age	10-13 years old	0	0.00%
	14-16 years old	65	63.11%
	17-19 years old	38	36.89%
Education background	Junior High School	6	5.83%
	High School	97	94.17%

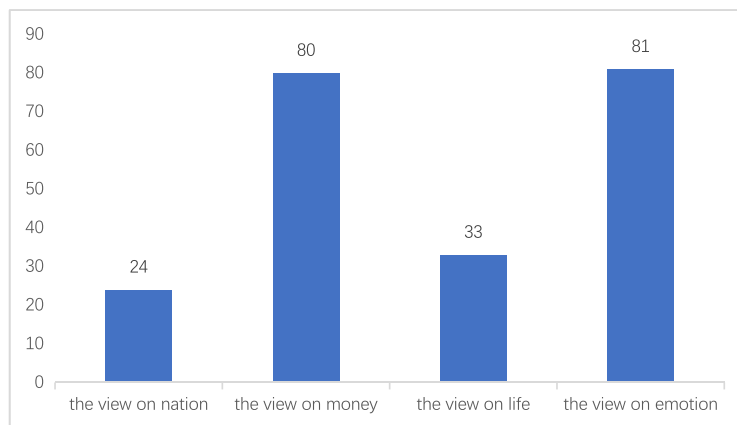
Note: n=103.

3. Research Results

3.1. Manifestations of Value Differences among Middle School Students

3.1.1. Value Systems

The value systems of middle school students are in a formative stage and may demonstrate conceptual variations compared to their peers during this developmental period. This study initially conducted an investigation and statistical analysis of the perspective differences present within the value systems of middle school students. As depicted in **Figure 1**, the most prominent differences among middle school students' values are observed in their attitudes toward money (e.g., the perceived importance of money) (80 out of 103 participants) and emotional responses (e.g., contrasting strategies for resolving interpersonal conflicts, such as avoidance versus negotiation) (81 out of 103 participants). In contrast, differences in views on nation(e.g., China-US relations and China-Japan relations) (24 out of 103 participants) and on life-related concepts (e.g., the meaning of life) (33 out of 103 participants) were comparatively less pronounced.

**Figure 1.** Differences in Value Concepts among Middle School Students

3.1.2. Objective Facts Understanding

Differences and disputes may also arise among middle school students regarding objective facts understanding (such as the correct answer to a specific question). This study examined and conducted a statistical analysis of variations in students' perceptions of objective facts understanding. As illustrated in **Figure 2**, 84 middle school

students reported divergent opinions from their peers concerning the question of “whether effort is significant,” 74 students indicated differing views on “whether IQ (Intelligence Quotient) is malleable,” and 43 students expressed disagreement regarding “the correct answer to a question.” These results indicate that discrepancies in objective facts understanding are prevalent among middle school students.

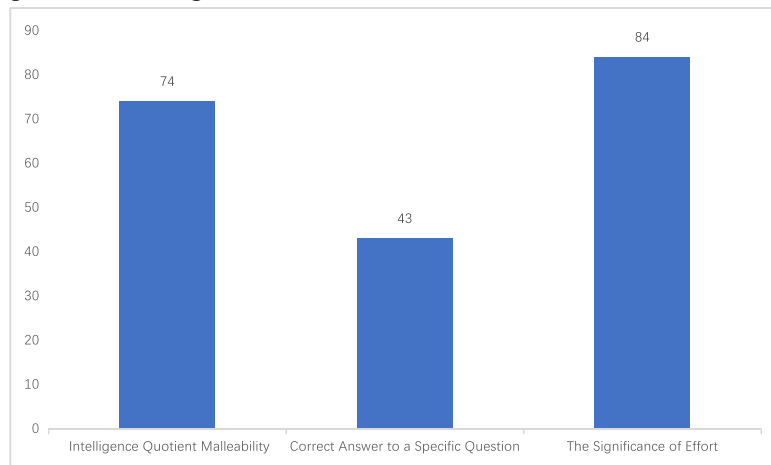


Figure 2. Differences in Middle School Students’ Perceptions of Objective Facts Understanding

3.1.3. Personal Preferences

During adolescence, middle school students often place a strong emphasis on individuality, which may result in varying views based on personal preferences. This study examined and conducted a statistical analysis of the differences in middle school students’ perceptions of personal preferences. As illustrated in **Figure 3**, notable differences were identified among students concerning their “favorite sports teams” (56 out of 103) and the “actual date for birthday celebration (lunar versus solar calendar)” (52 out of 103). Moderate variability was observed in preferences related to “favorite celebrities” (43 out of 103), “favorite foods” (35 out of 103), and “favorite bloggers” (27 out of 103). Conversely, disparities in preferences regarding favorite games, lifestyle choices, and political views were comparatively minimal, with fewer than 20 students indicating divergent opinions from their peers in these domains. These results suggest that although differences in personal preferences are prevalent among middle school students, they are most prominently manifested in the selection of favorite sports teams and the choice of birthday celebration date based on a different calendar.

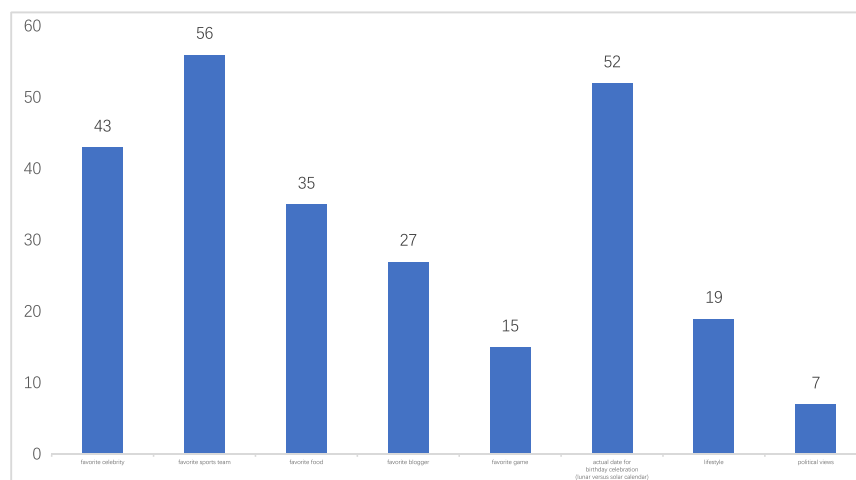


Figure 3. Differences in Personal Preference Concepts among Middle School Students

3.2. Group Differences in Middle School Students' Perspectives

3.2.1. Gender Differences in Middle School Students' Perspectives

Male and female students may prioritize different dimensions, resulting in distinct patterns of conceptual variation. For example, female students might emphasize values more, whereas male students may concentrate on objective facts. Accordingly, this study investigated gender-based differences in perspective variations among middle school students. As indicated in **Table 2**, no statistically significant differences were observed between male and female students regarding objective facts understanding ($t = 0.80$, $p > 0.05$), personal preferences ($t = 0.08$, $p > 0.05$), or values ($t = 0.62$, $p > 0.05$). These results imply that male and female students demonstrate comparable patterns of perspective differences.

Table 2. Gender Differences in Middle School Students' Perspective Variations

	Male	Female	t	p
Objective Facts Understanding	3.16	3.06	0.80	0.43
Personal Preferences	3.14	3.13	0.08	0.94
Values	3.11	3.03	0.62	0.54

Note: Two-tailed test.

3.2.2. Age Differences in Middle School Students' Perspectives

Middle school students of varying ages may prioritize distinct factors, resulting in differences in their conceptual understandings. For example, junior high school students tend to emphasize personal preferences, whereas junior high school students are more inclined to focus on objective facts. This study investigated age-related differences in conceptual distinctions among middle school students, with the results summarized in **Table 3**. According to **Table 3**, junior high school students showed significantly greater divergence in perspectives compared to junior high school students across all measured dimensions: objective facts understanding ($t = -6.04$, $p < 0.001$), personal preferences ($t = -5.54$, $p < 0.001$), and values ($t = -5.33$, $p < 0.001$). These results indicate that junior high school students exhibit substantially more pronounced conceptual differentiation than the junior high school students.

Table 3. Age Differences in Perspectives Discrepancies Among Middle School Students

	Junior High School	High School	t	p
Objective Facts Understanding	1.89	3.20	-6.04***	<0.001
Personal Preferences	1.94	3.21	-5.54***	<0.001
Values	1.79	3.16	-5.33***	<0.001

Note: *** indicates $p < 0.001$, two-tailed test.

3.3. Generalization Effects of Middle School Students' Perspective Differences

3.3.1. Descriptive Statistics Analysis of Positive Generalization Effects concerning Perspective Consistency

When discrepancies in perspectives among middle school students are minimal, they may demonstrate a state of attitudinal consistency. Encountering peers with similar viewpoints can also elicit a positive generalization effect. For example, sharing admiration for the same celebrity with a classmate may promote harmonious interpersonal relationships, potentially leading to one's idealization of the classmate. This study performed a statistical analysis

of the positive generalization effect resulting from attitudinal congruence among middle school students, with the results illustrated in **Figure 4**. As depicted in **Figure 4**, the generalization effect associated with perspective consistency among these students is manifested in dimensions such as relationship harmony, personal idealization, regional preference, and family background embellishment, with mean scores of 2.94, 3.12, 3.10, and 3.11, respectively. The overall distribution centers around the midpoint of 3 on a 5-point scale, indicating that the positive generalization effect derived from perspective consistency among middle school students is moderate in magnitude

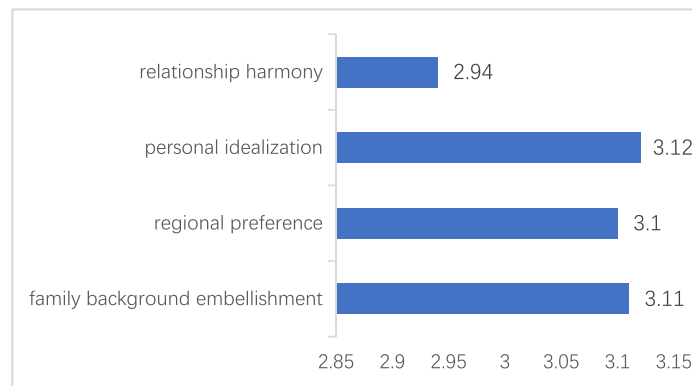


Figure 4. Positive Generalization Effect concerning Perspective Consistency among Middle School Students

3.3.2. Descriptive Statistical Analysis of the Negative Generalization Effect Related to Divergent Perspectives among Middle School Students

Notable differences in the viewpoints of middle school students often give rise to conceptual disagreements. Encountering peers with conflicting opinions can elicit a negative generalization effect. For example, tensions arising from differing preferences for sports teams may result in generalized personal criticisms directed at classmates in all dimensions. This study conducted a statistical examination of the negative generalization effect associated with divergent perspectives among middle school students. As illustrated in **Figure 5**, the generalization effect related to inconsistencies in viewpoints among middle school students is evident in dimensions such as family background bias, regional bias, personal attacks, and interpersonal conflicts, with mean scores of 3.01, 3.01, 2.99, and 3.06, respectively. The overall distribution centers around the midpoint of 3 on a 5-point scale, suggesting that the negative generalization effects resulting from divergent perspectives among middle school students occur at a moderate intensity.

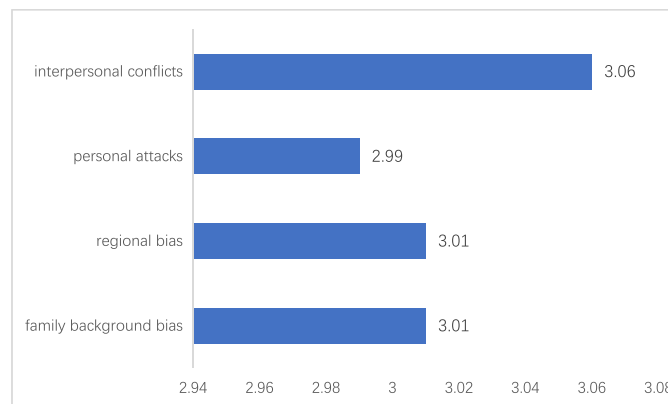


Figure 5. Negative Generalization Effect of Divergent Perspectives among Middle School Students

3.3.3. Regression Analysis of Positive Generalization Effects concerning Perspective Consistency among Middle School Students

The effects of positive generalization may differ across various dimensions of Perspective Consistency. Specifically, value harmony is generally associated with the enhancement of personal idealization, whereas preference consistency is more closely linked to the promotion of relationship harmony. In this study, value harmony, preference consistency, and factual harmony were selected as independent variables, and their impacts on relationship harmony, personal idealization, regional preference, and family background embellishment were examined through regression analyses. **Table 4** summarizes the results and reveals that value harmony exerts a significant positive effect on personal idealization ($\beta = 0.49$, $p < 0.001$), regional preference ($\beta = 0.18$, $p < 0.05$), and family background embellishment ($\beta = 0.19$, $p < 0.05$). Preference consistency was found to significantly and positively influence relationship harmony ($\beta = 0.65$, $p < 0.001$), personal idealization ($\beta = 0.17$, $p < 0.05$), and regional preference ($\beta = 0.72$, $p < 0.001$). Additionally, factual harmony demonstrated a significant positive effect on personal idealization ($\beta = 0.28$, $p < 0.01$) and family background embellishment ($\beta = 0.61$, $p < 0.001$). These results indicate that Perspective Consistency among middle school students in terms of values, personal preferences, and objective facts understanding substantially contributes to a positive generalization effect.

Table 4. Regression Analysis of Generalization Effects on Middle School Students' Perceptions

	relationship harmony	personal idealization	regional preference	family background embellishment
Gender	-0.14	-0.31	0.03	-0.1
Age	-0.08	-0.1	-0.01	-0.1
Educational Background	-0.38	0.02	-0.17	-0.04
Value Harmony	0.01	0.49***	0.18*	0.19*
Preference Consistency	0.65***	0.17*	0.72***	0.12
Factual Harmony	0.15	0.28**	0.07	0.61***
R ²	0.65	0.67	0.7	0.67
F	29.55	31.85	37.38	31.81

Note: * indicates $p < 0.05$, *** indicates $p < 0.001$, two-tailed test.

3.3.4. Regression Analysis of Negative Generalization Effects from Opposing Perspectives among Middle School Students

Negative generalization effects arising from opposing perspectives may vary across domains. For example, inconsistencies in objective facts understanding are more likely to provoke personal attacks, whereas divergences in preferences tend to result in relational conflicts. This study utilized differences in values, objective facts understanding, and preferences as independent variables to perform regression analyses on dependent variables, including relational conflicts, personal attacks, regional bias, and family background bias. According to the results indicated by **Table 5**, differences in values did not exert a statistically significant effect on relational conflict ($\beta = 0.02$, $p > 0.05$), personal attacks ($\beta = -0.17$, $p > 0.05$), regional bias ($\beta = 0.08$, $p > 0.05$), or family background bias ($\beta = 0.01$, $p > 0.05$). In contrast, differences in preferences demonstrated a significant positive association with relational conflict ($\beta = 0.65$, $p < 0.001$), personal attacks ($\beta = 0.69$, $p < 0.001$), regional bias ($\beta = 0.29$, $p < 0.001$), and family background bias ($\beta = 0.50$, $p < 0.001$). Additionally, differences in objective facts understanding were

significantly and positively related to personal attacks ($\beta = 0.39$, $p < 0.01$), regional bias ($\beta = 0.44$, $p < 0.001$), and family background bias ($\beta = 0.35$, $p < 0.01$). These results indicate that value differences among middle school students do not contribute to negative generalization effects, whereas variations in personal preferences and objective facts understanding tend to exacerbate such effects, manifesting as relational conflicts, personal attacks, and biases based on region and family background.

Table 5. Regression Analysis of Generalization Effects from Perspectives Differences among Middle School Students

	Relational Conflicts	Personal Attacks	Regional Bias	Family Background Bias
Gender	0.15	-0.19	0.04	-0.12
Age	0.06	-0.17	-0.12	-0.06
Educational Background	0.23	0.05	0.1	-0.23
Differences in Value	0.02	-0.17	0.08	0.01
Differences in Preference	0.65***	0.69***	0.29***	0.50***
Differences in Objective Facts Understanding	0.16	0.39**	0.44***	0.35**
R ²	0.62	0.76	0.46	0.48
F	30.12	21.84	13.8	14.62

Note: ** denotes $p < 0.01$, *** denotes $p < 0.001$, two-tailed test.

4.1. Conclusions

This study examined perspective differences among middle school students and their generalization effects through a questionnaire survey. The results show that such differences mainly manifest in three domains: values, objective factual understanding, and personal preferences. Value-related differences are reflected in divergent attitudes toward money and emotions; disagreements in objective understanding focus on IQ malleability and the role of effort; preference differences appear in favored sports teams and whether birthdays are celebrated using the lunar or solar calendar.

Group comparisons revealed no significant gender differences across these domains. However, high school students exhibited significantly greater divergence than junior high school students in values, objective understanding, and preferences.

Regarding generalization effects, perspective consistency among middle school students generated moderate positive effects, enhancing relational harmony and contributing to personal, regional, and family idealization. In contrast, perspective differences produced moderate negative generalization effects. Notably, only divergences in preferences and objective understanding—rather than values—were associated with relational conflict, personal attacks, regional bias, and family background bias.

4.2. Discussion

4.2.1. Manifestations of Perspective Differences

The findings indicate clear divergences among middle school students in three domains: values, objective factual understanding, and personal preferences. Value-related differences mainly concern attitudes toward money and emotion, which are strongly shaped by family upbringing and the variability of familial environments during adolescence. Differences in understanding objective facts—particularly beliefs about IQ malleability and the role

of effort—may stem from academic experiences. Students who achieve success through effort tend to believe IQ is changeable, while those who struggle despite exertion may view IQ as fixed, resulting in contrasting interpretations of ability and effort.

Personal preference differences, such as support for particular sports teams or choosing lunar versus solar birthday celebrations, largely reflect sociocultural influences, including gendered leisure activities and family traditions linked to rural or urban backgrounds.

4.2.2. Greater Perspective Differences among High School Students

High school students exhibit significantly greater divergence than junior high school students across all three domains. This can be explained by their higher cognitive maturity, which enables more complex reasoning about facts, preferences, and values. Their longer and more intensive academic exposure further broadens their knowledge base, fostering more differentiated viewpoints. Additionally, expanded social interaction with diverse peer groups increases contact with varied opinions, promoting the development of more heterogeneous perspectives. Together, cognitive development, enriched learning experiences, and wider social environments contribute to the heightened diversity of perspectives among high school students.

4.2.3. Positive Generalization Effects from Perspective Consistency

Perspective consistency produces moderate positive generalization effects among middle school students. Agreement in values, preferences, or factual understanding enhances relational harmony and increases the likelihood of forming friendships. Such consistency also promotes personal idealization, in which students overlook minor flaws and attribute positive traits to peers who share their viewpoints. Furthermore, once identification with an individual is established, favorable perceptions may extend to their family and regional background, generating family and regional idealization.

4.2.4. Negative Generalization Effects from Perspective Differences

Perspective differences lead to moderate negative generalization effects, particularly when involving preferences and factual understanding. Discrepancies in these areas are more salient to middle school students because their preferences and perceptions of objectivity are solidifying at this developmental stage, increasing their attachment to personal beliefs and intensifying conflicts, personal attacks, and regional or family biases. In contrast, value-based differences do not exert comparable negative effects. As value formation is a gradual, long-term process that continues into adulthood, middle school students' value systems remain relatively fluid, reducing the likelihood that value disagreements trigger strong negative generalizations.

5. Recommendations

5.1. Practical Recommendations

5.1.1. Guiding Middle School Students to Address Perspective Differences

The study shows that students differ in objective factual understanding, preferences, and values. To help them manage such differences, schools should promote objective thinking through examples, case analyses, and scientific reasoning to strengthen evidence-based judgment while fostering respect for alternative viewpoints. Respect for diversity should be cultivated through exposure to varied cultural, artistic, and athletic activities, broadening students' perspectives and reducing preference-based conflicts. Value education is also essential;

integrating ethical instruction and discussions on moral decision-making and social responsibility can improve inclusivity and tolerance. Strengthening communication and debate skills through structured discussions and mock debates further enables students to express ideas clearly and understand others' positions.

5.1.2. Targeted Guidance for Different Groups

Since junior high school students exhibit less conceptual divergence than high school students, differentiated guidance is needed. Junior students should focus on developing basic reasoning and communication skills, using situational cases to understand the consequences of differing opinions. High school students, who show greater ideological divergence, require advanced analytical and debating training to engage deeply with opposing viewpoints. Because negative generalization effects intensify with age, both schools and families should reinforce guidance that promotes recognition and acceptance of diverse opinions.

5.1.3. Preventing the Generalization of Perspective Conflicts

Given that divergent perspectives can generalize into relational conflict, personal attacks, and regional bias, targeted preventive measures are necessary. First, schools should prioritize critical thinking and information literacy so that students rely on credible evidence and avoid escalating disagreements into personal conflicts. Second, cross-cultural activities can enhance awareness of varied values and preferences, reducing the risk of disputes turning into biases. Third, establishing safe communication platforms and providing communication training can facilitate respectful dialogue. Fourth, conflict-resolution instruction can equip students with constructive strategies to manage disagreements. Finally, interdisciplinary and experiential learning that simulates real-world scenarios can foster comprehensive cognition, reducing conflicts rooted in misunderstandings.

5.2. Research Limitations and Future Directions

5.2.1. Further Exploration of the Impact of Perspective Differences

This study examined manifestations, group differences, and generalization effects of perspective divergence. Future research should deepen analyses of cognitive development, focusing on how developmental stages, reasoning patterns, and logical capacity influence viewpoint formation and expression. Studies should also investigate the role of family socialization—such as parenting style, communication, and family culture—in shaping students' oppositional attitudes. Additionally, school practices and peer influence warrant exploration, including curriculum design, pedagogical strategies, school climate, and the role of peer groups in reinforcing or mitigating opposing viewpoints.

5.2.2. Expanding the Sample Through Random Sampling

The study collected 103 responses using snowball sampling, resulting in a sample primarily from Shanghai. While sufficient for preliminary investigation, future research should expand sample size and geographic diversity through stratified random sampling across multiple provinces to improve representativeness.

5.2.3. Employing More Diverse Research Methods

This study relied on survey methods. Future research should incorporate mixed methods by integrating quantitative surveys with qualitative interviews or focus groups to capture deeper contextual insights. Field observations could provide ecological data on how conflicting viewpoints emerge in natural settings. Social network analysis would help reveal how perspectives spread and cluster among students in online environments. Experimental designs

could further identify causal mechanisms underlying perspective divergence, thereby enhancing theoretical and practical understanding.

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The Construction of a “Consistency Evaluation” System for Mid-to-High-End Domestic Medical Equipment and Imported Equipment

Yi Xiao†, Guangming Wang†, Kaiqi Zeng*, Renyong Lin, Yanxue Zhai, Qing Xie, Yiling Liao

Longhua District Central Hospital, Shenzhen 518110, Guangdong, China

†These authors contributed equally to this work.

*Author to whom correspondence should be addressed.

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Abstract: To break the “import-only” tendency of medical institutions towards medium and high-end domestic medical equipment, this study, based on health technology assessment, value-based healthcare and the full life cycle theory, constructs a consistency evaluation system for medium and high-end domestic and imported medical equipment. Through two rounds of Delphi expert consultation (n=19), the analytic hierarchy process was used to determine the weights of the indicators, and a final evaluation system was formed, which includes four dimensions of economy, technology, clinical adaptability, and full life cycle, as well as 25 secondary indicators. This system innovatively integrates multi-source evaluation theories and establishes a four-dimensional evaluation model covering technological breakthroughs, clinical value, cost control and risk management, providing a scientific decision-making tool for the substitution of domestic medical equipment for imported ones.

Keywords: Domestic medical equipment substitution; Consistency evaluation; Analytic hierarchy process; Delphi method; Full life cycle

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1. Introduction

As the core infrastructure of the national public health system, mid-to-high-end medical equipment represents a critical link in ensuring the autonomous and controllable nature of medical resources. Breakthroughs in technological barriers within fields such as medical imaging diagnostics (e.g., CT, MRI), in vitro diagnostics (e.g., chemiluminescence immunoassay analyzers), and rehabilitation therapy (e.g., rehabilitation robots, laser therapy devices) directly impact the strategic security of the nation’s healthcare system. However, medical institutions, as the primary users of mid-to-high-end medical equipment, generally exhibit a tendency to favor imported equipment, which essentially stems from a lack of scientific evaluation criteria regarding the performance and clinical compatibility

of domestically produced equipment. Exploring a scientific, comprehensive, and objective “consistency evaluation” method for comparing mid-to-high-end domestically produced medical equipment with imported counterparts can not only enhance the effectiveness and safety of domestically produced medical equipment, providing medical units with evidence-based grounds for adopting domestically produced equipment, but also reduce expenditure for medical institutions and drive rapid innovation and development in the domestic medical device industry.

The process of studying the consistency between two types of entities, X and Y, involves encoding specific instances x and y of X and Y using the same coding system and then comparing them ^[1]. In short, the essence of consistency is the manifestation of “non-contradiction” and “self-consistency,” which permeates the entire human system of seeking truth, reliability, and system design. In the medical field, “consistency evaluation” research is predominantly applied in the reevaluation of generic drugs, but it is equally applicable to the evaluation of medical equipment. Existing research primarily focuses on comparing the performance of domestically produced and imported equipment, analyzing economic benefits, evaluating user satisfaction, and investigating the current status of equipment allocation. Research methods have gradually evolved from early qualitative descriptions to quantitative analyses, with the introduction of scientific approaches such as the Analytic Hierarchy Process (AHP), Fuzzy Comprehensive Evaluation Method, and Real-World Data Analysis, enhancing the scientific rigor and credibility of research ^[2,3,4]. Studies by Feng Hanbo et al. indicate that the localization rate of basic hospital equipment, including monitors, infusion pumps, and syringe pumps, has exceeded 85% ^[5]. Further research by Yang Minmin confirms that for small medical devices such as surgical instruments, infusion pumps, monitors, and electrocardiogram (ECG) machines, domestic brands have fully matured in terms of technology. These devices, characterized by relatively simple functions, high production and sales volumes, assured quality, and superior after-sales service, have gained a competitive edge ^[6]. According to a survey conducted by Liu Yanning et al. on secondary and tertiary public hospitals in Liaoning Province, domestic ECG machines, digital radiography (DR) systems, and biochemical analyzers even outperform their imported counterparts in terms of return on investment and utilization rates ^[2]. However, existing research still exhibits significant shortcomings in terms of theoretical systematicness, methodological integration, dynamic perspective, and localization suitability of evaluation indicators, highlighting an urgent need to establish a more scientific and comprehensive integrated evaluation system.

Therefore, considering the characteristics of medical equipment and associated research costs, as well as incorporating localization features of domestic substitution, it is essential to construct a “consistency evaluation” system for medium-to-large medical equipment from multiple dimensions, including economic efficiency, clinical adaptability, technicality, and full lifecycle management. This system should address four core issues in the process of domestic substitution: cost control, technical benchmarking, clinical implementation, and long-term risk management, providing a scientific and reliable basis for relevant authorities to promote the substitution of imported medical equipment with domestic alternatives.

2. Subjects and Methods

2.1. Establishment of a Project Liaison Team

The Delphi method is a structured approach that involves conducting multiple rounds of anonymous, back-to-back opinion solicitation from experts on the issues to be predicted through written inquiries. Researchers aggregate and provide feedback on the experts’ opinions in each round until a consensus is reached among them ^[7]. The substitution of domestically produced medical equipment involves multidimensional issues such as technology, clinical application, economics, and policy. Experts from different fields may have divergent opinions. The

Delphi method, through its anonymous and multi-round feedback mechanism, systematically converges expert viewpoints, avoids bias from authoritative dominance or groupthink, and ensures the objectivity of indicator selection. To enhance the research progress and the efficiency of Delphi expert consultations, a project liaison team was established, consisting of one professor, one postgraduate student, and three medical equipment engineers. The primary responsibilities of the project liaison team include initially determining the original indicator content and quantity for the “consistency evaluation” of medium-to-large domestically produced medical equipment versus imported equipment, developing expert consultation questionnaires, selecting experts from various fields, coordinating expert consultation activities, and conducting statistical analysis of questionnaire results, ultimately organizing, summarizing, and evaluating the survey outcomes.

2.2. Preliminary Determination of Original Indicator Content and Quantity

By reviewing literature related to medical device evaluations and the implementation policies concerning domestic substitution, the project liaison team, starting from the research objectives of this project and integrating theories such as Health Technology Assessment (HTA) ^[8], Value-Based Health Care (VBHC) ^[9], Life Cycle Management (LCM) ^[10], and Cost-Benefit Analysis (CBA) ^[11], determined the content and quantity of the original indicators. During the process of constructing a “consistency evaluation” system for medium to large-sized domestic medical devices and imported devices, the team took into account the fundamental needs for medical devices to be affordable, effective, familiar, and durable. Indicators were set up from four aspects: economic efficiency, clinical adaptability, technicality, and life cycle management, resulting in the preliminary formulation of an evaluation system comprising 4 primary indicators and 50 secondary indicators.

2.3. Selection of Consultation Experts

After discussion by the project liaison team, the basic criteria for experts participating in the project consultation were established as follows: ① Their professional fields should cover medical device R&D, hospital equipment management, health policy research, clinical usage experts, medical device maintenance, and medical device procurement; ② They should possess experience in their respective fields and have been actively engaged in relevant positions for at least the past three years; ③ They should hold a deputy senior professional title or above, or a mid-level professional title with a postgraduate degree or higher; ④ They should be interested in scientific research and have sufficient time to fully cooperate with this research work. After unanimous discussion by the liaison team, 19 experts from public hospitals, R&D departments of imported medical device manufacturers, R&D departments of domestic medical device manufacturers, and policy-making institutions were selected as consultation subjects.

2.4. Conduct Delphi Consultation

From February to April 2025, two rounds of expert consultations were conducted through online meetings, with questionnaires distributed via QR codes. In the first round of expert consultation, a five-point rating scale was first employed to define and assign scores for four dimensions: importance, operability, data availability, and familiarity (see **Table 1**). Experts were then asked to make judgments on these four dimensions for each indicator based on their professional backgrounds and work experience. Based on the returned questionnaire results and feedback, revisions were made after comprehensive consideration of the opinions and suggestions to determine the final content of the evaluation indicators. The second round of expert consultation primarily sought opinions on the weights of the revised indicators, utilizing the Analytic Hierarchy Process (AHP) to determine the weights of each primary and secondary indicator.

Table 1. Definitions and Scoring Rules for the Four Dimensions

Dimension	Description	Scoring Rules
Importance	The criticality of this indicator for evaluating domestic substitution of imported equipment.	Very Important (5), Fairly Important (4), Moderately Important (3), Slightly Important (2), Not Important (1)
Operability	The feasibility and cost of measuring this indicator in practical application.	Extremely High (5), High (4), Moderate (3), Low (2), Very Low (1)
Data Availability	The difficulty level in obtaining the data required for this indicator.	Very Easy (5), Fairly Easy (4), Moderate (3), Fairly Difficult (2), Very Difficult (1)
Familiarity	The expert's degree of familiarity with this indicator.	Very Familiar (5), Fairly Familiar (4), Moderately Familiar (3), Slightly Familiar (2), Unfamiliar (1)

2.5. Data Processing and Statistical Methods

Data were organized and summarized using Excel spreadsheets, and then analyzed using Python software to assess the scoring results provided by each expert. Firstly, the liaison team conducted a quantitative assessment of the experts' qualifications based on their professional backgrounds, calculating data dispersion and information utility values to obtain a weighted average score for expert qualifications. The weight coefficients of each expert were then adjusted using the entropy weight method. Next, the original data from the 19 experts were integrated to construct a matrix, and weighted scores for importance, operability, and data availability were calculated for each indicator. A comprehensive screening threshold was applied, and the correlation coefficients of the indicators were calculated. Similar indicators were merged, and the final evaluation indicators were determined. Finally, the Analytic Hierarchy Process was used to construct a judgment matrix and calculate the consistency ratio ($CR < 1$), while the entropy weight method was employed to calculate information entropy and utility values, thereby determining the final weights of the evaluation indicators. In summary, the final evaluation system was established.

3. Results Analysis

3.1. Introduction to Basic Information of Experts

The liaison group selected a total of 19 experts to participate in this study, including 3 experts in the research and development of domestically produced medical equipment, 3 in the research and development of imported medical equipment, 4 in hospital equipment management, 2 in health policy research, 4 clinical users, 2 medical equipment maintenance personnel, and 1 medical equipment purchaser. Experts with a professional title of associate senior level or above accounted for 78.95%, and all experts had work experience of 10 years or more (see **Table 2**).

Table 2. Summary of Basic Information of Experts

Category	Characteristic	Number of Experts	Percentage
Gender	Male	13	68.42%
	Female	6	31.58%
Age	30-45 years	15	78.95%
	>45 years	4	21.05%
Education Level	Bachelor's Degree	5	26.32%
	Master's Degree or above	14	73.68%

Table 1 (Continued)

Category	Characteristic	Number of Experts	Percentage
Years of Experience	10-15 years	10	52.63%
	>15 years	9	47.37%
Professional Title	Intermediate Title	4	21.05%
	Deputy Senior Title or above	15	78.95%

3.2. Expert Enthusiasm

The enthusiasm coefficient of experts is represented by the response rate of the questionnaire^[12]. In the first round of expert consultation, a total of 21 experts were invited to participate in the questionnaire survey, and 19 valid questionnaires were collected, resulting in an expert enthusiasm coefficient of 90.47%. In the second round of expert consultation, a total of 19 experts were invited, and 19 valid questionnaires were collected, resulting in an expert enthusiasm coefficient of 100%. During the two rounds of expert consultation, in addition to providing professional scores, the experts also proposed a total of more than 30 suggestions and comments, indicating that the participating experts were highly interested in and concerned about this research topic.

3.3. Determination of Expert Weights and Indicator System

Construct an expert weight matrix (see Formula 1), where each row represents an expert, each column represents an indicator, and each cell contains the expert's ratings for the importance (1-5 points), operability (1-5 points), and data availability (1-5 points) of the indicator. Based on the qualifications and the weights (W_k) adjusted by the Delphi method, calculate weighted scores for each indicator after expert ratings, including weighted importance

$S_j^{\text{importance}} = \sum_{n=1}^{19} W_k * s_{jn}^{\text{importance}}$, weighted operability $S_j^{\text{operation}} = \sum_{n=1}^{19} W_k * s_{jn}^{\text{operation}}$, and weighted data availability

$S_j^{\text{data}} = \sum_{n=1}^{19} W_k * s_{jn}^{\text{data}}$, to ensure objective and authentic results. After completing the first round of expert

consultations, calculate the final contribution scores for each expert. The contribution score is calculated as follows: (importance \times 0.4 + operability \times 0.3 + data availability \times 0.2 + familiarity \times 0.1) \times expert weight. Use the threshold value method to screen indicators^[4], and combine expert opinions to add or delete indicators. Indicators with a contribution score ≥ 4.3 are ultimately included, resulting in an indicator system consisting of 4 primary indicators and 25 secondary indicators, as shown in **Table 3**.

$$X = \begin{bmatrix} X_{11} & X_{12} & \dots & X_{1j} \\ X_{21} & X_{22} & \dots & X_{2j} \\ \dots & \dots & \dots & \dots \\ X_{i1} & X_{i2} & \dots & X_{ij} \end{bmatrix}$$

Formula 1. Expert Weight Matrix

Table 3. Consistency Evaluation Indicator System for High-end Domestically Produced Medical Equipment and Imported Products

Primary Dimension	Secondary Dimension	Secondary Indicator Code	Secondary Indicator Name	Expert Consensus Score (Average)
A. Economic Dimension	A1 Initial Investment Cost	A1-1	Equipment Purchase Price (Tax-Inclusive)	4.60
	A2 Operation & Maintenance Cost	A2-1	Annual Preventive Maintenance (PM) Cost	4.82
	A3 Consumables & Compatibility	A3-1	Unit Price of Dedicated Consumables (vs. Imported Counterpart)	4.48
	A4 Asset Efficiency	A4-1	Daily Revenue Contribution Rate per Unit	4.30
B. Technical Dimension	B1 Core Performance	B1-1	Key Parameter Compliance Rate (vs. Imported Benchmark), e.g., Imaging Resolution, Detection Sensitivity/Specificity, Response Speed	4.88
		B1-2	Equipment Uptime Rate ($\geq 95\%$ Standard)	4.43
	B2 System Reliability	B2-1	Mean Time Between Failures (MTBF)	4.78
		B2-4	Comprehensive Incidence of Faults and Adverse Events	4.50
	B3 Technical Upgradability	B3-2	Hardware Module Expansion Compatibility	4.63
	B4 Localization Adaptation	B4-1	Completeness of Chinese User Interface	4.72
		B4-2	Regional Service Network Coverage (2-Hour Response Radius)	4.32
	B5 Safety	B5-1	Radiation Leakage / Bio-contamination Protection Level	4.92
		B5-2	Data Encryption & Transmission Compliance	4.68
		B5-3	Automatic Blocking Response Speed for Misoperation	4.40
	B6 User Support	B6-1	24/7 Remote Technical Support Connection Rate	4.58
C. Clinical Adaptability Dimension	C1 Diagnostic/Therapeutic Efficacy	C1-1	Improvement in Diagnostic Concordance Rate (vs. Gold Standard)	4.70
	C2 Departmental Operation	C2-1	Average Daily Number of Patients Treated per Device	4.55
	C3 Clinical Experience	C3-1	User Interface Friendliness (Clinician Evaluation)	4.80
		C3-4	Physician Satisfaction (Ease of Operation)	4.38
D. Full Life Cycle Dimension	D1 Procurement & Installation	D1-1	Equipment Delivery Lead Time (Contract Signing to Acceptance, days)	4.65
	D2 Operational Cost	D2-1	Annual Maintenance Cost Ratio (Maintenance Cost / Total Equipment Cost, %)	4.75
		D2-2	Spare Parts Supply Timeliness Rate (%)	4.35
	D3 Clinical Use	D3-3	Time per Examination	4.45
	D4 Repair & Response	D4-1	Average Repair Response Time	4.85
	D5 Decommissioning & Replacement	D5-2	Technology Obsolescence Cycle	4.52

3.4. Determination of Indicator Weights

After finalizing the indicator system, conduct a second round of expert consultations. First, experts are required to conduct pairwise comparisons of the relative importance of the four dimensions and pairwise comparisons of the secondary indicators within the same indicator layer (according to the 1-9 scale definition table). Calculate the

weights of indicators at all levels in combination with expert weights; then perform normalization and calculate the consistency ratio (if $CR < 0.1$, the test is passed; otherwise, rescoring is required), to obtain the final weights of the secondary indicators (see **Table 4**).

Table 4. Results of Indicator Weights

Comprehensive weight of first-level indicator (economic dimension)			
First-level indicator	Comprehensive weight	Consistency Check (Average CR)	Kendall's W
A. Economy	0.165	0.072	0.83
B. Technicality	0.341	0.068	0.79
C. Clinical adaptability	0.238	0.081	0.76
D. Full life cycle	0.256	0.085	0.72
Comprehensive weight of secondary indicators (economic dimension)			
Secondary indicators	Comprehensive weight	Consistency Check (Average CR)	Kendall's W
Purchase price of bare equipment	0.402	0.048	0.86
Annual PM expenses	0.263	0.051	0.81
Unit price of special consumables procurement	0.187	0.063	0.78
contribution rate of daily average diagnosis and treatment revenue per unit	0.148	0.074	0.71
Comprehensive weight of secondary indicators (technical dimension)			
Secondary indicators	Comprehensive weight	Consistency Check (Average CR)	Kendall's W
The key parameter compliance rate	0.218	0.055	0.84
Operating rate	0.132	0.062	0.8
MTBF	0.095	0.058	0.77
Failure incidence rate	0.072	0.067	0.74
Hardware expandability	0.063	0.07	0.72
Chinese interface	0.058	0.069	0.69
Maintenance network coverage rate	0.105	0.061	0.76
Protection grade	0.042	0.075	0.66
Data encryption	0.053	0.073	0.68
Misoperation blocking	0.047	0.071	0.65
Remote support	0.065	0.064	0.7
Comprehensive weight of secondary indicators (dimension of clinical adaptability)			
Secondary indicators	Comprehensive weight	Consistency Check (Average CR)	Kendall's W
Improvement in diagnostic accuracy rate	0.418	0.049	0.85
Average daily number of patients treated	0.227	0.057	0.79
User-friendliness of the operation interface	0.198	0.063	0.75
Doctor satisfaction	0.157	0.072	0.7
Comprehensive weight of secondary indicators (full life cycle dimension)			
Secondary indicators	Comprehensive weight	Consistency Check (Average CR)	Kendall's W
Delivery cycle	0.285	0.052	0.83
Maintenance cost proportion	0.208	0.061	0.78
Timeliness rate of spare parts supply	0.182	0.065	0.75
Time for a single inspection	0.125	0.074	0.69
Maintenance response time	0.105	0.071	0.67
Technology obsolescence cycle	0.095	0.076	0.64

4. Discussion

4.1. Method Selection

Both the Delphi method and the Analytic Hierarchy Process (AHP) are commonly used structured methods, each with its own advantages in structuring (see **Table 5**). In the initial stage, the Delphi method was employed to gather expert opinions and establish an evaluation index system. Subsequently, AHP was utilized to calculate the weights of each indicator. The key factor for the success of Delphi method predictions lies in the selection of experts ^[7]. The number of experts should be determined based on the complexity of the subject matter, with a general recommendation of 15 to 50 participants for consultations ^[13]. After rigorous screening by the liaison team, 19 experts were selected for this study, covering the fields of domestic medical equipment R&D, imported medical equipment R&D, hospital equipment management, health policy research, clinical use, medical equipment maintenance, and medical equipment procurement. These experts were spread across four provinces and cities in China, with 78.95% holding associate senior or higher professional titles and an average work experience of 15.95 years, reflecting their representativeness in their respective academic and professional domains. Meanwhile, the experts actively participated in the questionnaire survey and provided numerous valuable insights. The entire consultation process took nearly a month, with over 90% of the questionnaires returned being valid, further ensuring the quality of the research findings.

Table 5. Comparison of Advantages between Delphi and Analytic Hierarchy Process Methods

Dimension	Delphi Method	Analytic Hierarchy Process (AHP)
Core Objective	Convergence of Group Consensus	Multi-Criteria Weight Calculation
Input Form	Expert Qualitative Opinions (can incorporate quantitative ratings)	Quantitative Paired Comparisons (e.g., 1-9 Scale)
Process Focus	Multi-Round Iteration and Feedback	Matrix Construction and Mathematical Computation
Primary Output	Qualitative Group Consensus or Quantitative Statistical Indicators (e.g., Kendall's W, mean scores)	Weight Values and Ranking Across Hierarchical Levels
Common Structured Features	Standardized, Repeatable, and Transparent Process	Standardized, Repeatable, and Transparent Process

4.2. Interpretation of Results

After two rounds of expert consultations, the experts provided relatively consistent opinions on the first-tier indicators across four dimensions: economic viability, technical feasibility, clinical adaptability, and whole lifecycle management. Among these, technical feasibility had the highest weight (0.341), followed by whole lifecycle management (0.256), clinical adaptability (0.238), and economic viability (0.165). The ranking of these indicator weights also reveals that, under the policy trend of replacing imported medical equipment with mid-to-high-end domestically produced alternatives, technological breakthroughs serve as the core driving force for domestic substitution. The “key parameter compliance rate” stands out with a significantly higher weight (21.8%), aligning closely with the policy emphasis on the “autonomous control of critical components” strategy. Whole lifecycle management determines the sustainability of substitution, with the “technological obsolescence cycle” emerging as the most closely watched indicator. Medical institutions are concerned about the long-term cost risks associated with lagging equipment iteration speeds. Domestic manufacturers can establish ongoing technological upgrade mechanisms (such as modular design) and a spare parts supply system to break the vicious cycle of

“technological lock-in—high-priced maintenance” associated with imported equipment. Clinical adaptability reshapes medical value standards, with the “improvement in diagnostic accuracy rate” carrying a weight of 41.8%, far exceeding other indicators, reflecting experts’ ultimate pursuit of diagnostic precision. The paradox of economic viability weights reveals policy guidance; although the economic viability dimension has the lowest weight (16.5%), the “equipment base price” carries a high weight of 40.2%, creating a structural contradiction. This means that while policies do not encourage price wars, actual procurement by medical institutions remains constrained by budget considerations. Currently, the substitution process is in a technologically intensive phase guided by policies, focusing on overcoming technological hurdles and addressing “bottleneck” issues. Over the next 3-5 years, it will transition into an ecosystem-building phase, establishing local supply chains and forming differentiated advantages.

5. Summary

Based on Health Technology Assessment (HTA), Value-Based Healthcare (VBHC), and Life Cycle Management (LCM) theories, this study employs the classic Delphi method and Analytic Hierarchy Process (AHP) to construct an index system capable of objectively and systematically evaluating the substitution of imported medical equipment with mid-to-high-end domestic alternatives. However, the Delphi method is also prone to interference from subjective factors ^[14], potentially introducing risks of systematic bias. Subsequent empirical research will be conducted based on the consistency evaluation system for substituting imported medical equipment with mid-to-high-end domestic alternatives. This will involve selecting imaging equipment, in vitro diagnostic equipment, and therapeutic equipment to assess the scientific rigor of the selection process within the consistency evaluation system, thereby enhancing the robustness of the conclusions drawn from the Delphi method.

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The Gamified Social Allegory in Liu Cixin's Supernova Era

Zihao Yan*

Translation and Transcultural Studies, School of Modern Languages and Cultures, University of Warwick, Coventry, UK

**Author to whom correspondence should be addressed.*

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Abstract: Liu Cixin's *Supernova Era* presents a profound allegory of societal transformation through gamification. This article argues that the novel, depicting a world where children inherit the Earth after a supernova kills all adults, anticipates contemporary trends of gamification while critically examining its potential and perils. The article employs game studies and science fiction studies to examine four core games—leader selection, territorial simulation, Antarctic wargame, and territory exchange in the novel. It explores how the novel envisions the collapse of the centralized, adult-imposed industrial order and its replacement by a decentralized, play-driven society, facilitated by information technology and mass participation. It further dissects the Antarctic “wargame” as a cautionary tale, revealing the inherent dangers of violence, ethical erosion, and global conflict escalation when gamification loses control. Finally, the paper contextualizes Liu's vision within Chinese science fiction history and contemporary literature, highlighting his distinct “posthuman” perspective that challenges anthropocentric humanism. Combining discussions about the potentials and risks of a gamified society, *Supernova Era* thus serves as a prescient and critical commentary on the logic and consequences of societal gamification. Liu's science fiction imagination can therefore provide inspiration and broaden perspectives on the future direction of post-Cold War social structures.

Keywords: Liu Cixin; *Supernova Era*; Gamification / Ludification; Posthumanism; Chinese Science Fiction

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1. Introduction

Liu Cixin stands as a defining figurehead within contemporary Chinese science fiction literature. His works construct a highly distinctive science fiction aesthetic universe characterized by vast, awe-inspiring cosmic vistas, rigorous scientific rationality, and profound inquiries imbued with ultimate humanistic concern. His science fiction works often infuse their imagination of alternative history with reflections on real-world issues, carrying an element of elite consciousness.^[1] (Song 2020, 19) This trait is particularly evident in his unique insights into social transformation in *Supernova Era*.

Supernova Era was a novel composed during Liu Cixin's early creative period. Its initial draft was completed

in 1989, with the work first published in 2003. It depicts a post-apocalyptic world where children inherit Earth after a supernova's lethal radiation eliminates all adults over thirteen. Unlike his later epics *The Wandering Earth* and *The Three-Body Problem*, this novel carries stronger realist undertones and a pronounced focus on social critique, reflecting the exploratory nature of his early creative phase. Its revision history underscores this development: the 1989 draft critiques Chinese adult society and cultural conservatism; 1990s versions engage with post-Cold War geopolitics such as a war between China and NATO; and the 2000 fourth edition—now the standard published version—shifts to a global Antarctic wargame, prioritizing logical extrapolation of a “children’s world” to become a mature alternate-history SF narrative.^[2] (Zhang 2021, 39-44)

Notwithstanding its ties to 1990s historical contexts, the novel’s vision of a world reorganized by children uncannily resonates with 21st-century “gamification” discourse. In the story, Chinese child leaders fail to sustain industrial-era order because younger children refuse regimented labor. Then Chinese children’s society undergoes a fundamental reorientation, pivoting towards a structure fundamentally driven by the core principle of “play”. State-owned property loses its protected status; private property similarly diminishes in perceived value; only work perceived as inherently enjoyable or directly facilitating ongoing play finds willing participants. Furthermore, international power disputes find resolution through “war” games meticulously disguised as entertainment and competitive events. Liu’s conceptualization thus offers a degree of prescience regarding contemporary society’s gamification trajectory. Post-Cold War modern governments increasingly favor leveraging the positive feedback mechanisms inherent to games and the entertainment industry. They prioritize this approach over deploying explicit ideological narratives. Their goal in doing so is threefold: first, to guide mass behavior; second, to enhance public participation in civic affairs; third, to integrate playful elements into educational paradigms. This novel transcends the boundaries of mere post-apocalyptic fantasy, functioning instead as a potent allegory. It leverages the stark divergence between the children’s collective and adult society to reexamine underlying social-historical logic and envision the operational dynamics of a new generation’s society. This fully embodies Liu Cixin’s overarching aesthetic preoccupation with the collective fate of civilization.

The article proceeds by addressing three interrelated questions that frame its analysis: First, how do the four core games in *Supernova Era*—from the “leader selection” to the “territory exchange”—function as a narrative toolkit to dramatize the tension between centralized control and decentralized play in societal transformation? Second, what does the collapse of the Antarctic wargame reveal about Liu’s critique of gamification when stripped of ethical constraints—does it serve as a warning against weaponizing play, or a recognition of its inherent instability? Third, in the context of cross-cultural communication, how does the “territory exchange” game negotiate between local Chinese cultural norms (e.g., collective identity, “native soil sentiment”) and global game logics, and what does this negotiation suggest about Liu’s vision of a post-national, gamified civilization? To unpack these questions, Section I first examines the “territorial simulation game” as a microcosm of decentralized social restructuring before discussing the Antarctic wargame to expose the risks of unregulated gamification. Then I analyze the “territory exchange” game to explore its implications for transcultural identity reconstruction. Furthermore, I situate Liu’s imaginative endeavor within the historical context of Chinese science fiction literature and its contemporaneous literary milieu, analyzing how this specific vision challenges the entrenched humanist narratives favored by intellectuals while simultaneously responding to the enduring demand within Chinese science fiction to engage meaningfully with socio-political concerns.

2. The Allegory of Social Transformation within Decentralized Games

The overarching narrative arc of *Supernova Era* can be interpreted as unfolding through the sequential framework of four distinct games. The inaugural game materializes as Chinese adults confront the catastrophic reality of the supernova explosion, expending their remaining vitality to educate children and rigorously select exceptional individuals from among them to assume future leadership roles. Following the adults' demise, the fragile national order briefly maintained by the appointed child leaders can be perceived as a direct continuation of this foundational game. The second game emerges some time after the official commencement of the Supernova Era. Children congregating within burgeoning online communities spontaneously initiate simulations of potential new societal orders, culminating in a proposal to supplant the existing reality with a "play"-oriented society modeled within a territorial simulation game. Their collective vision ultimately garners overwhelming popular support, propelling all nations into the hedonistic and consumption-driven "Candytown" Era. The third game manifests as a wargame conceived by American child leaders, aiming to resolve their internal crisis of proliferating uncontrolled weaponry while perpetuating global hegemony. This entails a military competition staged in Antarctica, where national armies vie for territorial resource allocation. The fourth and final game transpires after the Antarctic wargame collapses due to uncontrolled nuclear escalation. Confronted with escalating political crises, China and the United States engage in an audacious "exchange territories" game, involving the complete reciprocal migration of their populations onto each other's soil, inheriting all assets and resources. The ultimate question of which populace will successfully adapt to this radically new environment is deliberately deferred into an indeterminate future.

The first game, encompassing the Chinese government's formalized selection of child leaders coupled with the child leaders' transient governance enacted according to adult tutelage, embodies, within Liu Cixin's conceptual framework, the quintessential transmission mechanism of an industrialized nation-state's ruling order. The Chinese state apparatus systematically divides a substantial cohort of high-potential children into distinct groups, allocating to each a territory possessing varied resources and conditions. Officials meticulously observe each group's capacity to sustain productive activities within their assigned territory and their aptitude for resolving conflicts of interest rationally when interacting with other miniature "nations." Ultimately, the selection process identifies three children – Huahua, Specs (Yanjing), and Xiaomeng – as the future supreme leaders of China.

A critical observation regarding this paramount power selection activity lies in the Chinese government's strategic decision to disguise the entire rigorous process as a game. This artifice serves to stimulate the children's cognitive engagement and encourage authentic emotional expression during the proceedings. When convening the children, Chinese officials adopt a deliberately casual tone, announcing: "Children, you've come here from all over the country. Now let me tell you the purpose of this journey: We're going to play a big game!" (34). Beneath this playful veneer, however, all activities adhere as closely as possible to principles of realism, extending even to the distribution of live ammunition weaponry to the children. While some children express puzzlement regarding the true nature of this exercise, Specs demonstrates precocious comprehension, articulating its underlying significance:

"It's a science experiment," Specs said to a few other children.

"Our twenty-four little countries are a model of the world, and the adults want to see how this model develops. Then they'll know what our country should do in the future." "Then why don't they run the experiment with adults?" someone asked.

"If the adults know it's a game, they won't play it seriously. We're the only ones who'll play a game seriously, and that's what makes the outcome real." (44)

Here, Liu Cixin effectively utilizes Specs as a narrative conduit to articulate his personal interpretation of game's significance within classical historical and cultural contexts. Players immersed in game activities consciously shed extrinsic utilitarian motivations, adhering earnestly and seriously to established rules. Throughout this process, they authentically enact a designated game procedure, thereby unlocking their intrinsic potential and revealing certain fundamental truths. This concept of "playing seriously" aligns seamlessly with foundational game theory. Johan Huizinga, a pioneering scholar in play studies, defined play thusly: "play is a voluntary activity or occupation executed within certain fixed limits of time and place, according to rules freely accepted but absolutely binding, having its aim in itself and accompanied by a feeling of tension, joy and the consciousness that it is 'different' from 'ordinary life' ^{[3]28} (Huizinga 1980, 28)". Within classical game theory, the rules of a game transcend mere operational logic, possessing the profound capacity to forge a utopian field. This field demarcates the game's world from the quotidian realm, empowering players to undertake independent, creative activities within its bounds. Consequently, Huizinga posited that all human cultural achievements inherently contained elements of play at their inception. Whether ritual, law, the order of war, or art, each originated from this non-utilitarian yet profoundly serious creative impulse. It was only through societal maturation and development that these creative endeavors became assimilated into the fabric of daily order, gradually ceasing to be recognized as play and solidifying into the myriad laws governing routine activity. Liu Cixin's perspective within the novel resonates strongly with this core tenet of classical game theory. He similarly espouses the conviction that the driving force of "play" constitutes civilization's primordial creative energy. Therefore, when human society confronts the necessity of post-crisis reconstruction and must entrust its legacy to young inheritors, the selection process cannot proceed under the guise of conventional education or assessment. Instead, it necessitates simulating authentic future scenarios through the modality of play, thereby stimulating children's latent potential.

However, the socio-political order the adults endeavor to transmit via this game represents a fundamentally centralized structure. The Chinese officials' overarching selection game possesses the explicit objective of identifying national leaders endowed with a macrocosmic vision, capable of steering society's operational direction. From the adult perspective, all technical roles potentially lie within the purview of children to inherit under parental or pedagogical guidance. Leadership capability, however, demands the most concentrated cultivation efforts. Its absence in a post-adult world inevitably precipitates societal collapse. Following the selection, the novel details the rigorous education imparted to the chosen leaders, encompassing skills such as analyzing national daily grain consumption from a macro perspective and utilizing strategic maps to dissect battlefield situations. These details of transmission subtly convey Liu's implicit viewpoint: the order underpinning an industrial nation-state constitutes essentially an elitist structure. Viewed through a gamification lens, only the individual leaders qualify as "players" conforming to classical game theory. They alone observe the nation's comprehensive information from a macro vantage, formulate strategic decisions, and subsequently disseminate their intentions downward through the hierarchy. Only the leaders engage interactively with the entire game system. Mass citizens merely execute designated activities based on obligation, unable to exercise subjective creativity within the systemic framework. This precise aspect constitutes a primary point of subsequent criticism directed at Huizinga's game theory. While championing the playful spirit animating the birth of cultural institutions, he simultaneously critiqued industrial assembly lines for stripping humanity of creativity and aesthetic sensibility. This perspective on game culture ultimately functioned to uphold the ruling status of elite and aristocratic strata, effectively sanctifying the pre-industrial reality where sovereignty resided exclusively with elites and attributing human culture's value solely to those elites who created early culture with a playful disposition.

The absolute demise of the adults and the dawning of the Supernova Era precipitate an immediate assault upon the established order. Children staffing various production departments find themselves utterly adrift, lacking adult leadership guidance. During a critical crisis, the three appointed Chinese child leaders recall the legacy entrusted to them by the adults: a quantum supercomputer designated “Big Quantum”. Leveraging this pinnacle of information technology, they instantaneously transmit the voice of Beijing leadership via telephone and radio to all departments, assuring other children of the leaders’ presence. Simultaneously, they command the computer to rapidly erect a nationwide surveillance mechanism, visualizing the status of departments across the country to facilitate strategic planning. Here, Liu Cixin exhibits his acute perceptiveness as a science fiction writer regarding the intricate relationship between technology and society, specifically illustrating how large governments employ computer technology to reinforce centralized control. Roberts (2006) pointed out that the core of science fiction is technology “enframing the world”.^[4] The “Big Quantum” is the embodiment of this logic. During the governance process, Specs metaphorically likens Big Quantum to their “eyes and mouth.” This metaphor encapsulates how information technology integrates into governmental administration, becoming the physical apparatus through which the political center observes and controls all subordinate units. Moreover, more potent information gathering and dissemination tools inherently empower the national leaders, acting as “players” within the system, furnishing them with significantly enhanced and more convenient instruments for action. Furthermore, the medium of Big Quantum may also metaphorically imply that technological progress has made it possible to implement comprehensive governance over the resources of an entire society. In the history of globalization, technological advancements—such as precision geography and comprehensive transportation networks—have turned all spaces into “homogeneous spaces” that can be calculated and allocated by rulers, thereby enabling the global governance of empires.^[5] (Sloterdijk 2013, 33) Moreover, the integration of information technology has undoubtedly made spatial governance more convenient and efficient.

Nevertheless, the concerted efforts of the three child leaders to perpetuate the old society according to adult directives culminate in failure. The workers and executors within subordinate departments remain fundamentally children under thirteen years old. They prove incapable of embracing the adult paradigm of regimented daily schedules and repetitive labor, ultimately compelling the nation towards the pleasure-centric “Candytown” society. Had the collapse of the old game resulted solely from inherent child psychology, the entire novel might have functioned merely as a disaster narrative. Liu Cixin’s profundity resides in his subsequent extrapolation, centering on information technology. He imagines that a *new* game narrative actively catalyzes the formation of the new society. The vision of the new order materializes within cyberspace, manifesting in the form of games, *before* the three leaders even recognize the old order’s disintegration. Within the narrative, Big Quantum’s deployment of the fastest nationwide internet simultaneously catalyzes the formation of multitudinous online communities. Chinese children, driven by loneliness stemming from the absence of adults, demonstrate heightened enthusiasm for forming online discussion communities. Spontaneously, within virtual space, they initiate territorial reconstruction games. Following a series of subversive destructions and reconstructions of the nation enacted within these virtual games, they present a comprehensive social reform proposal to the three leaders, advocating the abandonment of the old era’s work-hour system and property regime in favor of establishing a pleasure-centered order. Liu’s extrapolation effectively refutes Huizinga’s elitist cultural perspective, envisioning instead a new gamified society steered by decentralized mass preferences—a societal model strikingly congruent with today’s information age.

Two pivotal aspects of this new gamified society intrinsically link to the prevailing technological environment. Firstly, consensus regarding the new societal model emerges organically within the mass games

flourishing in cyberspace *before* the three leaders consciously perceive its necessity. The selection and territorial simulation games, which consumed vast resources under Chinese adult officials, now permit participation by every citizen at minimal cost within the internet space. Furthermore, simulation games operating at the network level possess demonstrably superior visual impact. When the three leaders inspect the territorial blueprints crafted by children within cyberspace, they encounter numerous counter-intuitive designs: Candytown constructed entirely from confectionery; A concept mandating residence for all within high-rise towers while restoring the majority of urban space to natural hunting grounds; Social activities conducted without currency, relying instead on barter and the exchange of self-invented toys. Crucially, the children explicitly demand the modification of reality to conform to these game plans. This mode of collective action fundamentally overturns the old order's operational paradigm where elites functioned as the sole subjects of the nation, signifying that information technology empowers the masses to become active societal subjects. Moreover, the visual simulations proliferating within cyberspace supersede the children's formal education, molding their societal imagination.

The second significant technical issue revolves around how information technology intrinsically reconstructs the political concepts underpinning the modern state. Citizen participation in elections to express opinions in the pre-information age fundamentally differs from political expression mediated by mass media in the information age. Pre-information age universal elections implicitly operated on the principle that citizens, as constituent parts of the national whole, bore responsibility for overall national affairs, exercising their rights accordingly. Political discourse within the mass media era of the information age, conversely, manifests as communitarian and fragmented. Individuals can intervene using a singular identity, focusing discussion on a specific issue, subsequently aggregated by media into public opinion. Analogously, within the novel, heterogeneous online citizens variously discuss urban construction, working hours, etc., their disparate inputs integrated by Big Quantum before presentation to the three leaders. Within the information age, "Like in the setting of a game, political issues appear as simple fragments of a much bigger picture; there is also the opportunity with these game-like politics to take part, but there is no obligation. Instead of a political idea or ideology, there is a simple challenge; instead of tackling common problems in the world as a whole, we stick with solving a demarcated field or question or problem; instead of asking the citizen to believe in a political program, the issues at stake ask us to take part in finding a solution to a particular problem" ^[6]. (Glas 2019, 283) This transformation, on one hand, grants citizens subjectivity to engage with diverse matters; on the other hand, it poses a profound challenge to the overarching political ethics of the state. Citizens cease to be uniform entities before their leaders; instead, they become players within the entire social system, possessing diverse subjectivities mediated through technology. In the view of ludologist Joost Raessens, a hallmark of modern society as a gamified society is the escalating importance of media literacy, "the term play is not only suitable for characterising our contemporary media culture (playful) but also for defining the knowledge and skills (ludoliteracy or play competence) required to function in media culture." ^[7](Raessens 2014, 109)

The transformation of political logic instigated by shifts in information technology and the media environment inexorably steers the nations of the Supernova Era towards the "Candytown" era—a development entirely unforeseen by any adult. Confronted by this abrupt, unforeseen shift, the three leaders within the novel initiate a profound reevaluation of their original conceptions of governance: "*Relax. History is a river that flows where it wills, and no one can stop it..... We're part of history, a few drops in that river. Go with it.*" (170). Ultimately, they accede to the citizens' proposal, reorienting their own efforts towards guiding the military and power departments to maintain order within the "Candytown" era. This reflects Liu's optimistic expectation that child leaders, sharing

the nature of their constituents, can adapt to the exigencies of the new epoch. Liu Cixin exhibits a keen fascination with imagining transformations in societal forms triggered by altered technological environments. Compared to certain extreme imaginings probing ethical boundaries in his later novels, he displays greater acceptance towards the children's entertainment-oriented society. He recognizes the child's playful spirit as a vital form of creativity consistently underestimated by modern rulers. He articulates a core view through the novel: game principles are more innovative and pioneering than economic principles, as play drives exploration of the world's mysteries; over time, play will evolve to a higher level, and unlike the adult era where economics fueled scientific progress, play will become a far more powerful driver—one that ultimately propels human civilization to an explosive leap, enabling it to meet or exceed the critical velocity needed for survival in the cold universe.

3. The Allegory of Social Conflict within War Games

If Liu Cixin adopts a measured and objective stance towards the “Candytown” era catalyzed by Chinese children's psychology and technological context, his portrayal of the global wargame ensnaring children from diverse nations employs brutal and absurd depictions to expose the dead end towards which uncontrolled global order veers, issuing a stark warning against societies lacking reason that blindly capitulate to gamification trends. Within the narrative, the United States, seeking to alleviate its internal crisis of proliferating uncontrolled weapons within the populace while simultaneously perpetuating the old society's hegemonic status, proposes a wargame to various nations. This entails determining the allocation of Antarctic resources through multiple competitive war events staged on the frozen continent. To safeguard their international standing, the majority of nations feel compelled to participate. A series of war events, initially structured as formal competitions, gradually spirals towards chaos following attempts by certain nations to challenge established rules, culminating in the war's termination after China and the U.S. deploy nuclear weapons.

Functioning as an allegory, the Antarctic wargame reveals that a society governed by the core principle of pleasure inherent to gamification harbors equally destructive potential for crisis and the abuse of violence, potentially abandoning ethical constraints more readily than the old society ever did. Within the novel's logic, the wargame's conception originates explicitly from the American imperative to sustain international hegemony. This narrative segment commences with a discussion between the two American leaders concerning America's essence. Vaughn explains to President Davey that America's possession of international hegemony in the prior era stemmed primarily from its foundational identity as an empire developed upon the principle of “play”, coupled with the global dissemination of its entertainment culture. Weapons themselves constitute humanity's primal toys, Vaughn asserts; the violent desire animating young people wielding firearms aligns intrinsically with the fundamental mentality of “play”. To ensure the continuity of U.S. international power, Vaughn declares: *“The world of play is dawning. Children of other countries and nationalities will play in different ways. Mr. President, what you need to do is to make the children of the world play according to America's rules!”* (201).

Here, Vaughn's assertion that violent activities and even warfare constitute a form of play engages directly with an issue explored since the inception of classical game theory. Huizinga contended: *“In the beginnings of civilization rivalry for first rank was undoubtedly a formative and ennobling factor. Together with a genuine naivete of mind and a lively sense of honour it produced that proud personal courage so essential to a young culture.”* ^{[3]101} (Huizinga 1980, 101) The rationalization of war derives from the pursuit of elevated status within civilization, a pursuit evolving into a martial spirit. Concurrently, the culture cultivated by this valor-based ethos

could potentially endow activities like war and duels with specific rules, confining violence within defined parameters. Consequently, subsequent descriptions of the wargame depict numerous lower-ranking soldiers deriving genuine enjoyment from earning merit through combat.

However, within the origin narrative of this specific wargame, Liu Cixin pointedly emphasizes the motivational factor of nations vying for international hegemony, thereby expanding the gamification discourse to encompass global conflict and political globalization. The governments within the novel accept the wargame proposal solely motivated by self-interest in securing Antarctic resources and bolstering international status. Yet, in mobilizing their internal armies, leaders employ propagandistic strategies that gamify warfare, guiding subordinate units to perceive their actions as stemming from non-utilitarian, even noble motives. Throughout the propaganda campaign, organizers deliberately package the event as an Olympic-style spectacle for broadcast:

“Children of the new world, welcome to the first Olympic Games of the Supernova Era. This is a war games Olympics, a fun Olympics, a thrilling Olympics, and a real Olympics! Children, the boredom of the Common Era has come to a close, and human civilization has returned to its childhood, to a happy, uncivilized age. We have left the dreary ground and returned to the freedom of the trees, we have shrugged off the clothes of hypocrisy and grown luxurious downy coats. Children, the new motto of the Olympic Games is: ‘Take part! Sharper, Fiercer, Deadlier.’ Let the world go crazy, children! Next, I’ll describe the events.” (246).

The mobilization for global warfare under the guise of competition within the novel bears disturbing resemblance to military mobilizations conducted in reality under banners like counter-terrorism or anti-despotism. Liu Cixin here exposes how the glorification of military action and the promotion of martial spirit have become integral components of hegemonic globalization within modern society. From the perspective of some scholars, military-themed video games themselves function as mediums of imperialist globalization. Gamified war, such as entertainment-edited war footage in video games, broadcasts, and videos, renders war a normalized component of daily existence, “The long-standing interaction of video game culture and the military apparatus is a component in this process of the banalization of war.”^[8] (Dyer-Witheford 2009, 99) Players enthusiastically engaging with war-themed games inherently participate in the process of legitimizing the empire’s global military endeavors. Within *Supernova Era*, Liu starkly reveals this brutal reality by transforming “players” into actual combatants in the wargame.

During the Antarctic wargame’s initial phases, all its inherent brutality remains cloaked beneath the formal structure of competitive events, displaying significant divergence from the warfare conventions of the old era. For instance, tank battles no longer necessitate mutual reconnaissance of numbers and formations; all information is transparently available. Victory is determined solely by tallying “kills” after close-quarters shooting encounters for point accumulation. Artillery engagements evolve into a mode resembling pistol duels. Opponents for all nations are not chosen through strategic selection but dictated by the predetermined competition schedule. This superficial veneer of civilized rules becomes the decisive factor enabling the war to proceed with an illusion of order.

“Careful thought reveals that this form of warfare is not entirely inexplicable. Rules and agreements suggest the establishment of a system, and a system gains inertia once established; a violation by one side implies the system’s collapse, with unforeseeable consequences. The key point is that this warfare system could only have been established in a children’s world where game thinking was determinative, and could never be reproduced in an adult world.” (259).

Nevertheless, the maintenance of this superficial order does not equate to a relatively mild wargame. On the contrary, within numerous infantry-dominated events, the absence of cover and maneuverability renders the

wargame significantly more brutal than adult wars of the previous era. Yet, the organizers persist in packaging death as mere “withdrawal,” perpetuating the bloodshed. This grotesque spectacle reveals the aspect of a gamified society operating beyond ethical restraint. The game rules themselves redefine values, “*Any game’s rule system is a critical site for analysis because it posits a claim about how the slice of reality modeled by the rules functions. It develops an ontology, a (full-fledged or sketchy) reality model that dictates what is, and as importantly what is not, part of that world. First, the rule system separates figures from the ground of messy reality by defining what elements are at play in a game: Board wargames modeled military units, not civilians or wildlife.*”^[9] (Huntemann 2010, 34) In real life, we can already see a series of politicized game practices, such as using video games to provide legitimacy for the post-9/11 war on terror.^[10] (Payne 2016) Within the novel’s wargame, death itself ceases to be linked to the irreplaceable loss of life in reality; instead, it becomes tightly coupled with points within the reward-punishment mechanism. Violence is dissociated from the cruel acts prohibited to civilized individuals by education; it morphs into sporting events, particularly in projects involving the active control of automated weaponry. The act of firing upon armored targets inherently alleviates guilt compared to directly attacking flesh-and-blood adversaries. Within this absurd game, Liu refutes the adults’ initial conjecture at the novel’s outset – that a children’s world would be devoid of war—demonstrating instead that the inherent logic of societal operation inevitably rationalizes violence to a level acceptable to its members. By hypothesizing an extreme gamified war, Liu reminds people of the extreme realities that gamification can lead to. This dystopian writing embodies the significance of science fiction: it brings readers back to reality and achieves a closed-loop cognitive cycle.^[11] (Suvin 1988, chap. 5)

The descent of the Antarctic war into uncontrollable chaos is itself intrinsically linked to the logic of games. Within the narrative, the collapse of the wargame commences with numerous nations testing the boundaries of the rules during the infantry events. In the cold weapons conflict, the Japanese army’s deployment of military dogs onto the battlefield drastically amplifies the conflict’s savagery, simultaneously shifting the Chinese troops’ mentality from competitive engagement towards frenzied retaliation. Ultimately, the cold weapons battle degenerates into a slaughter reminiscent of pre-modern warfare. This rupture violates the principle of orderly war culture lauded by Huizinga: “We can only speak of war as a cultural function so long as it is waged within a sphere whose members regard each other as equals or antagonists with equal rights; in other words, its cultural function depends on its play quality. This condition changes as soon as war is waged outside the sphere of equals, against groups not recognized as human.”^{[3]89} (Huizinga 1980, 89). However, the order is made by particular people to make the game “like a combat in which equality of chances is artificially created, in order that the adversaries should confront each other under ideal conditions, susceptible of giving precise and incontestable value to the winner’s triumph.”^[12] (Caillois 2001 15) Confronted directly with bloody violence in close combat, participants find themselves incapable of maintaining rational principles within their minds, descending instead into battles fueled by hatred.

Liu Cixin’s harrowing depiction of cold weapons combat strips away the narrative camouflage of gamified war, revealing its true visage. The portrayal of children regressing to primal bestiality amidst ferocious combat inevitably evokes William Golding’s *Lord of the Flies* (Golding 2006) for readers.^[13] Within *Supernova Era*, Specs explicitly references *Lord of the Flies* before the battle, hinting at the wargame’s potential descent into unforeseen cruelty—a prediction borne out by events. However, Liu Cixin’s conceptual logic for the Antarctic war diverges fundamentally from Golding’s. While *Lord of the Flies* similarly depicts humans exhibiting cruel and violent traits after separation from adult societal constraints, it tends to attribute this violent bestiality to

humanity's primal nature, serving as a cautionary tale about the role of societal ethical education in suppressing humanity's inner savagery. Liu Cixin, conversely, depicts the war game's cruel scenes entirely through a lens of cold, natural logic. In Liu Cixin's view, ethics and morality are products shaped by social norms, and specific ethical frameworks are merely molded by the social configuration of a given era. The children of the *Supernova Era* descend into a wargame crueler and more absurd than the old era solely because their society's gamified discourse has shaped a comprehensive set of values that trivialize life education; this descent is the inevitable consequence of their societal form. This reflects the aspect of Liu Cixin's science fiction aesthetics that questions humanism, championing instead rational logic and a naturalistic perspective.

Another work bearing similarity to this wargame is Kinji Fukasaku's film *Battle Royale* (*Tokyo Battle Royale*), which similarly depicts adolescents killing each other under game rules within an extreme scenario. The terrible game in the film "is a critique of Japan's post-bubble capitalist society, which rendered youth 'economic competitors' rather than 'future inheritors'." ^[14](Barroso 2012, 175) Liu Cixin acknowledges being influenced by this film, recognizing it as a work of science fiction. He states, "The greatest charm of *Battle Royale* lies in it being a grand allegory about human society, ruthlessly peeling back layers of veils to expose certain very essential things in human society... The revelation of natural laws only makes us suddenly realize, but when the laws of human society are revealed, especially when vividly expressed through literature or visual arts, it makes many people nervous." ^[15]⁶⁵ (Liu, 2015, 65) Barroso argues that *Battle Royale*'s portrayal of adolescent violence where students are forced to kill each other under a totalitarian "game rule"—is a critique of Japan's post-bubble capitalist society, which rendered youth "economic competitors" rather than "future inheritors." ^[14] (Barroso, 2012, 175) Liu's commentary also reflects the distinction between his concept of depicting children's war and the film's. The adolescent violence in *Battle Royale* reflects a situation where capitalist society, developing to an extreme economic state, ceases to educate children as future inheritors, instead viewing them as direct economic competitors to adults, thus antagonizing them. It imagines a scenario following the collapse of youth's cultural significance. In contrast, the war in *Supernova Era* allegorizes how the gamified context of contemporary society cannot conceal real conflicts of interest, depicting the collapse of rhetorical discourse within war.

The wargame's complete loss of control stems from the U.S. violation during the intercontinental missile game, employing nuclear weapons to bombard a base. When the Chinese representative furiously accuses the U.S. of breaking the rules, the American side retorts that fun constitutes the paramount rule. Ultimately, the Chinese children activate the nuclear weapons secretly preserved by the adults as a contingency, initiating nuclear war and forcing the U.S. to abandon the wargame under reciprocal nuclear deterrence. By employing the weapons most likely to annihilate civilization to end the conflict, Liu Cixin implicitly argues that restraining war through game rules and maintaining violent conflict within an ordered framework is impossible. From the perspective of game theory, all competitive game orders inherently involve a calculus of costs and benefits. War, however, as an act of violence, implies the potential for the complete annihilation of the opponent or complete annihilation by the opponent. When the subjects of the game face the peril of total destruction, rational calculations of input and output lose all meaning, "all the protagonists might spend more than they gain from the competition---the War, the Leviathan, and Civilization might all lose---yet remain bound to the race and survive as long as their relative losses do not become crippling." ^[16](Gat 2006, 411)

A profoundly ironic reality surfaces: the Chinese child leaders believed they had entered a new era emancipated from adult guidance, participating in this war driven by a mindset focused on contending for international status. Yet, when the wargame spiraled out of control, it was the nuclear weapons force clandestinely

cultivated *by the adults* as a precaution that afforded them the opportunity to retaliate and terminate the conflict. This validates the adults' anxieties on the eve of the Supernova Era: leadership ability is the competence most demanding of mature experience; nascent leaders lacking life experience will inevitably subject civilization to a series of setbacks. This also reflects Liu Cixin's ambivalence on the issue of intergenerational transmission. On one hand, as a science fiction writer, he is fervently drawn to imagining scenarios where a new generation's society sheds old societal discourses, embracing new technologies in entirely novel forms. On the other hand, he harbors deep reservations about whether the new generation can develop smoothly after severing ties with old civilizational traditions, revealing a persistent undercurrent of national anxiety within his fiction.

4. Historical and Cultural Concerns within the Gamified Allegory

Following the Antarctic wargame, the populace of both China and the U.S. plunges anew into an atmosphere of disillusionment and pessimism, consuming resources aimlessly. Seeking to mitigate the nascent order's collapse and explore the possibility of establishing a genuinely stable new civilization, the newly appointed U.S. President proposes an "exchange territories" game to China. The populations of both nations completely migrate onto each other's soil, inheriting all property and resources of the reciprocal territory. Thus, within an entirely novel social environment, the citizens of both countries are expected to reignite their vitality. At the migration's conclusion, the three Chinese leaders depart their homeland carrying the only objects permitted for removal: three antique pottery jars.

This profoundly symbolic denouement alludes to Liu Cixin's ultimate contemplation on how the new generation of humanity might rebuild civilization. The cruel and meaningless game war effectively negates the possibility that a gamified society founded on the principle of pleasure can evolve into a stable new civilizational order, thereby compelling national leaders to explore alternative pathways for civilizational forms. Substantively, the "exchange territories" maneuver represents a more radical deconstruction of the old civilization than the wargame itself. It signifies that the children of the Supernova Era will utterly obliterate traditional national identity consciousness, eradicate the attachment to native soil—particularly significant for Chinese people—and fundamentally reconstruct their own cultural genes, thereby exploring a new future.

This radical rupture with cultural identity constitutes a vital component of Liu Cixin's science fiction aesthetics. Numerous commentators on Liu Cixin observe that a key distinction setting him apart from past Chinese science fiction writers lies in the strong posthuman coloration and tendency to question humanism within his science fiction imagination. The development of Chinese science fiction creation, originating in the late Qing Dynasty, has consistently harbored aspirations towards proximity to political reform. Science fiction novels from the late Qing Dynasty to the Republic of China often contain the connotations of spreading scientific knowledge and imagining a Chinese utopia, and embody the "suppressed modernity" of Chinese society.^[17] (Wang 1997) "During the Mao era, it became a vehicle for molding a new socialist man by popularization of modern science and technology, among young people in particular. During the post Mao thaw, Chinese SF responded to the Party's imperative to achieve the Four Modernizations."^[18] (Li 2021, 11) This methodology of intertwining scientific progress with national destiny was once cited by sinologist C.T. Hsia as evidence for his critique that Chinese writers were excessively obsessed with political intervention, exhibiting an "obsession with China." Liu's science fiction imagination, however, diverges markedly. He does not contemplate philosophical problems with human society as the ontological foundation but rather analyzes and extrapolates human society as extensively

as possible from the scale of the universe and the perspective of nature. As David Der-Wei Wang articulated, “*In Liu’s fictional world, human society is often treated as a minor problem when compared to the extravagant and grandiose scale of the universe. Human survival is made possible merely through the mercy of a supreme alien species, and the extinction of humanity does not have much of an impact on the universe. Most of Liu’s work can be called ‘posthuman’ because of its highly technologized and omnipotent perspective, Experimenting with ideas of changing physical reality, he creates entire new universes and depicts them.*”^[19] (Wang, 2017, 953)

Consequently, for Liu Cixin, the cultural inheritance of the nation-state is not a core concern. Conversely, on the cosmic scale, constructed national culture represents merely a fleeting moment, a contingent ideology, and frequently even exerts a negative influence by obstructing civilized individuals from apprehending nature’s truths. At the very outset of the *Supernova Era*, Liu depicts the state of existence for various civilizations on Earth at the moment of the supernova explosion. In England, it is the Greenwich Observatory’s observation of the supernova; in North America, it is the Lexington event that altered the colonies’ destiny. In China, Liu narrates the eternal sunrise greeted by ancient Chinese people:

“One can’t step twice in the same river’ is nothing more than the babbling of an ancient Greek, for the river of time is the river of life, and this river flows endlessly at the same unchanging speed, an eternal flow of life and history and time. That’s what the people of this city thought. That’s what the people of the plains of northern China thought. That’s what the people of Asia thought. And that’s what the carbon-based life-forms called humans everywhere on the planet thought. On this hemisphere, they were being lulled to sleep by the flow of time, convinced that the sacred eternal was unbreakable by any force, and they would wake up to a dawn identical to that of countless previous mornings. That faith, lurking in the depths of their consciousness, granted them the same peaceful dreams woven for untold generations.” (15).

Simultaneously, he describes Emperor Qianlong within the Forbidden City perusing classical texts passed down through Chinese antiquity, texts describing the world’s eternal, immutable laws. In Liu Cixin’s view, the Chinese attachment to native land and cultural traditions, pursuing an eternal, unchanging order, has fostered a Chinese cultural character leaning towards conservatism and pragmatism. Therefore, when confronting a new era of tumultuous change, or even a rupture crisis like the hypothetical *Supernova Era*, the Chinese should particularly transcend cultural traditions to seek a viable path forward. In the novel’s afterword, he posits that the children’s society depicted in *Supernova Era*, devoid of parental guidance, serves precisely as a microcosm of contemporary human society: “All humanity is an orphan who cannot find the hands of its parents, filled with fear and bewilderment. At the same time, letting the flames of childishness and wildness in human nature rise, finally burning into the fire of crazy destruction... We are far less fortunate than the children in the novel because no one teaches us.”^[15]⁷⁵ (Liu, 2015, 75) The Chinese children he portrays, after exchanging territories and facing an indeterminate future, embody his expectations for a new Chinese generation that transcends the limitations of native land sentiment to explore the real, cold laws of nature.

Liu Cixin not only breaks away from the political reform interest characteristic of the Chinese science fiction tradition but also harbors profound skepticism towards the humanist tradition permeating contemporary Chinese literature as a whole. Liu’s critique of anthropocentrism—evident in his rejection of mainstream Chinese literature’s “human narcissism”^[20] (Liu 2014, 107)—is amplified by the “territory exchange” game: by forcing children to abandon “native soil sentiment” (a core Chinese cultural value) through game rules, Liu suggests that gamification can break cultural rigidity—yet only if paired with respect for natural laws.” Liu’s critique of mainstream literature connects intrinsically with the literary concepts prevalent in China in the 1990s. Following

the Reform and Opening Up, mainstream Chinese intellectuals engaged in literary research and creation dedicated themselves to reconstructing intellectual subjectivity and attempting to establish a literary tradition centered on intellectuals, supplanting the previous official narrative centered on class theory (Chen 1998; 2001).^{[21][22]} This naturally carried expectations of mending historical trauma and rebuilding cultural context. However, from the perspective of Liu Cixin, a science fiction writer, this reconstructed literature centered on humanism and cultural elites fails to convincingly address the question of where Chinese people, or even humanity, should go. What holds genuine persuasive power, he argues, are the laws of nature and the cosmos. Examining and extrapolating human civilization from the perspective of natural laws can yield grander and more magnificent imaginations, uncovering more possibilities for human evolution. Liu Cixin's posthuman thinking within science fiction creation represents a pioneering expansion beyond the limitations of Chinese literature. His writing returns to the source of the Chinese literary spirit in the 1980s, that is, to maintain an imagination open to the world (Song 2023, 28).^[23]

However, is the imagination of human history based on a cosmic perspective that Liu Cixin pursues truly a human extrapolation devoid of humanist presuppositions? Combining science fiction theory and re-examining the implicit concept of play within *Supernova Era*, one discerns this is not the case. At the novel's conclusion, the leaders of China and the U.S. accept the exchange territories game, anticipating that this final game will reactivate the inherent strengths of both nations. From Vaughn's perspective, the cowboys of the American pioneering era embodied the group most representative of the quintessential pioneering American spirit:

"They lived lives far less romantic than in the movies. In the Wild West, they faced a constant threat of hunger and disease, and their lives were always in danger from attacking wildfires, wolf packs, and Native Americans. With just a horse and a revolver, they rode off smiling into a cruel world to forge the American miracle, pen the American epic, their strength drawn from a desire for hegemony over the new world."

"...Before the supernova, our fathers and mothers hid themselves inside the hard shells of skyscrapers, under the impression that they had the world in their pocket. Ever since the purchase of Alaska and Hawaii, they no longer expanded into new territory, no longer dreamed of new conquests, but turned slow and lazy, and the fat on their bellies and necks grew thick..." (307-308).

Here, Vaughn essentially hopes that the exchange territories game can recreate the American founding myth, enabling citizens to rediscover a new direction within a harsh, unfamiliar environment. Within Liu Cixin's understanding of human history, the primordial strength of the nation-state originated from the creative spirit of exploration ignited when confronting survival crises, unburdened by heavy historical ethnic consciousness. This creative force is precisely the "play spirit" studied and expounded by Huizinga—the spirit that birthed all human cultural institutions. Here, Liu effectively circles back to the novel's first game: the selection game that placed children in a state of ignorance to simulate nations and exhibit leadership potential. After navigating a series of extrapolations within extreme scenarios, Liu guides the children to realize that the various legacies inherited from the old society – antiquated concepts of social order, property resources enabling prolonged hedonism and profligacy – obstructed their construction of a civilizational form suited to their own needs. They must transcend the obscuration of old cultural identities to become the original founders of the new order, just as Specs articulated in the selection game: "play it seriously". Liu invests his hope in this play spirit of recreation confronting nature, indicating he does not deny humanity's potential to transform nature and build a better society in response to cosmic laws and natural crises. He does not even reject nationalist myths, as evidenced by his ultimate expectations vested in the pioneers' founding myth.

The plot where several children take earthenware jars with Chinese soil as their final keepsakes seems to

imply that Liu Cixin believes the new generation of China can also reactivate the most vital elements of Chinese culture. Jameson (2005) points out that the treatment of traditional culture in utopias often presents a dialectic of both deconstructing and inheriting: utopias dissolve rigid cultural dogmas while preserving symbols with vitality. It can “a registering apparatus for detecting the feeblest positive signals from the past and the future and for bricolating and combining them and thereby producing what looks like a representational picture (Jameson 2005, 29).^[24]” This logic is particularly evident in the plot of the ancient earthenware jars: the Chinese child leaders carry the earthenware jars while relocating—on one hand, they abandon the traditional belief, and on the other hand, they embody the memories of homeland culture through the jars. Liu Cixin does not completely repudiate traditional culture; instead, through the gamified scenario (the territory exchange game), he transforms nostalgia for the homeland into collective rationality that adapts to the laws of nature. Meanwhile, in his writing of the “territory exchange” game, Liu Cixin emphasizes the respective national myths of the Chinese and American peoples through science-fictional speculation, and explores the trajectories of national identities in the future. This kind of writing aligns with the era when globalization entered a new phase of changes after the Cold War, and conforms to the trend where non-Western science fiction writers “tell the story of the evolution of the transnational and multimedia manifestations of science fiction.”^[25] (Link & Canavan 2019, 3) thereby contributing to breaking down Western-centrism in science-fictional imagination.

5. Conclusion

Throughout the entire novel, the spirit and imperative of play propel the development of children’s **society**. Although it once led people astray, it ultimately emerges as the driving force propelling them towards the new era. The concept of “game” within *Supernova Era*, much like Liu Cixin’s concept of “science fiction” within his creative theory, presents superficially as an objective reflection of changes in the material environment. Yet, it inherently embeds a logic of technological progressivism. Within the novel, games function as simulations guiding children towards serious social role-playing, discovering their own potential and the manifold possibilities of social configurations. Within the writer’s creative theory, science fiction similarly constitutes a simulation severing ties with the real cultural context, exploring the multiple potentialities of social and civilizational evolution. In Suvin’s classic definition of science fiction, he states: “*Thus SF takes off from a fictional (“literary”) hypothesis and develops it with totalizing (“scientific”) rigor—the specific difference between Columbus and Swift is smaller than their generic proximity. The effect of such factual reporting of Fictions is one of confronting a set normative system—a Ptolemaic-type closed world picture—with a point of view or look implying a new set of norms; in literary theory this is known as the attitude of estrangement*” (Suvin, 1979, 6).^[26] This power to shatter closed discourses and engender possibilities is precisely what Liu Cixin strives to preserve within his world imagination. Compared to more radical, individualized posthuman discourses like Donna Haraway’s, Liu Cixin’s posthuman science fiction aesthetics consistently preserves the possibility for the progress of humanity as a collective entity. And because Liu’s aesthetic persistently insists on maintaining humanity as a whole as the narrative subject, resisting movement towards narratives of individual liberation, an element of technological progressivism invariably persists. As Csicsery-Ronay argues, “*SF orients itself within a concept of history that holds that science and technology actively participate in the creation of reality, implanting human uncertainty into the natural/nonhuman world. At the same time, sf’s hesitations also involve a sense of fatality about instrumental rationality’s power to transform or to undermine the conditions of thought that gave rise to it. The same freedom that detaches*

nature from a mythology of natural necessity restores that fatality, ironically, in the irrepressible drive of human beings to transform nature continually and without transcendental limits." (Csicsery-Ronay 2008, 4)^[27]

It thus becomes comprehensible why Liu Cixin's *Supernova Era* could achieve a degree of foresight and warning regarding the gamification of contemporary society. He observed that the driving force of play constitutes a crucial motivation for the post-Cold War new generation of youth to imagine and attempt transitioning towards new social forms, leveraging new technological media. This creative drive has already been analyzed within classical game theory and was entrusted by Liu with the expectation of transcending traditional Chinese cultural contexts and intellectual centrism to forge a culture for the new era. And the reason Liu places hope in the creative power of play is precisely because this adolescent capacity to generate possibilities aligns perfectly with his creative theory of imagining humanity's collective destiny through the medium of science fiction.

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Research on the Selection of Emergency Response Plans for Sudden Incidents Based on Uncertain Information

Furui Deng*

The Party Work Department (Human Resources) of Sichuan Shudao Smart Transportation Group Co., LTD., Chengdu 610000, Sichuan, China

**Author to whom correspondence should be addressed.*

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Abstract: Emergency response plans are the core link in the process of dealing with unexpected incidents. However, the various types of information faced in responding to unexpected incidents are highly uncertain. Therefore, how to select a relatively satisfactory emergency response plan for unexpected incidents under uncertain information is an urgent problem to be solved in emergency management. To effectively select emergency response plans for unexpected events under uncertain information, this paper proposes a decision-making method based on the combination of the Analytic Hierarchy Process (AHP) and the fuzzy comprehensive evaluation method. Firstly, various influencing factors of emergencies are obtained through data collection and actual research. The AHP method is adopted to conduct weight analysis of the influencing factor indicators, and the key influencing factors of emergencies are obtained. Secondly, design alternative emergency response plans based on key influencing factors; Secondly, a fuzzy comprehensive evaluation model is constructed to conduct a comprehensive assessment of each alternative plan, and the best emergency response plan is determined based on the scores of the alternative plans. Finally, the feasibility of the proposed selection technology is illustrated through a research example of the campus fire emergency plan.

Keywords: Emergency; Uncertain environment; Emergency response plan; Fuzzy comprehensive evaluation method

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1. Introduction

With the accelerating pace of social development, the demand for various resources worldwide is growing larger and larger. Both the natural and social environments are facing unprecedented and huge threats. At the same time, the frequency and scale of various emergencies are also increasing dramatically. For the occurrence of emergencies, conducting scientific and effective emergency response plan planning can reduce the negative impact brought by emergencies^[1]. Therefore, the selection of emergency response plans has received high attention. The

research on the selection of emergency response plans is carried out by conducting in-depth analysis of various influencing factors of unexpected events and the purposes and requirements for formulating emergency response plans, and then choosing the best emergency response plan.

At the same time, with the advent of the information society, the information uncertainty characteristic of human society has become increasingly obvious. In traditional human thinking, uncertainty is often associated with risk. However, information is probabilistic, which also emphasizes the need to view uncertainty and uncertain information correctly. It is necessary to recognize both the potential dangers associated with uncertain information and its positive role and intrinsic value, and to regard it as a governance resource with objective characteristics that can be used to effectively respond to emergencies and quickly manage major crises. Emergency response plans for unexpected events often require the selection of relatively satisfactory emergency plans in an incomplete information environment. To optimize the utilization of resources, determining the importance of indicators that affect the selection of emergency response plans is particularly important for decision-makers to determine the focus of resource allocation.

A method for characterizing fuzzy language information based on the set of language terms is proposed^[2]. Language vocabulary with fuzzy attributes is called fuzzy language, such as very good, excellent, unsatisfactory, very important and extremely expected, etc. A set of fuzzy languages with hierarchical differences and similar features is usually called a multi-dimensional fuzzy language set^[3]. Uncertain language information refers to the information represented by two multi-dimensional fuzzy words, such as [relatively satisfied, very satisfied, which represents the uncertainty of the information between relatively satisfied and very satisfied, and also represents the boundary hesitation of things between these two states, or the hesitation of evaluators between the two evaluations^[4]. For research on theories related to uncertain language information, a subscript symmetrical language assessment scale, where the middle language scale indicates an assessment value of “no difference”, and the other language scales are symmetrical^[5]. The concept of the set of hesitant fuzzy language terms was proposed, then the uncertain language expressions containing modifiers were presented, using weak modifiers to describe the degree of uncertainty of language information^[6].

Therefore, in order to effectively solve the problem of choosing emergency response plans for unexpected events, this paper adopts a method combining the Analytic Hierarchy Process (AHP) and the fuzzy comprehensive evaluation method to study emergency response plans for unexpected events. The Analytic Hierarchy Process (AHP) hierarchies and systematizes the influencing factors of emergencies, identifies the key influencing factors of emergencies, and designs alternative emergency response plans based on this. Meanwhile, the fuzzy comprehensive evaluation method assesses and screens multiple alternative schemes, and finally obtains a relatively satisfactory scheme. It plays an important and positive role in both theoretical and practical aspects for the prevention of emergencies and the implementation of emergency plans.

2. The construction of a multi-objective satisfaction evaluation model

In the process of selecting emergency response plans, clarifying the significance of the influencing factors of unexpected events is a crucial step. Only in this way can a more satisfactory emergency response plan be chosen from multiple alternative options to prioritize the allocation of resources. Due to the numerous and constantly changing factors influencing emergencies, the collected information is always in an uncertain environment. To reduce the uncertainty in the research process, a determination method combining AHP and fuzzy comprehensive evaluation analysis is proposed.

(1) According to the idea of the Analytic Hierarchy Process, the evaluation objective is set by the research object of the emergency response plan for unexpected events. Then, several first-level influencing factors are set based on the possible influencing factors of the unexpected events. Among them, there are several second-level influencing factors under the first-level influencing factors. Through data collection and actual research, various influencing factors of emergencies were obtained and input into the analytic hierarchy process model. The risk assessment index system is obtained through the analytic hierarchy process (AHP) model. Based on this, AHP is used to conduct pairwise comparisons of risk factors at all levels to construct a judgment matrix, and the eigenvector corresponding to the maximum eigenroot of the matrix is solved as the weight value of the risk assessment index.

$$a_{ij}^* a_{ji} = a_{ik}^*, i, j, k = 1, 2, \dots, n \quad (1)$$

If the obtained judgment matrix is A consistent matrix, for example A, then it is natural to take the normalized eigenvector corresponding to the eigenroot n to represent the weights of each factor U to the upper-level factor. This vector is called the weight vector. If the judgment matrix A is not a uniform matrix but is within the allowable range of inconsistency, then the eigenvector (normalized) corresponding to the maximum latent root of A (denoted as λ) is taken as the weight vector w by using Equations (2) and (3).

$$\bar{R}(\omega) = \frac{1}{I} \sum_i \bar{R}_i(\omega) \quad (2)$$

$$D_M(\check{a}, \check{b}) = \frac{1}{2[V(x_r) - V(x_{-r})]} (|\Delta^-(s_i^*, \alpha_1^*) - \Delta^-(s_i, \alpha_1)| + |\Delta^-(s_j^*, \alpha_2^*) - \Delta^-(s_j, \alpha_2)|) \quad (3)$$

In practical application scenarios, judgment matrices are often not consistent, and it is necessary to ensure that the degree of inconsistency is within an acceptable range. From this theorem and the fact that λ continuously depends on a_{ij} , it can be known that the greater λ is than n , the more severe the inconsistency of A becomes, and the greater the judgment error caused by using the feature vector as the weight vector. Based on the constructed judgment matrix, the weights of each factor in the first-level and second-level indicators are obtained, the comprehensive weight values of each factor for the evaluation target are calculated, and the weight ranking is listed.

(2) According to the ranking of the importance of the influencing factors of emergencies, the key factors affecting emergencies are obtained. Based on this, alternative emergency response plans for emergencies are designed. Then, through the fuzzy comprehensive evaluation method, the designed alternative emergency response plans are comprehensively evaluated to select the best emergency response plan. The calculation formulas for this stage are as follows:

$$S_M(\check{a}, \check{b}) = 1 - D_M(\check{a}, \check{b}) \quad (4)$$

$$E = \sum_{k=1}^K \left[\frac{1}{M \times N} \sum_{m=1}^M \sum_{n=1}^N D_M(c_t^k, c_t^{k'}) \right] \quad (5)$$

3. Examples and analysis of results

This chapter mainly conducts research on emergency plans for campus fires by using the Analytic Hierarchy Process (AHP) and the fuzzy Comprehensive Evaluation method. Firstly, through the query of event materials and data, select the campus fire cases that have occurred for analysis to identify various influencing factors of campus

fire risks. Subsequently, by using the AHP concept in combination with the fuzzy comprehensive evaluation method, the fire risk analysis of the buildings in the university dormitory area was conducted based on the selected fire risk influencing factors. Then, based on the analysis results, the campus fire emergency plan analysis of this dormitory area was carried out.

(1) During the process of fires in university buildings, different fire protection targets will have varying degrees of impact on various factors. Therefore, this paper adopts different perspectives and analytical methods to establish a risk assessment system for student dormitories, in order to evaluate the safety status of university student dormitory buildings. This is of great significance for the emergency management of universities. This research mainly focuses on densely populated buildings such as dormitory areas. Based on the analysis of the causes of campus fires that occurred in the past, the constituent factors of the campus fire risk assessment system can be obtained. The fire risk assessment of university dormitory buildings includes the following five first-level indicators: the nature of the building: fire-resistant materials, evacuation routes and facilities, fire compartments, etc. Human factors: the density of people, their educational level, self-rescue ability and fire safety awareness, etc. External environment: including building spacing, fire lanes, outdoor fire hydrants and water sources; Fire protection facilities: fire extinguishers, alarm systems, indoor fire hydrants, automatic fire extinguishing systems, etc. Fire management: safety training, personnel on duty, maintenance and inspection of fire protection facilities, fire prevention regulations, etc. The evaluation table of risk factors involved in campus fires was obtained, and a list of risk factor indicators for campus fire projects was constructed in combination with the first-level judgment matrix. The summary is shown in **Table 1**

Table 1. The weight of campus fire risk factor indicators

First-level indicators	first-level indicator weights	second-level indicators	second-level indicator weights
The nature of the building	0.140	Refractory materials	0.200
		Evacuation routes and facilities	0.600
		Fire compartment	0.200
Human factors	0.420	Personnel density	0.160
		Self-rescue ability	0.360
		Educational attainment	0.080
		Fire safety awareness	0.410
External environment	0.175	Fire lane	0.429
		Outdoor fire hydrants and water sources	0.429
		Building spacing	0.143
Fire protection facilities	0.175	Fire extinguisher	0.300
		Alarm system	0.395
		Indoor fire hydrant	0.173
		Automatic fire extinguishing system	0.132
Fire management	0.090	Safety training	0.210
		On duty	0.090
		Inspection and maintenance of fire protection facilities	0.483
		Fire prevention system	0.212

(2) Based on the comprehensive ranking of various factors calculated earlier, the key influencing factors of the emergency are fire safety awareness, self-rescue ability, evacuation routes and facilities, fire lanes, outdoor fire hydrants and water sources, alarm systems, and personnel density, etc. According to these factors, alternative emergency response plans are designed. Generally speaking, the degree of influence of different levels and factors on the final outcome varies. Now, five expert representatives (M1 to M5) are randomly selected from the university dormitory area to score the alternative plans, and the weights of the expert representatives (ω_1 to ω_5) are obtained by using the weighted average method as $\omega=(0.23, 0.20, 0.18, 0.22, 0.17)$. The evaluation information of each alternative plan is as follows respectively.

$$H_1 = \begin{bmatrix} 0.1 & 0.3 & 0.3 & 0.1 & 0.2 \\ 0.2 & 0.2 & 0.4 & 0.1 & 0.1 \\ 0.2 & 0.3 & 0.2 & 0.2 & 0.1 \\ 0.3 & 0.2 & 0.3 & 0.2 & 0.1 \\ 0.3 & 0.3 & 0.2 & 0.1 & 0.2 \end{bmatrix}, H_2 = \begin{bmatrix} 0.2 & 0.3 & 0.1 & 0.2 & 0.2 \\ 0.1 & 0.3 & 0.2 & 0.1 & 0.3 \\ 0.3 & 0.2 & 0.2 & 0.2 & 0.1 \\ 0.2 & 0.4 & 0.1 & 0.1 & 0.2 \\ 0.1 & 0.3 & 0.3 & 0.1 & 0.2 \end{bmatrix}, H_3 = \begin{bmatrix} 0.4 & 0.1 & 0.1 & 0.2 & 0.2 \\ 0.3 & 0.2 & 0.1 & 0.1 & 0.3 \\ 0.3 & 0.1 & 0.2 & 0.3 & 0.1 \\ 0.2 & 0.3 & 0.1 & 0.2 & 0.2 \\ 0.3 & 0.2 & 0.2 & 0.1 & 0.2 \end{bmatrix}.$$

(3) Then the fuzzy comprehensive evaluation information of each alternative scheme using Equation (5) can be obtained.

$$E_1 = 0.216 \times 5 + 0.258 \times 4 + 0.285 \times 3 + 0.14 \times 2 + 0.14 \times 1 = 3.387;$$

$$E_2 = 0.181 \times 5 + 0.304 \times 4 + 0.172 \times 3 + 0.141 \times 2 + 0.202 \times 1 = 3.121;$$

$$E_3 = 0.23 \times 5 + 0.20 \times 4 + 0.18 \times 3 + 0.22 \times 2 + 0.17 \times 1 = 3.198.$$

Since $3.387 > 3.198 > 3.121$, it is easy to see that the alternative plan D_1 performs well and has the highest membership degree, accounting for 25.8%. Therefore, plan D_1 is considered good. Option D_2 performed well and had the highest membership degree, accounting for 30.4%, while Option D_2 was considered good. The alternative plan D_3 has the highest membership degree due to its excellent performance, accounting for 30.1%. Plan D_3 is considered excellent. However, the comprehensive scoring options $D_1 > D_3 > D_2$ indicate that the comprehensive importance of option D_1 is higher. Therefore, option D_1 should be selected.

4. Conclusions

This paper focuses on the design and selection of emergency response plans for unexpected events in reality. Combined with the current research status, it proposes an idea for the selection of emergency response plans for unexpected events based on the Analytic Hierarchy Process and the fuzzy comprehensive evaluation method. Take the design and selection of campus fire emergency response plans as an example to prove the feasibility and effectiveness of the proposed ideas. The key influencing factors are obtained by constructing an analytic hierarchy process model, and based on this, alternative emergency response plans are designed. Then, a fuzzy comprehensive evaluation model is constructed to conduct a comprehensive evaluation of the alternative plans, and the plan with the highest comprehensive score is selected as the optimal emergency plan.

The method proposed in this paper based on the AHP (Analytic Hierarchy Process) and the Fuzzy Comprehensive Evaluation method can fully determine the influence degree of the influencing factors of emergencies and reduce the uncertainty of the influence of key factors. In the process of designing and selecting emergency plans, it provides a reference for emergencies where it is difficult to grasp the importance of the influencing factors and cannot deal with uncertain information. The method proposed in this paper is simple and easy to implement. It uses quantitative methods to analyze the qualitative indicators of various influencing factors

of emergencies, which improves the efficiency and accuracy of emergency plan selection.

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Cosmetic Production Technology and Quality Control

Dong Guo, Linlin Ye, Huanxing Liu

Hangzhou Yayan Cosmetics Co., Ltd., Hangzhou 311100, Zhejiang, China

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Abstract: With the rapid development of the national economy and the continuous improvement of residents' consumption levels, cosmetics have increasingly become an indispensable consumer product in people's daily lives. In recent years, cosmetic safety issues have become a social hotspot, making more consumers pay attention to cosmetic production technology, raw materials, and quality, and putting forward higher requirements for the production technology and quality control of cosmetic manufacturing enterprises. This paper conducts an in-depth study on the production technologies of different types of cosmetics, and elaborates on four aspects: improving quality control measures such as raw material management, establishing and implementing traceability management systems, conducting self-inspections of quality management systems, and optimizing sample retention and monitoring systems. The aim is to improve the quality of cosmetic production and promote the healthy development of the cosmetics industry.

Keywords: Cosmetics; Production technology; Quality control; Product quality

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1. Introduction

To standardize cosmetic production licensing and supervision and inspection work, and implement the "Cosmetic Production Quality Management Specifications", the National Medical Products Administration has organized the formulation of the "Inspection Points and Judgment Principles for Cosmetic Production Quality Management Specifications". It clarifies the production quality standards for different types of cosmetics, such as general liquid, cream and emulsion, powder units, aerosols, and organic solvent units, urging cosmetic manufacturing enterprises to standardize production and provide regular and safe cosmetics for consumers. This paper analyzes the characteristics and processes of production technologies for different types of cosmetics, clarifies quality standards for each link, and puts forward corresponding suggestions for cosmetic production and quality control. Cosmetic manufacturing enterprises must strictly control raw materials, establish a traceability management mechanism, retain samples of products in a timely manner, ensure that the number of microorganisms and bacterial colonies in products is within standard limits, strictly control the use of additives, and improve the quality of cosmetic production.

2. Analysis of Cosmetic Production Technologies

2.1. Production Technology of General Liquid Units

Liquid cosmetics are the most common and widely used type of cosmetics, and also one of the most concerned by consumers. Taking toner production as an example, cosmetic manufacturing enterprises must strictly control raw materials, disinfect all raw materials used, and only raw materials that pass inspection can enter the clean workshop for accurate weighing to control the dosage of raw materials. In this production link, enterprises also need to conduct high-temperature sterilization and ultrasonic cleaning of toner packaging materials, and send the sterilized packaging materials to the clean workshop. Technicians should pre-mix raw materials according to the cosmetic formula, put raw materials into the mixing tank in accordance with the formula ratio and feeding sequence, heat and stir the mixture, and then let the liquid cool naturally to the corresponding temperature to complete the preparation^[1]. After the toner preparation is completed, enterprises need to take samples for physical and chemical tests and microbial tests, such as determining the pH value, viscosity, density, heat resistance, and cold resistance of the samples; testing microbial indicators such as the total number of bacterial colonies, mold, and yeast in the samples. Only after confirming that the samples pass the inspection can the semi-finished products be transferred to the filling workshop for final filling and packaging. Qualified products after quality inspection can be directly put into storage.

2.2. Production Technology of Cream and Emulsion Units

The production technology of creams and emulsions is relatively complex, with high requirements for production temperature, proportioning, and processing sequence. Taking oil-in-water skin care lotion as an example, cosmetic enterprises must do a good job in semi-finished product preparation and emulsification technology to ensure that the lotion has a soft texture and a comfortable skin feel. First, technicians should disinfect raw materials according to the formula, weigh them accurately, and prepare sterilized oil tanks and water tanks. Put the weighed raw material A into the oil tank for preparation, and raw material B into the water tank for preparation. Then put the prepared raw materials A and B into the emulsification tank for emulsification treatment. Second, technicians should process the emulsified semi-finished products, remove air bubbles using a vacuum pump, add raw material C and continue stirring. After mixing evenly, transfer the mixture to a storage tank for standing. During this process, technicians should inspect the standing semi-finished products, such as the color, texture, and microbial indicators of the skin care lotion semi-finished products, to ensure they meet quality standards. Filling can only start after the semi-finished products pass the inspection and the standing process is completed^[2].

2.3. Production Technology of Powder Units

The production technology of powder cosmetics is relatively simple, and different types of powder products have different quality standards. The weighing, crushing, mixing, and filling of raw materials for powder cosmetics must be completed in a negative-pressure clean area to ensure that raw materials are not contaminated by the environment. To ensure the fineness and skin feel of powder products, cosmetic enterprises should be equipped with raw material crushers to crush rod-shaped, flake-shaped, and block-shaped raw materials, ensuring that the ground powder meets the required fineness standards. At the same time, powder production is inseparable from mixers, such as double conical drum mixers and vertical kneading mixers, which replace manual mixing to make powder semi-finished products more uniform^[3]. After the powder mixing is completed, technicians should inspect the semi-finished products, focusing on physical and chemical tests and microbial tests, and conduct different

quality inspections according to product characteristics. For makeup powder products such as setting powder and loose powder, technicians should also test the smearing function, oil control, and hydrophobicity of the products to improve consumers' skin experience and product setting effect.

2.4. Production Technology of Aerosol and Organic Solvent Units

The raw materials of aerosol and organic solvent cosmetics are relatively special. Many cosmetics use flammable and explosive dangerous goods such as ethanol and essential oils, which are prone to explosions during stirring, mixing, and filling, threatening the personal safety of employees. Therefore, cosmetic enterprises must produce aerosols and organic solvent cosmetics in explosion-proof workshops and ensure that the workshops are in low-temperature conditions to minimize safety accidents during production. Taking perfume production as an example, enterprise technicians should weigh raw materials according to the formula, put the weighed raw materials into explosion-proof mechanical equipment for stirring, and operate in a low-temperature environment to avoid the volatilization of essential oils and maximize the retention of fragrance. Let the stirred mixture stand for a few days, then perform alcoholization treatment to filter out solid particles and impurities, age the filtrate, and finally conduct quality inspection^[4]. In addition, technicians must strictly control the perfume filling process, use high-speed limited liquid level vacuum filling machines for filling to ensure the stability of the perfume liquid level; conduct pressure testing on the tank body, and finally inspect the nozzle to ensure that the sprayed mist is fine and uniform.

3. Quality Control Measures for Cosmetic Production

3.1. Improve Raw Material Quality Control Measures and Enhance Raw Material Safety

Cosmetic enterprises must strictly control the quality of raw materials, select product raw materials in accordance with the "Cosmetic Product Safety Assessment Report", clarify the standards for intermediate products and semi-finished raw materials required in cosmetic production, sample and conduct laboratory tests on raw materials, and only qualified products can be used as product raw materials. First, enterprises should select raw materials according to cosmetic functions and formulas, conduct physical and chemical tests and microbial tests on all raw materials and semi-finished materials, and ensure that raw material quality indicators meet the technical requirements of cosmetic registration or filing data. Enterprise inspectors should test heavy metal content, pathogenic bacteria, etc., in cosmetic raw materials, select raw materials that meet national standards, and ensure the safety of cosmetic production from the source^[5]. At the same time, enterprises should test microorganisms, humidity, temperature, etc., in raw material storage warehouses to avoid deterioration of raw materials during storage. For example, in lipstick production, it is necessary to test raw materials such as fragrances, pigments, and glycerin, and try to use natural fragrances and pigments to ensure the safety of lipstick. Second, enterprises should inspect cosmetic inner packaging and outer packaging materials, clarify quality standards for paper packaging boxes and plastic packaging, avoid the use of contaminated materials, and try to use degradable environmentally friendly packaging materials to reduce environmental damage. In this link, enterprises should conduct sampling inspections on finished products of different batches of cosmetics, clarify sample sampling requirements, inspection operation procedures, and qualified standards, and only qualified products can leave the factory for sale to establish a good corporate reputation^[6].

3.2. Establish and Implement Traceability Management Systems and Clarify Management Responsibilities

The “Cosmetic Production Quality Management Specifications” put forward new requirements for cosmetic quality management, requiring enterprises to control and trace the entire process of cosmetic raw materials, production processes, and quality inspections, and establish a cosmetic traceability management system. Against this background, cosmetic enterprises should establish the development concept of “quality first”, abide by laws and regulations such as the “Cosmetic Production Quality Management Specifications”, establish a sound traceability management system, clarify the responsible person and quality inspection standards for each link, timely identify problems in the cosmetic production process, and promptly destroy unqualified products to prevent them from flowing into the market. For example, enterprises can implement batch number management, clarify the naming standards for batch numbers of cosmetics produced in different batches, conduct random inspections of cosmetics of different batches through batch numbers, accurately locate unreasonable product batches, and improve the quality of cosmetic production quality management. A “batch” refers to products produced in the same production cycle and with the same production process, generally composed of any combination of numbers or numbers plus letters. It is the only identifier for cosmetics, which can help enterprises accurately trace and review the production history, production technology, and quality standards of cosmetics of different batches, and improve the efficiency and quality of cosmetic production quality supervision^[7]. In addition, cosmetic enterprises can implement batch number management for raw materials, inner packaging materials, semi-finished products, and finished products, link all records related to the production of each batch of cosmetics, facilitating quality supervision of different production links. Once abnormal quality test data is found, the batches of problematic raw materials, packaging materials, and semi-finished products can be confirmed in the first place, realizing full traceability of all activities such as material procurement, product production, quality control, sales, and recall of each batch of products.

3.3. Conduct Self-Inspections of Quality Management Systems and Improve Cosmetic Production Quality

To standardize the production of cosmetic enterprises and promote the healthy development of the cosmetics industry, the National Medical Products Administration has not only clarified cosmetic production quality standards but also issued relevant penalty clauses, cracking down on illegal enterprises with unqualified random inspections and delayed rectification to create a good market environment. First, cosmetic enterprises should actively carry out self-inspections, conduct self-inspections on different types of cosmetics produced by the factory and products of the same type in different batches, formulate self-inspection standards for product production technology and quality testing with reference to national relevant regulations, and clarify details such as self-inspection time, procedures, departmental responsibilities, and result evaluation to ensure the smooth progress of internal self-inspection work. For example, enterprises can randomly select employees from different workshops, quality inspectors, and management personnel to form a self-inspection team to conduct random inspections on various cosmetics produced recently, covering raw materials, semi-finished products, finished products, and packaging materials of different batches, conduct inspections in internal laboratories, timely identify problems in the production process of cosmetics of different batches, and urge relevant departments to rectify to improve the quality of cosmetic production^[8]. Second, enterprises should urge relevant departments to complete self-inspection reports, urge them to conduct self-inspections on raw materials, production technology, semi-finished products,

and packaging materials of their own departments, and require them to truthfully fill in relevant data in the self-inspection reports, such as raw material heavy metal residues and microbial test data. Urge all departments to conduct self-inspections on the cosmetic production process, timely identify problems in the production process, and improve the efficiency and quality of cosmetic production. In addition, cosmetic enterprises should standardize the disposal process of unqualified raw materials, semi-finished products, and finished products, promptly destroy unqualified products harmful to the human body, and conduct harmless treatment of non-reusable raw materials to reduce pollutant emissions and achieve the goal of green development.

3.4. Optimize Sample Retention and Monitoring Systems and Improve Quality Management Efficiency

Under the new “Specifications”, cosmetic enterprises should establish a sound sample retention and monitoring system, retain samples of each batch of products to facilitate internal self-inspection and inspections by departments such as the Medical Products Administration, thereby improving the efficiency of cosmetic production quality management work. For example, enterprise quality inspectors should retain samples of raw materials and semi-finished products entering the workshop on the same day, as well as samples of finished products produced on the same day, and store the samples in the laboratory, controlling the humidity and temperature of the sample storage environment to avoid deterioration of samples during storage^[9]. For factory-finished cosmetic products, enterprises should take samples of the original sales packaging. If it is a set containing multiple cosmetics, only the smallest sales unit can be retained, but the set packaging should be preserved to facilitate traceability management. For factory semi-finished products, enterprises should preserve sample packaging and labels, clarifying information such as the production batch, storage conditions, and service life of the semi-finished products. In addition, cosmetic enterprises should set up a dedicated sample retention room or area, store samples classified according to sample standards, and establish a sample warehousing database, entering information such as sample collection time, storage conditions, and production batches, clarifying the responsible person for sample collection and information entry. The sample retention period shall not be less than 6 months after the expiration of the product’s service life. Quality inspectors should regularly inspect the retained samples, checking whether the sample form has changed, whether there is mold growth, whether there is a pungent odor, etc. Once samples are found to be deteriorated within the service life, the cause should be analyzed in a timely manner, and products of the same batch should be recalled to avoid harming the legitimate rights and interests of consumers, establish a good brand reputation, thereby improving the brand influence of cosmetic enterprises and attracting more loyal customers^[10].

4. Conclusion

In summary, cosmetic production is a complex production chain with high requirements for raw materials and production technology. Therefore, cosmetic enterprises should select high-quality raw materials that meet safety standards, regularly clean and maintain processing equipment, conduct physical and chemical and microbial tests on semi-finished products and finished products, and eliminate unqualified products; establish a sound cosmetic quality traceability management mechanism, supervise each production process, and provide high-quality cosmetics for consumers. In the future, cosmetic enterprises should integrate artificial intelligence technology into production to achieve intelligent production, improve the precision and quality of cosmetic production, and

actively develop traditional Chinese medicine (TCM) cosmetics, integrating TCM into cosmetics to develop products more suitable for Chinese people's skin, allowing Chinese cosmetic brands to go global.

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Research on the Activation Path of Weifang Kite Intangible Cultural Heritage from the Perspective of Multiple Stakeholders

Le Li, Xiaoqi Guan

MTA Education Center, Hainan Tropical Ocean University, Sanya 572022, Hainan, China

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Abstract: Based on grounded theory, this study uses NVivo 14 to conduct in-depth interview coding analysis on five types of stakeholders (government, inheritors, enterprises, residents, and tourists) in the activation of Weifang Kite intangible cultural heritage (ICH). The research finds that each subject shows significant differentiation and collaborative potential in dimensions such as policy and fund dependence, adherence to craftsmanship authenticity, cultural tourism experience design, market-oriented transformation, and cultural identity reconstruction. Inheritors face resource dilemmas and intergenerational gaps; enterprises lead industrialization transformation but have tensions with authenticity; government support shows structural misalignment; communities and tourists assume the functions of cultural communication and consumption respectively. The study constructs a multi-stakeholder collaborative framework of “government guidance — inheritor adherence — enterprise transformation — community empowerment — tourist feedback”, providing theoretical support and practical paths for the sustainable activation of ICH.

Keywords: Intangible cultural heritage; Multiple stakeholders; Collaborative governance; Weifang Kite; Grounded theory

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1. Introduction

1.1. Research Background

Global ICH protection faces a structural contradiction between the sustainability of “living heritage” and modern transformation. Under the wave of commercialization, the core value of ICH is simplified into easily consumable symbolic labels, ritual significance and community functions are weakened, and the social dimension and spiritual core of culture are marginalized^[1]. Excessive intervention of digital tools severs the “bodily practicality” of craftsmanship inheritance, triggering a crisis of cultural authenticity^[2]. China’s ICH protection has long been placed in a dual structure of “government-market”. Government intervention shows misalignment between policy supply and community needs, with resources concentrated in the front-end of “application-certification” and lacking subsequent dynamic evaluation^[3]. Market intervention stimulates economic value but weakens cultural

depth. As a craft-based ICH, Weifang Kite, relying on its material attributes and implicit knowledge, imposes more complex requirements on activation methods. As a national-level ICH project, Weifang Kite's ternary symbiotic structure of "craftsmanship - festival - community" demonstrates deep local embedding characteristics. However, existing research focuses on static craftsmanship analysis, lacking systematic analysis of the role paths of multiple subjects such as government, enterprises, and tourists. It is necessary to sort out the real context of ICH inheritance as a social process of multi-party game from the practice site.

1.2. Research Issues

When the government entrusts cultural continuity to the application competition for lists, ICH is separated from its original context and becomes a certified object. The market simplifies living inheritance into consumption symbols but does not bear inheritance costs. Communities are marginalized into the end of consumption under the influence of policies and capital. The rupture of subjectivity suspends ICH outside real life. Technology-empowered "perpetual preservation" is actually cultural deconstruction: virtual reality replaces the warmth of handicrafts, making ICH separated from bodily experience; blockchain rights confirmation transforms collective memory into tradable fragments, severing intergenerational inheritance; algorithm-driven approaches strip away the original context, and technology replaces the flowing and growing nature of ICH with standardized digital templates^[4]. Cultural genes based on bodily practice are encapsulated as static digital objects, and the "immortality" of ICH supported by technology actually loses its living nature and inherent soul^[5].

2. Literature Review

2.1. Multi-Dimensional Challenges in ICH Activation

From the perspective of inheritors, authenticity is a holistic concept integrating traditional customs, inherited meanings, and practitioners' identities^[6]. However, studies have found that inheritors face multi-dimensional dilemmas such as powerlessness, loss of meaning, lack of norms, isolation, self-alienation, and cultural alienation in the process of tourism commercialization^[7]. This alienation not only affects inheritors' attitudes towards tourism development but also threatens the sustainable inheritance of ICH. Tourists' perceptions of ICH are also complex, with their experiences including multiple dimensions such as information services, experience authenticity, price value, and environmental atmosphere. Tourists with different demographic characteristics have significant differences in evaluating these dimensions^[8].

Wider practices show that ICH activation paths are generally limited by the dissolution of original contexts and insufficient institutional support. The weakening of folk rituals and loss of living scenes make ICH gradually decoupled from daily life. The deepening involvement of market forces leads to symbolization and homogenization tendencies, and some projects are alienated driven by consumption logic^[9]. Urbanization and tourism development squeeze cultural space, weaken community agency, and make the subject role increasingly marginal^[10]. Protection mechanisms have problems such as difficulty in policy implementation, insufficient fund investment, and fragmented execution^[11]. Some crafts are difficult to respond to contemporary contexts due to insufficient innovation capacity and rigid expression forms. Although digital paths have been developed, in-depth integration remains limited.

2.2. Research Progress on Stakeholder Collaboration

The collaborative relationship among multiple subjects in ICH activation is facing structural tensions. Problems

such as uneven interest distribution, vague rights and responsibilities boundaries, and lack of participation mechanisms are widespread. Communities and inheritors are often in marginal positions, and the one-way governance model led by the government compresses the expression space of local subjects. Market logic promotes commercial interpretation, which is likely to trigger changes in cultural authenticity. Intergenerational gaps weaken endogenous inheritance motivation, and insufficient institutional support leads to resource fragmentation and ineffective execution. Studies call for building a three-dimensional collaborative mechanism of institution, market, and community to achieve a multi-governance pattern with clear rights and responsibilities, effective incentives, and balanced participation^[12].

The application of stakeholder theory in cultural heritage management has received increasing attention. Pioneering research by Aas et al. emphasizes the key role of stakeholder collaboration in heritage management and tourism development, pointing out that effective collaboration requires establishing communication channels, generating income for heritage protection, and promoting community participation in decision-making^[13]. Recent studies further reveal that policy changes will drive the reconstruction of relationships among stakeholders, and their strategic evolution presents phased characteristics of “open confrontation - implicit game - dynamic balance”^[14]. A systematic review shows that the main themes in ICH tourism research include ICH protection and inheritance, tourism impacts, planning and management and sustainability, and community participation. Different types of stakeholders play differentiated but interdependent roles in these themes^[15].

3. Research Methods

This study adopts qualitative research methods, using NVivo 14 for data coding and analysis, and constructs a theoretical framework of multi-stakeholder collaborative participation based on procedural grounded theory. Weifang Kite was selected for its typicality: as a national-level ICH project, the Weifang International Kite Festival has been held for more than 40 sessions. The core bearing area of Yangjiabu gathers a large number of inheritors, enterprises, and residents, forming a complex interest network. The study uses purposive sampling to select five core stakeholder groups: government cultural management departments, ICH inheritors, kite production enterprises, community residents, and tourists.

Data collection was conducted in three phases from April to August 2025. The pre-survey phase involved on-site observation and relationship building; the formal interview phase adopted semi-structured in-depth interviews. Interviewees included 5 government staff, 5 ICH inheritors, 5 kite enterprise managers, 4 community residents, and 5 tourists. Each interview lasted about 10-15 minutes, and recordings were transcribed with consent. A total of 24 in-depth interviews were completed, forming approximately 36,000 words of interview texts.

Data analysis adopted the three-level coding procedure proposed by Strauss and Corbin (1990)^[16]. The open coding phase formed 678 valid conceptual nodes; the axial coding phase generated 7, 6, 6, 7, and 6 secondary categories for the five subjects respectively; the selective coding phase identified the core categories of each group. Coding saturation test showed that theoretical saturation was achieved. The study used matrix coding query analysis: the row dimension was set as the five stakeholder groups, and the column dimension was refined into five core themes (policy and fund support, inheritor training and craftsmanship authenticity, cultural tourism integration and experience design, market-oriented and innovative transformation, community participation and cultural identity). By calculating the coding frequency of each group under different themes, a stakeholder-activation theme matrix was formed, providing empirical support for constructing a closed-loop mechanism of

“government policy guidance - inheritor craftsmanship adherence - enterprise market transformation - community participation empowerment - tourist experience feedback”.

4. Research Results

The dependence of various stakeholders on policies and funds is significantly differentiated. The coding frequency of inheritors in seeking external support resources is as high as 26, highlighting their strong dependence on funds, venues, and market resources; enterprises have a coding frequency of 15, showing certain initiative in resource integration; residents have a coding frequency of 17, reflecting expectations for government-enterprise collaborative support; tourists have a coding frequency of 0, focusing on consumption experience. Some funds flow to cultural and creative enterprises rather than craftsmanship inheritance. Traditional kite making involves complex processes, and inheritors' monthly income is lower than that of ordinary workers. The imbalance between input and output restricts innovation and inheritance. Inheritors demand targeted support and venue construction; enterprises obtain support through government training and expositions; communities expect publicity support and infrastructure improvement.

The coding frequency for craftsmanship authenticity is the highest (28). Inheritors emphasize that every link from frame making, paper pasting to painting is irreplaceable, criticizing formalistic inheritance in training that “values form over connotation”. The government has a coding frequency of 26 in addressing the crisis of intergenerational inheritance, as young people have low willingness to inherit due to insufficient economic attractiveness. Enterprises have formed a model of “inheritor leadership + enterprise production”, where inheritors are responsible for design creativity and quality control, and enterprises produce simplified tourist versions. Tourists' perceptions are differentiated: some recognize the value of handcrafts and are willing to pay a premium, while others prioritize portability and practicality.

Inheritors have the highest coding frequency (46) in balancing the depth and breadth of experience. The core contradiction lies in the long time required for traditional production while tourists' experience only lasts 1-2 hours. Inheritors design hierarchical experience programs, opening simple links: minors are limited to painting and pasting, while adults can try bamboo strip splitting. At the same time, they explain historical culture, balancing time constraints and cultural transmission. Enterprises launch innovative products such as customized orders and DIY material packages. Tourists particularly emphasize the cultural symbolic value of kite flying experiences. The government promotes kite culture in schools through a reimbursement system and builds museums and digital display systems to expand communication depth.

Enterprises lead industrialization transformation, using hierarchical supply to realize mechanized production of consumer kites to improve efficiency and reduce prices, while high-quality collection-level kites ensure traditional craftsmanship under the guidance of inheritors. They expand markets through multiple channels such as e-commerce, live streaming, and scenic spot cooperation. Inheritors have limited market-oriented capabilities and generally face economic difficulties. Some adopt a hierarchical strategy of collection-level high-quality products and mass-market goods to balance authenticity and market survival, but they are still a vulnerable group overall. Residents have witnessed the shrinkage of the market from widespread village production to a few workshops, with population loss and cultural gaps coexisting.

The coding frequencies for cultural identity reconstruction and subject consciousness activation are 17 and 15 respectively. Veteran artisans have transformed from “livelihood means” to “guardians of craftsmanship

authenticity”, realizing cultural awareness from instrumental rationality to value rationality. However, young people’s sense of identity is significantly weakened, influenced by electronic products and preferring jobs with quick returns, highlighting the necessity of differentiated incentive mechanisms. During the peak period of kite tourism, participating residents earned over 10,000 yuan per month. Income and welfare sharing enhanced their sense of belonging, and some young people working outside returned to start businesses. Residents demand publicity support and facility improvement but lack digital marketing skills, revealing a new digital divide problem. Tourists recognize kite craftsmanship and spread it through social media, with cultural resonance among non-local tourists crossing regional boundaries.

5. Conclusion

5.1. Multi-Stakeholder Collaborative Mechanism and Innovation of Activation Paths

The five types of subjects (government, inheritors, enterprises, communities, and tourists) form an interdependent relationship network, but each subject faces role dilemmas: the government has low resource allocation efficiency and misaligned policy supply with grassroots needs; inheritors and enterprises are caught in a dilemma between adhering to authenticity and market survival; community residents have superficial cognition and insufficient emotional identity; tourists’ demands show experiential and emotional trends. The predicament of ICH activation is structural and systematic. Kite making was originally embedded in seasonal customs and social interactions, and modernization has fragmented its cultural ecology. The breakthrough path lies in institutional innovation and mechanism design: establishing a classified and hierarchical support system; innovating inheritance mechanisms integrating master-apprentice system with modern educational concepts; stimulating endogenous motivation through empowerment. The core of path innovation is to realize the organic integration of tradition and modernity: maintaining the authenticity of core craftsmanship while introducing modern tools at the craftsmanship level; developing new cultural and creative products to expand consumption scenarios at the product level; using digital technology to expand influence while retaining offline experiences at the communication level; promoting enterprise-oriented mechanisms to maintain traditional cultural characteristics at the organizational level.

5.2. Theoretical Contributions and Practical Value

This study proposes an analytical framework for multi-stakeholder collaborative participation in ICH activation, breaking through traditional dualistic thinking. It understands ICH activation as a complex system involving multiple subjects, elements, and goals, integrating the forces of government, market, and society, and covering the entire chain of cultural production and consumption. The practical value lies in providing action guidelines for different subjects: the government should transform from a manager to a service provider and establish a precise policy system; inheritors should improve their capabilities and strengthen joint training of successors; enterprises should balance economic and cultural responsibilities to promote innovation and assume social responsibilities. The research findings have universal reference significance. The concept of multi-stakeholder collaboration can be extended to different types of ICH. Stimulating endogenous motivation is the key; market mechanisms need to be used cautiously; technological application should be moderate. ICH protection and activation require realizing the contemporary expression of traditional culture through creative transformation, promoting excellent culture to radiate vitality.

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Research on Adaptive Design and Lightweighting Technology for Agricultural Machinery in Hilly and Mountainous Regions

Ming Hai*

College of Engineering Technology, Southwest University, Chongqing 400715, China

**Author to whom correspondence should be addressed.*

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Abstract: Hilly and mountainous regions constitute a vital part of China's agricultural production landscape. However, their complex natural environments pose unique challenges for the deployment of agricultural machinery. Existing machinery often suffers from poor mobility, low operational efficiency, and inadequate adaptability in these areas, thereby hindering agricultural modernization. This paper addresses the specific characteristics of agricultural production environments in hilly and mountainous regions, thoroughly analyzing how factors such as terrain, soil conditions, and crop types influence machinery design. It explores the theoretical foundations and a collaborative framework integrating adaptive design with lightweighting strategies. By focusing on adaptive design of the working system, running gear, and control system—and combining this with material selection for lightweighting, structural optimization, and integrated design approaches—the study establishes a co-optimization model that jointly considers adaptability and lightweighting. The coupling relationship between these two objectives is analyzed, and appropriate algorithms are selected to achieve optimal solutions. The findings provide theoretical support and practical guidance for the development of specialized agricultural machinery tailored to hilly and mountainous regions, offering significant implications for enhancing agricultural productivity and promoting sustainable agricultural development in these areas.

Keywords: Agricultural machinery for hilly and mountainous areas; Adaptive design; Lightweight design; Collaborative optimization; Agricultural production efficiency

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1. Introduction

Hilly and mountainous areas in China cover vast territories across multiple provinces and play a crucial role in meeting the food demands of a large population and supporting the development of specialty agriculture. Unlike the plains, agricultural production in these regions has long been constrained by challenging natural conditions, with traditional manual and animal-powered operations still accounting for a significant proportion. Consequently,

the level of mechanization remains far below the national average.

With the advancement of China's rural revitalization strategy, agricultural mechanization has emerged as a key driver for enhancing productivity in hilly and mountainous areas. However, most existing agricultural machinery is designed primarily for flat terrain and exhibits significant inadequacies when deployed in the complex environments of hilly and mountainous regions. Fragmented land plots and steep slopes impede stable machine operation, while variations in soil adhesion and diverse cropping patterns frequently lead to malfunctions of working components. Moreover, excessive machine weight not only increases energy consumption but may also cause soil compaction, further degrading arable land quality^[1].

Therefore, research into adaptive and lightweight design of agricultural machinery tailored for hilly and mountainous areas addresses urgent practical challenges in current production systems and aligns with the inevitable trend toward precision, efficiency, and sustainability in agricultural equipment development. This work holds substantial practical significance for ensuring national food security and promoting high-quality agricultural development.

2. Analysis of Agricultural Production Environment Characteristics in Hilly and Mountainous Areas

2.1. Topographic and Geomorphic Features of Hilly and Mountainous Areas

Hilly and mountainous areas feature significant terrain undulations, with slopes commonly between 15° and 35°, and exceeding 40° in places. Farmland is fragmented into small plots, typically under 0.07 hectares, often separated by ridges and ditches. Rural roads are narrow, winding, unpaved, and turn muddy and slippery in rain. These conditions demand high maneuverability, steering agility, and climbing ability from machinery. Large equipment often cannot access fields, while smaller machines struggle with limited turning radius and unstable travel. Additionally, elevation variations create diverse microclimates that indirectly affect machinery performance and durability^[2].

2.2. Soil and Crop Characteristics in Hilly and Mountainous Areas

Hilly and mountainous areas have diverse soils—primarily red, yellow, and purple—with varying textures. Some regions have clay-rich soils that compact when wet and harden when dry, while others are sandy with poor water and nutrient retention. Soil moisture is topography-dependent: slopes drain quickly and stay dry, whereas low-lying areas retain water and become saturated.

Crop cultivation is highly diversified and vertically layered. Besides staples like rice, maize, and wheat, a wide range of economic crops such as tea, fruits, and medicinal herbs are grown. These crops differ in planting density, spacing, and structure, leading to varied mechanization needs for tillage, seeding, and harvesting. Contour farming, commonly practiced, further complicates field operations.

2.3. Problems with Current Agricultural Machinery Applications

Existing agricultural machinery faces several challenges in hilly and mountainous areas. The running gear often mismatches the terrain: wheeled machines slip on slopes, while tracked versions compact soil and lack maneuverability.

Most working systems have limited width and depth adjustability, performing poorly across varied plots and crops, leading to uneven seeding or fertilizing. Additionally, machinery tends to be bulky and heavy, increasing

energy consumption, while insufficient power on steep slopes reduces efficiency^[3].

Furthermore, inadequate protective design leaves components vulnerable to corrosion and wear in humid, dusty conditions, raising failure rates, complicating maintenance, and ultimately increasing farmers' operating costs.

2.4. Design Requirements for Agricultural Machinery in Hilly and Mountainous Areas

Agricultural equipment for hilly and mountainous areas must meet key design requirements:

Mobility: small turning radius, strong climbing ability, and stable travel for challenging terrain.

Operational Flexibility: adjustable working width/depth and multifunctionality to suit diverse crops and soils.

Structural Design: lightweight yet strong to reduce soil compaction and energy use while bearing operational loads.

Usability & Reliability: simplified, intelligent controls and environmental resilience to humidity, dust, and temperature changes for reliable field use.

3. Theoretical Foundations of Adaptive and Lightweight Design for Agricultural Machinery

3.1. Theory and Methods of Lightweight Design

Lightweight design reduces machinery weight while maintaining performance and reliability, mainly through material, structural, and process optimization.

Material-based lightweighting replaces conventional steel with high-strength, low-density alternatives like aluminum/magnesium alloys and engineering plastics. Structural lightweighting uses topology, size, and shape optimization to remove excess material and refine components under strength and stiffness constraints. Process-oriented methods, such as precision casting and improved welding, enhance accuracy and reduce waste. Crucially, lightweighting must balance weight reduction with operational requirements to avoid compromising functionality or durability.

3.2. Theoretical Framework for Collaborative Adaptive and Lightweight Design

The collaborative design framework for adaptability and lightweighting is grounded in systems engineering principles, treating the two objectives as an integrated, interdependent whole rather than isolated goals^[4].

This framework begins by clearly defining the operational requirements and environmental constraints specific to agricultural machinery in hilly and mountainous areas. It then establishes a comprehensive set of design indicators for both adaptability and lightweighting, assigning appropriate weights and priorities based on practical needs.

During the design process, a multidisciplinary collaborative optimization approach integrates knowledge from mechanical engineering, materials science, control engineering, and other relevant fields to holistically analyze and optimize the machine's structure, performance, and material selection.

A coupling relationship model between adaptability and lightweighting is developed to quantitatively assess their mutual influences. This ensures that enhancements in adaptability do not undermine lightweighting effectiveness—and vice versa—thereby preventing trade-offs that could degrade overall system performance.

Through this synergistic design strategy, an optimal balance among performance, weight, and environmental adaptability is achieved, ultimately improving the machinery's cost-effectiveness, operational efficiency, and

market competitiveness^[5].

4. Adaptive Design of Agricultural Machinery for Hilly and Mountainous Areas

4.1. Adaptive Design of the Operating System

The operating system's adaptive design should address varied crop and soil needs. A modular approach allows quick replacement of tillage, seeding, and harvesting modules, enhancing versatility. To suit fragmented plots, the working width should be steplessly adjustable. Tillage components need adjustable penetration angle and depth, controlled hydraulically or electrically for precise soil adaptation. For seeding, a multi-row mechanism with adjustable spacing meets different crop densities, while a precision seeding system improves uniformity^[6].

4.2. Adaptive Design of the Traveling System

The traveling system is key to stable operation in hilly terrain. A combined wheel-track structure merges wheel mobility with tracked adhesion, switching modes based on road conditions. The chassis is optimized to lower the center of gravity, improving slope stability and reducing rollover risk. Off-road tires with large diameter, wide tread, and deep patterns enhance ground contact and grip while reducing soil compaction^[7]. An independent suspension system absorbs terrain shocks, protects components, and increases comfort. A differential lock and anti-slip control further improve safety on wet or muddy surfaces.

4.3. Adaptive Design of the Control System

The adaptive design of the control system focuses on operational convenience and stability. Electro-hydraulic proportional control technology is adopted to achieve precise control of various mechanical actions, simplify the operation process, and reduce labor intensity. An adjustable driver's seat and control handle are designed to adapt to farmers of different heights and operating habits, improving operational comfort. An intelligent navigation and positioning system is equipped, which combines topographic data of hilly and mountainous areas to realize automatic path planning and precise operation of the machinery, reduce manual operation errors, and improve operational efficiency. During slope operations, the system can automatically detect changes in slope angle, and maintain the horizontal state and operational stability of the machinery by adjusting parameters of the traveling system and operating system. In addition, emergency braking and safety protection devices are installed^[8]. When the machinery is in dangerous situations such as excessive tilt angle and excessive speed, braking is automatically triggered to ensure the safety of operators.

5. Lightweight Design of Agricultural Machinery for Hilly and Mountainous Areas

5.1. Selection and Application of Lightweight Materials

The selection of lightweight materials shall comprehensively consider factors such as material mechanical properties, cost, and processing technology. For the mechanical body and frame, high-strength aluminum alloy materials are adopted, which possess advantages of low density, high strength, and corrosion resistance. Compared with ordinary steel, they can reduce weight by 30%-40% while meeting structural strength requirements. For operating components such as seeders and fertilizer applicators, engineering plastics or carbon fiber composite materials are selected. These materials are not only lightweight but also have good wear resistance and corrosion resistance, which can effectively reduce the weight of components. For key parts in the transmission system

such as gears and shafts, high-strength steel is used for precision forging. On the premise of ensuring strength, the material consumption is reduced by optimizing cross-sectional dimensions. During the material application process, strict performance testing and reliability analysis must be conducted to ensure the applicability and durability of materials in actual operating environments^[9].

5.2. Structural Lightweight Optimization of Key Components

Topology optimization methods are used to optimize the structure of key mechanical components such as frames and chassis crossbeams. Under the constraints of meeting strength and stiffness requirements, software simulation is used to analyze the stress distribution of components, and materials in areas with low stress are removed to form hollow or special-shaped structures, realizing efficient material utilization. Hollow structure design is adopted for shaft components, which can significantly reduce weight compared with solid shafts under the same bending and torsional resistance performance. The tooth profile and structural parameters of gears are optimized, and modified gear design is adopted to reduce the volume and weight of gears while improving their transmission efficiency and load-bearing capacity. For box-type components, thin-walled structure design is adopted, and the optimized arrangement of reinforcing ribs is used to enhance structural stiffness and reduce material consumption. After structural optimization, prototype trial production and performance testing shall be carried out to verify the effectiveness and reliability of the optimization scheme.

5.3. Lightweight Achievement through Integrated Design

Integrated design reduces the number of components and achieves overall weight reduction by integrating multiple functional components of the machinery. Power transmission components such as engines, gearboxes, and hydraulic systems are arranged in an integrated manner, and the design of pipelines and circuits is optimized to reduce connecting components and space occupation, thereby lowering the overall volume and weight of the machinery. Multifunctional integrated components are adopted, such as integrating seeding and fertilization functions into one operating module^[10]. By sharing the power transmission system and control system, the number of independent components is reduced. The control system is integrated, and a centralized control panel is adopted to integrate multiple operating functions into one controller, reducing the number of control handles and buttons and simplifying the structure of the control system. Integrated design must ensure the coordinated operation of various components, avoid functional interference, and facilitate maintenance and upkeep.

6. Collaborative Optimization Design of Adaptability and Lightweight

6.1. Establishment of the Collaborative Optimization Design Model

The collaborative optimization design model constructs a multi-objective optimization model with mechanical operating efficiency, driving stability, structural strength, weight, etc., as objective functions, and terrain conditions, soil characteristics, crop requirements, etc., as constraint conditions. Quantitative expressions for each objective function are determined: for example, operating efficiency is represented by the operating area per unit time, driving stability by the maximum rollover angle, structural strength by the maximum stress of components, and weight by the total mass of the machinery^[11]. Adaptive design indicators and lightweight design indicators are converted into design variables of the model, such as the adjustment range of operating width, ground contact pressure of the traveling system, material density, and component dimensions. By establishing the mathematical relationship between objective functions and design variables, a complete collaborative optimization design model

is formed, providing a foundation for subsequent optimization calculations.

6.2. Analysis of the Coupling Relationship between Adaptability and Lightweight Design

There is a complex coupling relationship between adaptability and lightweight design. On the one hand, lightweight design may affect mechanical adaptability: for instance, excessive weight reduction may lead to a decrease in structural strength, impairing the machinery's operational stability and durability in complex terrain. On the other hand, certain measures in adaptive design, such as adding adjustment mechanisms and adopting modular structures, may increase the machinery's weight, conflicting with the lightweight goal. Through simulation analysis and experimental research, the degree of coupling between the two is quantified, and a coupling relationship matrix is established to clarify the influence coefficients of different design variables on adaptability and lightweight indicators^[12]. For example, the use of high-strength materials can both reduce weight and improve structural strength, which is conducive to enhancing mechanical adaptability; while improving the shock absorption performance of the suspension system may increase a certain weight, it can improve driving stability and strengthen adaptability. The analysis of the coupling relationship provides a basis for collaborative optimization and realizes the coordinated development of the two^[13].

6.3. Selection and Implementation of the Collaborative Optimization Algorithm

According to the characteristics of the collaborative optimization design model, the Non-dominated Sorting Genetic Algorithm II (NSGA-II) is selected as the optimization algorithm. This algorithm has excellent multi-objective optimization capabilities and can find multiple Pareto optimal solutions in a complex solution space, providing designers with diversified optimization schemes. During the algorithm implementation process: first, design variables are encoded, and their value ranges and precision are determined. Algorithm parameters such as population size, number of iterations, crossover probability, and mutation probability are set, and the optimal parameter combination is determined through experimental debugging^[14]. The constructed collaborative optimization design model is imported into the algorithm for iterative calculation. In each iteration, individuals undergo evaluation, selection, crossover, and mutation operations to gradually approach the optimal solutions. After the iteration, the scheme with the best comprehensive performance is selected from the Pareto optimal solution set, which is the optimal design scheme for the collaborative optimization of adaptability and lightweight. Finally, verification and analysis of the optimization scheme are conducted to ensure it meets the design requirements^[15].

7. Conclusion

Through an in-depth analysis of the agricultural production environment in hilly and mountainous areas, this study has clearly identified the limitations of existing agricultural machinery and the specific design requirements for such regions. A theoretical framework for the collaborative design of adaptability and lightweighting has been established, and systematic research has been conducted on both adaptive and lightweight design methodologies tailored to agricultural machinery in these challenging terrains. Furthermore, a synergistic optimization approach integrating both objectives has been successfully implemented.

The research demonstrates that modular and intelligent adaptive design strategies can significantly enhance machinery's capability to cope with the complex terrain, diverse soil conditions, and varied cropping systems

typical of hilly and mountainous areas. Meanwhile, through the strategic selection of lightweight materials, structural optimization, and integrated design, substantial weight reduction can be achieved without compromising mechanical performance—thereby lowering energy consumption and minimizing soil compaction.

The co-optimization of adaptability and lightweighting enables their organic integration, achieving an optimal balance among machine performance, weight, and environmental suitability. These findings provide a practical and technically viable pathway for the development of specialized agricultural machinery for hilly and mountainous regions, contributing to the advancement of mechanization, and supporting more efficient, precise, and sustainable agricultural production in these areas.

Future work should further integrate intelligent technologies—such as digital twins, AI-driven design, and real-time sensing—into the collaborative optimization process to enhance design efficiency and accuracy. Additionally, extensive field trials are needed to validate the real-world performance of proposed designs, thereby offering stronger empirical support for the industrial-scale adoption and promotion of next-generation agricultural machinery.

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Digital Intelligence-Driven Innovation in the Bio-Industry: A New Model for Accelerating Evidence-Based Nutraceutical Development

Amy Zhou

WALVE Biotech Pty Ltd, Sydney NSW 2000, Australia

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Abstract: This study addresses common bottlenecks in the global biopharmaceutical industry, including slow R&D cycles, high compliance costs, and challenges in international market access. It proposes an evidence-based accelerated model for nutritional supplements that integrates digital intelligence, biotech innovation, and regulatory science. Centered on Australia's TGA pharmaceutical-grade regulatory framework, the model establishes an integrated global system encompassing R&D, efficacy validation, and international compliance. Leveraging a big data platform for active ingredients and an AI-driven formulation engine, it combines biological mechanism analysis with real-world evidence (RWE) validation. The architecture features standardized core modules and region-specific customization to accommodate global regulatory variations. A practical case study of WALVE Biotech's Revefore® ternary synergistic formulation demonstrates the model's effectiveness. Research confirms that this approach not only enhances profit margins per product unit but also enables rapid adaptation to global markets through dynamic integration with regional regulatory databases like FDA and EFSA. The model provides a high-standard, efficient R&D solution for the evidence-based nutrition industry, offering broad applicability across the sector.

Keywords: Bio-industry; Digital intelligence; Nutrition and health product development; Data model

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1. Introduction

The global biopharmaceutical industry is undergoing a profound transformation from experience-driven to evidence-based approaches. This shift stems from consumers' growing demand for scientifically validated product efficacy and safety, while being constrained by inherent limitations of traditional R&D models. Conventional development relies on empirical ingredient combinations and large-scale physical testing, which not only face challenges like lengthy formula iteration cycles and high evidence-based validation costs, but also face regulatory compliance delays of 6-12 months across markets due to regional differences, making it difficult to meet global competition demands. In this context, digital intelligence technologies have become crucial for breakthroughs.

AI enables predictive simulations of synergistic ingredient effects and early toxicity risk assessments, big data integrates multi-source evidence to support precision R&D decisions, while real-world evidence (RWE) fills gaps in traditional clinical data. These three elements synergistically drive the R&D process toward “precision, cost efficiency, and rapid iteration,” providing technical pathways for the industry to transcend traditional limitations.

This study selects Australia’s WALVE Biotech as a case study to demonstrate the industrial value of digital intelligence. Leveraging its 116 proprietary formulations and 26 TGA-certified products, the company applied AI technology to model synergistic effects in anti-aging and anti-aging series. By integrating global consumer health data and clinical literature through big data, combined with TGA regulatory standards, they established a digital evidence-based validation system. This approach achieved remarkable results: a 40% reduction in formula iteration cycles and a 50% improvement in cross-regional compliance efficiency. Based on this, the study focuses on WALVE Biotech’s three-dimensional integration of “digital intelligence, biotech innovation, and regulatory science,” proposing a new model to accelerate evidence-based nutraceutical R&D. The research aims to fill the theoretical gap in integrating digital technology with evidence-based development and provide actionable pathways for global nutraceutical companies to achieve “scientific evidence + digital efficiency + compliant international expansion,” ultimately driving the industry toward higher-quality innovation paradigms.

2. literature review

2.1. Application of AI in the Research and Development of Nutritional and Health Products

AI technology has become the core driving force in reshaping the R&D paradigm of nutritional supplements. Research in this field follows a three-phase approach: “multi-source data integration, algorithmic precision optimization, and evidence-based efficacy validation,” forming a closed-loop system from fundamental research to industrial application. In functional ingredient screening and mechanism analysis, Zhang J from MIT integrated molecular structure data of 2 million natural compounds with 12 million clinical studies using Transformer architecture, achieving end-to-end prediction of ingredient-target-efficacy associations. The model demonstrated 91% accuracy in predicting the synergistic mitochondrial activation mechanism between NMN and PQQ, outperforming traditional bioinformatics methods by two orders of magnitude. This model has been adopted by global nutrition leader Nestlé for anti-aging product development, reducing candidate ingredient screening cycles from 18 months to 3 months ^[1]. In probiotic research, Academician Zhang Heping (2025) from Inner Mongolia Agricultural University proposed an “AI-driven full-chain probiotic R&D framework.” Their support vector machine (SVM) model, through 16S rRNA gene sequence analysis, achieved 97% accuracy in predicting probiotic acid and bile salt tolerance. The screened *Lactobacillus plantarum* KLDS 1.0344 strain produced antimicrobial peptides with 92% inhibition rate against *E. coli*, and the technology has been commercialized into three probiotic products ^[2]. Personalized formulations and evidence-based validation represent another core breakthrough in AI applications. Professor Jebb S A from the University of Cambridge (2024) developed a reinforcement learning model that integrates genetic data, gut microbiome sequencing results, and wearable device monitoring data from 1,023 subjects to achieve personalized dosage recommendations for vitamin D supplements. Customized solutions for individuals with “slow CYP2D6 metabolism” increased the vitamin D attainment rate by 67%, three times higher than the general dosage regimen ^[3]. In industrial practice, Amway (China) Kan Juntao (2020) established a visual health scoring prediction system based on 504 feature data from 303 eye fatigue subjects, accurately matching personalized ratios of lutein esters and zeaxanthin, with intervention plan adaptability improving by 40%

compared to traditional models ^[4]. These studies confirm that AI has evolved from a technical auxiliary tool to a core engine driving the industry's transformation toward "precision-evidence-based-globalization," while also exposing issues such as insufficient data standardization and the need for enhanced algorithmic interpretability. Optimizing models by integrating regulatory standards like TGA will become a key direction for future research.

2.2. Regulatory Recognition and Application of Real-World Evidence (RWE)

Real-world evidence (RWE) has evolved from a supplementary form of traditional clinical data to a core support for evidence-based development and regulatory submission of nutritional supplements, with its value increasingly recognized in global regulatory systems. Through retrospective studies, Harvard Medical School's Ryan P. Kelleher (2021) demonstrated that RWE based on electronic health records (EHRs) and health insurance data achieved 89% consistency with randomized controlled trial (RCT) results in long-term safety assessments of vitamin D supplements, while also covering elderly populations with comorbidities that were difficult to include in RCTs ^[5]. In its 2021 "Guidelines for Real-World Evidence of Therapeutic Products," Australia's Therapeutic Goods Agency (TGA) explicitly stated that RWE could be used for long-term efficacy monitoring and risk signal identification in nutritional supplements. Research by Lisa J. Bowden at the University of Sydney Medical School showed that using TGA-approved RWE standards reduced the re-registration cycle for WALVE Biotech's Revefore brand NMN product by 40% compared to pure RCT pathways, while successfully identifying rare drug interaction risks ^[6]. Regarding standardized application and regulatory coordination of RWE, although the European Food Safety Authority (EFSA) maintains a cautious stance, its 2022 revised "Guidelines for Scientific Assessment of Nutrition and Health Claims" now allows "third-party-verified user feedback data from e-commerce platforms" as supplementary evidence. Martin G. Tovey from the University of Oxford (2023) improved the validity rate of user feedback data from 58% to 82% through an AI data cleaning algorithm, and this system has been included in the EFSA's reference standards ^[7]. Meanwhile, the "Technical Guidelines for Supporting the Development and Evaluation of Nutritional Supplements with Real-World Evidence (Trial)" released by China's NMPA in 2024 draws on these international experiences, clarifying the application path of RWE in formula iteration and population suitability assessment. Notably, Jennifer L. Malin from Johns Hopkins University (2022) pointed out that the core bottleneck in current RWE applications lies in insufficient cross-regional data interoperability. Her proposed "federated learning + blockchain" data sharing model achieved standardized integration of RWE for nutritional supplements in Australia, the United States, and China while protecting privacy, providing a technical solution for global regulatory collaboration ^[8].

2.3. Research on the Integration of Digital Intelligence and Regulatory Science

The deep integration of digital intelligence and regulatory science has become a critical pathway to resolve the contradiction between "efficient R&D" and "standardized regulation" in the nutritional supplement industry. Its core value lies in enhancing regulatory efficiency and achieving precise risk prevention. Aaron S. Kesselheim from Stanford University School of Medicine developed an "AI-driven regulatory decision support system" that automatically analyzes regulatory texts from 12 global regions through natural language processing (NLP). By combining machine learning algorithms to match R&D data with regulatory requirements, this system reduced the FDA's compliance review time for fish oil products from 14 to 3 working days and lowered the review error rate from 8.2% to 1.5%, establishing a milestone technical paradigm for the digital transformation of regulatory science ^[9]. In terms of standardization and coordination of integration pathways, Lisa M. Schwartz from Johns

Hopkins University proposed a three-dimensional framework of “data standards-algorithm specifications-result interoperability.” She demonstrated that R&D data based on FHIR standards can achieve 92% result interoperability between FDA and EMA regulatory models. This framework has been incorporated into the 2024 work guidelines by the International Council of Medicines Regulatory Authorities (ICMRA) ^[10]. In industrial practice, the Feihe Aiben R&D team collaborated with Huawei Cloud (2025) to propose a regulatory-adaptive AI R&D model, which embeds algorithmic constraints from both NMPA and TGA regulatory dimensions during the formula design phase. The “Yuedong Protein Nutrition Powder” they developed achieved a 58% reduction in regulatory response time compared to the industry average when submitted simultaneously in multiple countries, and their achievements were promoted by NMPA as a typical case of “digital regulation empowering the industry” ^[11]. Catherine M. Sharkey’s research at MIT proposed that algorithmic bias may lead to regulatory decision-making deviations, and her “regulatory algorithm fairness evaluation index system” has become a mandatory standard for FDA (Food and Drug Administration) to review AI regulatory tools, providing theoretical assurance for risk prevention during integration ^[12].

Current research in the nutritional supplements sector demonstrates a three-pronged approach: AI-powered solutions, real-world evidence (RWE) applications, and the integration of digital intelligence with regulatory science. These advancements are driving the industry’s paradigm shift from experience-based practices to evidence-based precision. However, challenges persist: AI implementations face data standardization gaps and algorithmic interpretability limitations, RWE quality control systems require refinement, and digital regulatory tools carry algorithmic bias risks. Future research must prioritize addressing these issues through two key strategies: establishing unified data standards and optimizing AI algorithmic transparency. By aligning with global regulatory frameworks like the TGA and NMPA, and enhancing cross-regional regulatory collaboration mechanisms, we can provide sustained support for standardized innovation in the nutritional supplements industry.

3. research technique

This study uses systematic literature review, comparative analysis, case study and expert interview to explore the application of digital intelligence in the development of nutrition and health products, especially how to accelerate the development of evidence-based nutrition and health products and adapt to global regulatory standards.

3.1. Systematic Literature Review

This study investigates the application of digital intelligence in the R&D process of nutritional supplements. Through systematic literature reviews of academic databases (PubMed, Web of Science, Scopus) and industry reports/regulatory documents, we synthesize existing research findings. The analysis identifies current applications, challenges, and development trends of digital intelligence in this field, providing a theoretical foundation for future research.

3.2. Comparative Analysis Method

This study employs comparative analysis to examine regulatory requirements from major global health authorities, including Australia’s TGA, the U.S. FDA, and the EU’s EFSA. These regulatory differences provide critical insights for designing and implementing a digital R&D framework. By analyzing cross-regional regulatory frameworks, the research identifies challenges in regulatory alignment and establishes a globalized digital

intelligent R&D framework.

3.3. Case Analysis Method

This study examines WALVE Biotech as a case study, analyzing its practical experience in developing digitally intelligent nutritional supplements. Through a detailed breakdown of the company's R&D process, it explores the specific applications of digital intelligence technologies. By evaluating key metrics such as R&D efficiency, regulatory compliance, and market performance, the research assesses how digital technologies enhance corporate competitiveness and proposes a global R&D model.

3.4. Expert Interviews

To better understand the practical applications and challenges of digital intelligence in nutritional supplement R&D, this study conducted expert interviews. Through analyzing interview content and data, we gained profound insights into the real-world challenges of digital intelligence in R&D processes, bottlenecks in technology application, and strategies to enhance digital R&D capabilities in global competition. These findings lay the foundation for establishing a digital innovation framework.

4. Digital Innovation Framework

4.1. Big Data Platform for Component Analysis

The ingredient big data platform serves as the cornerstone of the digital innovation framework, designed to address critical pain points in nutritional supplement R&D—fragmented ingredient data, limited correlation dimensions, and inefficient data mining. Guided by principles of comprehensive data coverage, unified standards, privacy compliance, and functional scalability, it integrates multi-source data, establishes standardized systems, and incorporates intelligent modules. This enables precise cross-dimensional correlation across “ingredients-targets-efficacy-regulation”, providing foundational support for AI-driven formula optimization, efficacy analysis, and cross-regional regulatory compliance.

The platform adopts a modular design featuring a “four-layer architecture with dual support systems,” leveraging core technologies including component knowledge graphs, federated learning, and intelligent semantic retrieval to form a closed-loop process of “data input-governance-mining-output.” The data access layer collects multi-source data through three methods: APIs, direct database connections, and offline imports. During data integration, a format parsing engine automatically identifies 12 common formats such as PDF, Excel, and JSON, achieving 40 times higher efficiency than traditional manual entry. The data governance layer serves as the core for standardization and quality control, enhancing data value through cleaning, standardization, association, and validation. The core functionality layer, as the central module for R&D empowerment, includes four intelligent modules: precise component screening, efficacy mechanism analysis, safety assessment, and regulatory compliance, enabling data conversion into R&D value. The application interface layer adopts a “general interface + customized services” model to ensure seamless integration with downstream systems. Additionally, the platform's operation relies on two critical systems: technical support and security assurance. The technical support system employs cloud computing architecture to handle high-concurrency access, separates data storage from computation through distributed databases, and accelerates model training via GPU clusters. The security assurance system establishes comprehensive protection across the entire process through data encryption, access permission classification, and operation log auditing, in addition to privacy protection measures in the data access layer.

4.2. AI Formula Engine

The AI Formula Engine serves as the core transformation hub of the digital innovation framework, designed to address the pain points of traditional formula development—excessive reliance on experience, challenges in balancing multiple objectives, and regulatory compliance delays. Powered by standardized data from the ingredient big data platform, the engine integrates multimodal AI models to analyze “ingredient correlation patterns, efficacy mechanisms, and regulatory requirements.” This enables intelligent processing of the entire workflow from R&D needs to compliant formulations, transforming the conventional trial-and-error approach into a precision-driven development model.

The engine leverages component-effect association reinforcement learning, multi-objective dynamic weighting algorithms, and lightweight deployment technologies, adopting a four-layer architecture of “data input-model algorithms-core functions-application output” to form a closed-loop R&D process. The data input layer serves as the integration portal for multi-source requirements and data, consolidating three categories of structured information: R&D requirements, foundational data, and constraint conditions. The model algorithms layer forms the core of the engine, utilizing hybrid architectures including component combination prediction models, multi-objective optimization models, regulatory rule embedding models, and lightweight modules to achieve precise formula generation. The core functions layer empowers the entire R&D process through five modules: R&D requirement analysis, intelligent formula generation, formula simulation verification, regulatory pre-validation, and formula iterative optimization, enabling deep coupling between technology and R&D scenarios. The application output layer adopts a “standardized report + custom interface” model to achieve R&D report generation, system integration, and web-based interaction.

4.3. GMP Intelligent Manufacturing Integration Module

The GMP Intelligent Manufacturing Integration Module serves as the implementation hub for the digital innovation framework, with its core mission to address three critical pain points in translating AI-driven formula innovations into practical production: parameter discontinuity, compliance delays, and traceability gaps. Guided by pharmaceutical GMP (2020 Edition) and the ICH Q10 international guidelines, this module processes precise formula parameters generated by the AI formula engine. Through a technical pathway of “data standardization conversion, intelligent process adaptation, and GMP full-process control,” it achieves seamless integration between formula requirements and intelligent manufacturing systems. This establishes a digital closed loop encompassing “formula design, process execution, quality control, and compliance documentation,” ensuring compliance, stability, and traceability throughout the production process of nutritional supplements.

The module employs a “four-layer integration + dual safeguards” technical architecture to achieve end-to-end digital transformation and control from formulation to production. The data integration layer serves as the module’s data “transfer hub,” with its core function being standardized data docking and bidirectional flow across multiple systems. The process transformation layer acts as the module’s “core converter,” enabling precise mapping and optimization of formulation parameters into production processes. The GMP compliance control layer, centered on GMP standards, establishes a comprehensive control system covering “pre-event prevention, in-process monitoring, and post-event traceability.” The production coordination layer functions as the central hub for equipment and personnel collaboration, ensuring synchronized scheduling and efficient coordination of production elements.

4.4. Global Regulatory Compliance Matrix

The Global Regulatory Compliance Matrix serves as the compliance hub for digital innovation frameworks, addressing industry pain points in the global distribution of nutritional supplements such as fragmented regulatory rules, ambiguous compliance interpretations, and inefficient application processes. Built on an international regulatory database from a big data platform for active ingredients, this matrix integrates AI formula engine pre-validation logic with GMP compliance records. Through its technical approach of “intelligent regulatory analysis, end-to-end compliance management, and precise application empowerment,” it establishes a comprehensive regulatory response mechanism covering “compliance of efficacy claims in R&D, compliance of labeling in production, and data adaptation in applications.”

Matrix tackles the core challenges of global compliance through three technological breakthroughs: multilingual regulatory semantic mapping, dynamic compliance weighting algorithms, and compliance risk quantification models. Its four-tier architecture—data support layer, intelligent interpretation layer, full-process control layer, and application output layer—transforms regulatory rules from static texts into dynamic compliance directives. As the data foundation, Matrix enables comprehensive aggregation, standardized processing, and real-time updates of global regulatory data. The intelligent interpretation layer, serving as the system’s “brain,” provides in-depth analysis and precise mapping of regulatory rules. The full-process compliance control layer establishes an embedded compliance management system covering R&D, production, and regulatory submission stages, seamlessly integrating with preceding modules. The application output layer adopts a “customized services + standardized interfaces” model to meet diverse corporate compliance needs.

4.5. Digital Clinical and RWE System

The Digital Clinical and RWE (Real-World Evidence) System serves as the “Evidence Transformation Hub” within the digital innovation framework, addressing the dual pain points of traditional nutritional supplement clinical research—protracted cycles, high costs, and low-evidence quality—alongside RWE challenges like fragmented data, quality control difficulties, and disconnection from R&D. Built on the efficacy mechanism data from a component big data platform, this system integrates AI formula parameters with GMP production quality control data. Through a technical pathway of “digitalized clinical research management, multi-source RWE integration, and intelligent evidence quality enhancement,” it establishes a comprehensive evidence chain covering “target validation at the R&D stage, efficacy confirmation in clinical trials, and evidence submission to regulatory authorities.”

The system addresses core bottlenecks in evidence generation and transformation through an integrated clinical-RWE data fusion model, real-time evidence quality assessment engine, and digital twin subject model. Adopting a four-layer architecture of “data acquisition layer-data governance layer-core function layer-application output layer”, it achieves a closed-loop process of “data input-quality control-evidence generation-outcome delivery”. The data acquisition layer serves as the “source” of evidence data, enabling comprehensive collection and real-time integration of clinical and RWE data. The data governance layer ensures regulatory compliance by enhancing data value through a four-step process: “cleaning-standardization-de-identification-quality validation”. The core function layer establishes four modules: digital clinical design, RWE intelligent integration, regulatory-grade evidence generation, and efficacy/safety dynamic monitoring, enabling deep collaboration with R&D and production processes. The application output layer adopts a “customized reports + standardized interfaces” model to meet diverse needs and deliver evidence across multiple scenarios.

5. case study

5.1. Basic Situation of Enterprise Digital R&D

WALVE Biotech Pty Ltd (hereinafter referred to as “WALVE Biotech”), headquartered in Sydney, Australia, was founded in 2016 and underwent strategic restructuring in 2021. Specializing in evidence-based nutritional supplements, the company has established a comprehensive operational system encompassing R&D, production, and global distribution. Its product portfolio focuses on three high-growth segments: anti-aging, metabolic regulation, and gut health.

As of October 2025, Wolf Biology has accumulated 116 exclusive formulas. Among its products, 26 have obtained registration as therapeutic goods with the Australian TGA (included in the ARTG), 16 have completed filing as dietary supplements with the US FDA (in compliance with DSHEA standards), and 7 have entered the EU market (in line with EFSA nutrition claim specifications). With the acceleration of its international layout, the company’s products are now sold in 12 major economies worldwide, with the Asia-Pacific market contributing 68% of revenue and the North American market contributing 22%, gradually forming a growth pattern centered on Australia and the US with global collaborative expansion.

WALVE Biotech’s R&D investment and technological strategy underscore its innovation-driven approach. In 2023, the company’s R&D expenditure accounted for 18% of its revenue, more than double the global average for the nutrition and health supplement industry. Its core investments focus on integrating digital technologies with evidence-based research. Since launching the “Digital R&D Empowerment Program” in 2021, WALVE Biotech has been a pioneer in Asia-Pacific nutrition enterprises applying AI technology to ingredient screening. By 2022, it had established the region’s first enterprise-level RWE data collection system. As a benchmark in digital R&D for nutrition and health supplements in the Asia-Pacific, Walve biotech’s digital transformation exemplifies both technological foresight and industry-wide applicability, making it a prime case study.

5.2. Implementation of the Digital Innovation Framework

To address the key pain points of Revefore® NMN formulation—its single anti-aging efficacy and inadequate oxidative stress improvement—and WALVE Biotech’s challenges of high trial-and-error costs and lengthy R&D cycles in ingredient synergy, the digital innovation framework adopts a logic of “AI-driven synergy mechanism analysis—formulation optimization—full-process compliant implementation” to specifically overcome the R&D and commercialization challenges of the NMN+PQQ+ergothioneine ternary synergy model. The framework implementation centers on the “ternary synergy model” as the core target, establishing a targeted path of “data-driven energy—AI modeling—closed-loop validation,” while simultaneously configuring a “R&D-led + cross-departmental support” system to ensure technology-demand alignment.

5.2.1. The first stage: mining of collaborative mechanism

This phase primarily leverages the component big data platform to identify the dual targets of “mitochondrial activation + oxidative stress inhibition,” elucidating the synergistic interaction nodes of NMN, PQQ, and ergothioneine. Serving as the “data foundation” for mechanism elucidation, the platform extracts key information from 52,000 experimental data points using NLP technology, constructing a three-dimensional knowledge map of “components-targets-pathways.” It also mines synergistic signals from 380,000 RWE feedbacks, validating the safety advantage of the ternary combination over the binary one in reducing adverse reaction rates. By interfacing

with PubMed, the platform captures real-time new research on the “ergothioneine-Nrf2 pathway,” elevating the accuracy of mechanism elucidation to 91%.

5.2.2. Phase Two: AI Model Optimization

This phase primarily utilizes an AI formulation engine and collaborative mechanisms to generate optimal formulations that are “highly active, cost-effective, and compliant.” The AI formulation engine, serving as the “core tool” for collaborative optimization, employs a hybrid architecture of “Graph Neural Network (GNN) + multi-objective genetic algorithm.” The GNN module learns component synergy patterns based on knowledge graphs, while the genetic algorithm optimizes dosage using an objective function that maximizes antioxidant activity and mitochondrial activation rate while minimizing cost and hepatic metabolic burden. Through transfer learning, the system calibrates the synergistic coefficient between ergothioneine and NMN/PQQ, clarifying ergothioneine-related characteristics. The final formulation achieves a 68% increase in antioxidant activity compared to the original formulation, with cost growth controlled at 8.5%. A visual interface enables R&D personnel to adjust parameters in real-time, reducing technical barriers.

5.2.3. The third stage: pilot test and verification

This phase utilizes the GMP bridging module and the Clinical & RWE system to achieve seamless transition from formulation to production, completing efficacy validation. The GMP bridging module, serving as a bridge for formulation conversion, automatically matches processes for ergothioneine’s thermal sensitivity, directly transmitting parameters like mixing speed and granulation time to the Yonyou U9 MES system. It collects real-time raw material purity and particle moisture data, automatically generating adjustment plans when anomalies occur to ensure product compliance with formulation requirements. The Clinical & RWE system acts as an efficacy evidence engine, managing clinical data through the EDC system, demonstrating a 45% increase in SOD activity and a 38% rise in ATP content ($P < 0.01$). Using NLP to annotate RWE feedback and PSM matching control samples, it confirms a 68% “self-rated excellent rate for anti-aging efficacy,” representing a 23% improvement over the original formulation group.

5.2.4. Phase 4: Compliance and Promotion

The Global Regulatory Compliance Matrix enables cross-border regulatory validation for Australia, the US, and Europe, facilitating synchronized global formulation launches. Serving as a compliance navigator, it automatically matches tri-nutrient ingredient regulations through its preloaded regulatory database. This system supports dual objectives: obtaining EU No 1169/2011 certification for ergothioneine applications and securing US “dietary supplement” labeling for NMN. By integrating AI-driven formulation data, GMP records, and clinical evidence, it generates region-specific regulatory submissions. Within 72 hours, it also complies with EU labeling requirements for ergothioneine origin disclosure. Furthermore, its clinical and RWE systems deliver GRADE A evidence reports that are recognized by the TGA for efficacy claims.

5.3. Summary of Case Effectiveness