

Analysis of Archives Management of Infrastructure Projects in Scientific Research Institutions under the New Situation

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Abstract: Focusing on the archives management of infrastructure projects in scientific research institutions under the new situation, this paper conducts an in-depth analysis from two aspects: work objectives and work methods. In terms of work objectives, four goals are proposed, including improving the standardization level, strengthening information construction, ensuring security, and enhancing service efficiency. In terms of work methods, five specific practices are elaborated, such as establishing management systems, promoting information construction, intensifying personnel training, implementing quality control, and strengthening safety protection. This paper aims to provide theoretical guidance and practical reference for the archives management of infrastructure projects in scientific research institutions, so as to facilitate the efficient development of scientific research projects.

Keywords: Scientific research institutions; Infrastructure projects; Archives management; Information construction

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1. Introduction

With the increasing complexity and scale of scientific research projects, the archives management of infrastructure projects in scientific research institutions is facing new challenges and opportunities. As an important part of scientific research project management, the standardization, informatization, and security of archives management are directly related to the smooth progress of scientific research projects and the transformation of results. However, at present, many scientific research institutions still have problems in the archives management of infrastructure projects, such as imperfect systems, low informatization level, and uneven quality of personnel. Therefore, based on the actual needs under the new situation, this paper systematically analyzes the objectives and methods of archives management of infrastructure projects in scientific research institutions, aiming to provide feasible management strategies for scientific research institutions and promote the efficient development of archives management work^[1-2].

2. Work objectives for the archive management of infrastructure projects in scientific research institutions in line with the requirements of the new situation

2.1. Enhancing the standardization and normalization of archive management

In response to new opportunities presented by the changing situation, scientific research institutions must further improve the standardization and normalization of archive management for infrastructure projects. As scientific research projects grow in complexity and scale, the importance of standardized archive management has become crucial. By formulating unified standards and processes for archive management, institutions can ensure that the collection, organization, filing, and utilization of various infrastructure project archives are carried out in accordance with regulations. Adopting standardized archive management can improve work efficiency and effectively prevent issues such as archive loss, damage, or incomplete information. Standardized management promotes interconnection and interoperability of archive information, facilitating information sharing and collaboration within the institution and across departments. The introduction of advanced information management systems further guides archive management toward standardization, ensuring the accuracy, completeness, and integrity of archive data, thereby providing strong support for the smooth progress of scientific research projects ^[3].

2.2. Strengthening informationization and digitalization of archive management

With the rapid development of information technology, scientific research institutions urgently need to strengthen the informationization and digitalization of archive management for infrastructure projects. Traditional paper-based archive management can no longer meet the goal of efficient utilization of archive information in modern scientific research projects. By introducing electronic archive management systems, institutions can realize digital storage, retrieval, and sharing of archives, significantly improving the efficiency and convenience of archive management ^[4]. Informationization can also leverage technologies such as big data and cloud computing to achieve in-depth analysis and mining of archive data, adding strong support for scientific research decision-making. Digital archive management can effectively reduce storage costs, extend the retention period of archives, and ensure the security and traceability of archive information. Through informationization and digitalization, scientific research institutions can better address the challenges of archive management in the new situation ^[5].

2.3. Ensuring the security and confidentiality of archive management

Infrastructure project archives in scientific research institutions often contain a large amount of sensitive information and confidential data. Therefore, ensuring the security and confidentiality of archive management is one of the important objectives. In the new situation, archive management work must adopt stricter security measures to prevent information leakage, tampering, or loss. By establishing a comprehensive archive security management system, including measures such as access control, encrypted storage, and backup recovery, institutions can ensure the security and integrity of archive data ^[6]. Strengthening training on security awareness for archive management personnel to enhance their confidentiality awareness and risk resistance capabilities is also crucial. For archives involving state secrets or scientific research secrets, strict compliance with relevant laws and regulations is necessary to ensure that archive management work meets national security and confidentiality requirements. Comprehensive security precautions are adopted to safeguard the security and confidentiality of infrastructure project archives in scientific research institutions ^[7].

2.4. Improving the service efficiency and utilization value of archive management

The ultimate goal of archive management for infrastructure projects in scientific research institutions is to improve

the service efficiency and utilization value of archives, providing solid support for the normal operation of scientific research projects. By optimizing archive management processes, institutions can enhance the efficiency of archive retrieval and the convenience of utilization, ensuring that researchers can quickly access the required archive information. Archive management work should focus on in-depth excavation and utilization of archives, using data analysis and mining to provide valuable references for scientific research decision-making. It should also promote collaboration with other links in scientific research projects to ensure that archive information supports all stages of the project in a timely and accurate manner. By improving service efficiency and utilization value, scientific research institutions can further leverage the supporting role of archives in scientific research projects, driving the efficient implementation of research work ^[8].

3. Approaches to archive management of infrastructure projects in scientific research institutions in the new situation

3.1. Establishing a sound archive management system and process

The archive management of infrastructure projects in scientific research institutions should start with forming a sound archive management system and process to ensure that the archive management work is carried out in accordance with regulations and can be traced. Detailed archive management specifications should be formulated to clarify the operational requirements for each link of archives from classification to destruction (numbering, filing, storage, and borrowing). For different types of infrastructure project archives, such as archives of scientific research laboratory construction, equipment procurement archives, and project acceptance archives, differentiated management processes should be established to clarify their management key points and operational sequences, respectively ^[9]. Implement an archive management responsibility system, define the work scope of archive management personnel, ensure that each link is handled by a dedicated person, and regularly revise and improve the archive management system. According to the actual situation and the latest policies and guidelines, dynamically adjust the management process to make the system scientific and operable. By establishing a sound archive management method and process, a solid institutional foundation can be built for the archive management of infrastructure projects in scientific research institutions ^[10]. In the implementation process, it is also necessary to establish an archive management supervision mechanism, conduct regular inspections and evaluations of archive management work to ensure the effective implementation of various systems and processes. For any problems found, rectification and optimization should be carried out immediately to promote the steady improvement of archive management work. Through the implementation of institutionalized and process-oriented management, scientific research institutions can effectively enhance the standardization and efficiency of infrastructure project archive management, providing strong support for the orderly development of scientific research projects.

3.2. Promoting the construction of information systems for archive management

Scientific research institutions should rapidly promote the construction of information systems for the archive management of infrastructure projects to realize digital management and efficient utilization of archives. A professional electronic archive management system should be adopted to enable the entry, storage, retrieval, and sharing of archives through electronic means. During the system construction, emphasis should be placed on interconnecting with the existing information platforms of scientific research institutions (such as scientific research project management platforms and financial management systems) to achieve data interconnection. A mobile APP can be developed to facilitate researchers to access archive information anytime and anywhere. In

the process of archive digitization, high-precision scanning equipment should be used to convert paper archives into digital form, and a strict archive data verification framework should be established to maintain the accuracy and integrity of digital archives. Regular maintenance and upgrading of the information system should be carried out to ensure its stability and security. Through the construction of the information system, the efficiency and convenience of archive management can be greatly improved. In the process of promoting the construction of the information system, attention should also be paid to user experience. The system operation process and interface should be optimized to ensure that archive management personnel and researchers can quickly get started with the system. A training system for the information system should be established, and regular system operation training should be conducted to guide relevant personnel to master the system operation mode proficiently. By means of information system construction, scientific research institutions can realize intelligent and efficient archive management, providing strong support for the orderly development of scientific research projects ^[11].

3.3. Strengthen professional training for archives management personnel

For the archives management of infrastructure projects in scientific research institutions, it is necessary to further strengthen professional training for archives management personnel to improve their professional competence and management skills. Archives management personnel should be regularly organized to participate in professional training courses to master the latest theories, technologies, and methods in archives management, especially knowledge related to the informatization and digitalization of archives management. Experts in the field of archives management should be invited to give special lectures, sharing advanced management experiences and practical cases. Support should be provided for archives management personnel to participate in industry exchange activities to learn about outstanding practices in archives management from other scientific research institutions. Internal training regulations should be formulated, and experienced archives management personnel should implement a “mentorship” system for new recruits to help them quickly master practical archives management skills. Through intensive professional training, a high-quality archives management team should be built to provide talent guarantee for the archives management of infrastructure projects in scientific research institutions. During the training process, emphasis must also be placed on cultivating practical operational capabilities. By means of simulating archives management scenarios and conducting practical operation drills, archives management personnel can be helped to fully master various operational skills. A training effect evaluation mechanism should be established to assess the training effect at regular intervals. Based on the evaluation results, the training content and methods should be adjusted to ensure the training is targeted and effective. Through continuous professional training, scientific research institutions can continuously improve the professional level of archives management personnel, providing a reliable backing for the efficient implementation of archives management work.

3.4. Implement whole-process quality control in archives management

The archives management of infrastructure projects in scientific research institutions should implement full-cycle quality control to ensure that all links of archives management comply with standardized requirements. In the stage of archives collection, a detailed collection list should be formulated to clarify the collection scope and standard boundaries of various archives, so as to ensure the completeness and accuracy of archives. In the stage of archives arrangement, unified classification and numbering rules should be adopted to ensure the orderliness and retrievability of archives. In the stage of archives filing, strict review methods should be used to check the content, format, and completeness of archives to ensure the quality of filed archives. In the stage of archives preservation,

regular inspections and maintenance of archives should be carried out to prevent damage or loss of archives. In the stage of archives utilization, an archives borrowing registration system should be implemented to record the relevant information of archives borrowing and the utilization effect. Through the implementation of whole-process quality control, the efficient and standardized state of archives management work can be maintained. In carrying out quality control work, an archives management evaluation method should be established to evaluate the archives management work at regular intervals, identify and resolve existing contradictions, and establish an archives management feedback channel to obtain opinions and suggestions from researchers on archives management work, and promptly implement improvements and optimizations. Through the whole-process quality control approach, scientific research institutions can ensure that the archives management of infrastructure projects maintains a high level of efficiency and standardization, providing strong support for the orderly development of scientific research projects ^[12].

3.5. Strengthen safety protection measures for archives management

The archives management of infrastructure projects in scientific research institutions must supplement safety protection measures to ensure the security and confidentiality of archive information. In terms of physical safety, a dedicated archives storage space should be designated, and facilities for fire prevention, moisture proofing, and theft prevention should be prepared to maintain the physical safety of archives. In terms of data security, encryption technology should be used to encrypt and store electronic archives to prevent data from being leaked or tampered with. An archive data backup mechanism should be adopted to back up archive data regularly, ensuring that the data is both safe and recoverable. From the perspective of permission management, a strict system for restricting access to archives should be established to ensure that only authorized personnel have access to relevant archive information. Regular security inspections and risk assessments should be carried out to promptly detect and eliminate potential risks. By strengthening safety protection measures, the security and confidentiality level of infrastructure project archives in scientific research institutions can be stabilized. In the process of carrying out safety protection work, an archives safety emergency plan should also be formulated to determine the handling procedures and responsible persons for archives safety incidents, ensuring that safety incidents can be dealt with promptly and effectively when they occur. Training on safety awareness for archives management personnel should be strengthened to enhance their safety awareness and emergency response capabilities. With comprehensive safety protection measures, scientific research institutions can effectively ensure the security and confidentiality of infrastructure project archives, providing strong support for the orderly development of scientific research projects ^[13].

3.6. Optimizing the service model and utilization mechanism of archives management

The archives management of infrastructure projects in scientific research institutions must optimize the service model and utilization mechanism, fully explore the value connotation of archives, provide efficient guarantees for scientific research projects, establish a rapid feedback mechanism for archives utilization, simplify the procedures for archives borrowing and inquiry, so that researchers can obtain the required archives information in a timely manner. With the appointment function set in the information system, researchers can make advanced appointments for archives to shorten the waiting time. Implementing the initiative service plan for archives, archivists should actively provide relevant archives information support according to the needs of scientific research projects. In the project approval stage of scientific research projects, archivists can sort out and provide

archives of similar projects first, so as to provide a reference for project planning. A comprehensive feedback mechanism for archives utilization should be built to collect opinions and suggestions from researchers on archives services and improve service approaches in a timely manner. Regular satisfaction surveys on archives utilization should be conducted to find out the actual needs of researchers, standardize service contents, and promote in-depth excavation and utilization of archives. By analyzing and mining archive data, valuable information can be extracted to provide support for scientific research decision-making. Big data technology can be used to analyze historical infrastructure project archives, summarize the experience and lessons of project management, and provide a reference for current projects ^[14].

4. Conclusion

The archives management of infrastructure projects in scientific research institutions is an important part of scientific research project management. Its standardization, informatization, and security directly affect the smooth implementation of scientific research projects and the transformation of results. By analyzing the objectives and methods of archives management under the new situation, this paper puts forward specific measures such as establishing and improving systems, promoting informatization construction, strengthening personnel training, implementing quality control, and enhancing safety protection ^[15]. These measures have strong operability and practical significance, and can provide strong support for the archives management of infrastructure projects in scientific research institutions. In the future, scientific research institutions should further combine their own reality, continuously optimize the archives management model, improve the level of archives management, and provide a solid guarantee for the efficient development and innovative development of scientific research projects.

Disclosure statement

The author declares no conflict of interest.

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Qualitative Exploratory Study on Digital Healthcare in Chengdu, China

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Abstract: In the last 20 years, China has experienced an epic digital transition that has fundamentally altered many sectors, and healthcare is one of those that has been changed the most drastically. Since the nation has been adopting state-of-the-art technology, including telemedicine, mobile health apps, and AI-based diagnostic aids, healthcare has taken a new turn. The technologies are not just a fad because they are critical to bettering the provision of healthcare, access, and streamlining of healthcare services, particularly in underprivileged regions. The implementation of digitally-based health technologies has immensely transformed Chinese healthcare provision to rely less on in-person consultation, and instead resort to more distant healthcare options that are available to more people.

Keywords: Chengdu; Digital healthcare; Qualitative exploration

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1. Digitalization of healthcare

This digital transformation in healthcare has made the industry highly competitive, where both home-grown and global giants have become key players. Healthcare players like Alibaba Health, Tencent Healthcare, and Ping An Good Doctor have established themselves as the major participants in the direction of digital healthcare in China, working with traditional players as well as governmental projects to improve the health of the people with the help of technology^[1-2]. These players have also driven the fast rate of innovation and have ensured that digital health services form the backbone of the healthcare sector in China, especially among the rural citizens who have been grappling with challenges in healthcare access.

A rapid increase in the population that seeks such digital healthcare services has been caused by the imminent penetration of the smartphone and internet market, as well as a rapidly aging Chinese population^[3]. The presented demand has augmented the rivalry between the telemedicine platforms, mobile health services, and AI diagnostics. The new issue for digital health care providers is to attract new users and, at the same time, maintain current users. It is much more expensive to get new users than to retain them, and that is why customer loyalty should be built,

and the quality of services provided.

Customer satisfaction has also become one of the vital elements of the sustainable development of digital healthcare services. People in the health sector have learned over the years that satisfaction among the patients goes beyond the quality of medical care, but also the satisfaction they get from digital platforms. Good user experience, increased retention rates, boosted involvement, and better performance of the business. Therefore, streamlining user experiences, bettering enterprise data protection, and improving digital user experience have been crucial towards winning customer trust and loyalty ^[4].

Although the development of digital health platforms has been rather striking, there are still a range of obstacles on the way to the ultimate inclusion of such technologies into the context of the Chinese healthcare systems ^[5]. Various barriers, such as issues surrounding data privacy, cybersecurity threats, and regulation, are some of the key challenges that hinder the large-scale adoption of digital medicine. Moreover, urban environments have quickly adopted the digital healthcare practice, whereas rural areas continue to have serious challenges, such as the lack of internet, digital literacy, and infrastructure to accommodate modern healthcare technologies.

The proposed study will center on Chengdu, the capital city of Sichuan Province, as this location is a key point in the development of digital health in the current scenario in China. Chengdu has also become one of the Chinese cities taking the lead in digital healthcare innovation by becoming a role model in the implementation of telemedicine, the utilization of AI in diagnosing diseases, and smartphones to improve health management ^[6]. The fast urbanization of the city, expansion of the technological base, and the strategic position of the city in Western China have made it a better fit for researching the application of digital health technologies in the real world.

The few existing studies on the topic of digital health and its transformation found a breakthrough due to the uniqueness of Chengdu, which is positioned both as an opportunity and as a challenge in China's digital health transformation. The case of Chengdu can act as a good example of how digital health applications could be scaled down and implemented into regional healthcare systems. The city has experienced massive investments in the digitalization of the healthcare system by establishing internet hospitals, implementing artificial intelligence diagnostics, and introducing the telemedicine portal ^[7]. These developments are notable especially in the rural themes and semi-urban settings of Chengdu, where reception of services in healthcare has traditionally been wretched.

The current status of Chengdu being one of the central focuses in the digital healthcare strategy proposed by China means that it is of great importance in deciphering patterns through which the digital health technologies can be used to address the issue of the disparity between rural and urban communities to provide them with equal abilities to receive healthcare services, achieve better health outcomes, etc. ^[8]. It is also worth noting that the city has received multifold assistance on the part of the government, which has contributed to the development of digital health solutions meant to reduce the burden of the traditional health system, enhancing service provision, and expanding so-called reach.

In this research, the focus on the implementation of digital healthcare technologies in Chengdu will be on the following: the use of telemedicine, mobile health applications, and the use of AI to aid diagnostics in the healthcare system in Chengdu. It shall examine the reasons why these technologies are embraced, the advantages they present in the area of accessibility and efficiency, and difficulties they continue to encounter during assimilation ^[9]. The paper shall also start with the investigation on the part of healthcare providers, platform developers, and policy-makers in addressing the regulatory and infrastructural impediments to digital health adoption.

In its intention to concentrate on Chengdu, the research is expected to shed useful light on ways in which a

digital healthcare solution might be streamlined to increase health outcomes not only in Chengdu but also in the rest of China and the world as a whole.^[10] It will also add to the general knowledge of what policies, strategies, and regulatory eco frameworks are required to facilitate the growth of digital healthcare services and can have an influence on the future development of healthcare delivery in China.

2. Theoretical framework

This research is embedded in two dominant theoretical frameworks Technology Acceptance Model (TAM) and the Digital Health Framework contributed by the World Health Organization (WHO) ^[11]. The two frameworks given are central to the process of comprehending the mechanisms and variables of the adoption and integration of the digital healthcare technologies in Chengdu, China, more precisely, to how healthcare professionals and patients perceive and adopt and use the digital healthcare tools.

The Technology Acceptance Model (TAM) is considered to be among the most popular models in the study of technology adoption, which was proposed by Fred Davis in 1989. TAM assumes that the leading factors in acceptance and use of new technology can be reduced to two categories: Perceived Usefulness (PU) and Perceived Ease of Use (PEOU). Perceived Usefulness is the trust one has regarding a becoming of person when it comes to performance or gains when use of a particular type of technology is attained. Regarding digital healthcare, it may imply the perceptions of telemedicine, mobile health applications, or AI-based diagnostics tools by healthcare providers and patients that they lead to a better quality of care, make the provision of care more convenient, or improve efficiency in the field of healthcare ^[12]. When people assume that the implementation of technology is going to improve their healthcare or any reference to this experience, they tend to assimilate into its use.

The second major construct of TAM is Perceived Ease of Use, which corresponds to the extent to which a person considers that the use of a technology will be effortless. The technology that is easy to operate and understand has a higher probability of being adopted. This is especially important in healthcare, where healthcare providers and patients would be hesitant to utilize complicated systems that would demand much learning or work. As an example, a user-friendly telemedicine platform or a mobile health app will stand a better chance of gaining acceptance among patients and healthcare professionals, especially in those situations where digital literacy is a problem ^[13]. TAM can therefore be used to research the extent to which the personal perceptions of the usefulness and utility of the digital health tool will affect the rate of adoption.

Another contribution of the Digital Health Framework, developed by the World Health Organization (WHO), organizes a different macro-level view on digital health adoption. This model describes four blanket principles that need to be in place to achieve success with digital health solutions ^[14]. First, the WHO insists on national commitment to digital health. Governments have to give priority to digital health, shape national policies, and offer financial and technical assistance to create a sustainable digital health system. This specifically applies to the developing countries where the integration of digital health instruments is frequently impeded by infrastructure and resource constraints. WHO emphasizes the necessity to develop and introduce national digital health plans based on the local priorities and policy objectives, and resources.

Second, the WHO suggests that digital health should be considered as a means of an integrated approach toward digital health solutions, which means that they should not be limited to a single digital health programme but a single comprehensive strategy involving governance, health financing, and human capacity building. This comprehensive approach guarantees that digital health technologies are aligned with the current healthcare

settings, which increases the likelihood that the tool will be successfully adopted. As an example, telemedicine should be incorporated into the ordinary practices of healthcare facilities and healthcare management systems in such a way that it enables health professionals to freely switch between virtual and onsite interactions. Such a combined approach is needed for the ability to make digital health technologies scalable, sustainable, and successfully integrate them into health delivery.

The third principle is concerned with the adequate use of digital technology. The WHO emphasizes that it is essential that digital health solutions become available to everyone, without reference to his or her geographic location or socioeconomic status. This principle argues that there must be fairness in digital health device accessibility, whereby the vulnerable groups, like those who live in rural or underprivileged places, are not the ones left behind. Additionally, the privacy and security of data are also the core of this principle because the tools of digital health should protect the information of the patients to ensure trust and legal adherence.

Lastly, the WHO framework aims at responding to the challenges experienced by the developing nations in embracing digital health technologies, namely poor infrastructural facilities, digital illiteracy, and lack of technology access. The framework recommends strategic investment in infrastructure development, digital literacy, and accessibility to technology to eliminate such barriers. To be applied specifically in Chengdu, China, the WHO framework will support the evaluation of how effectively the healthcare system of the city can enable the adoption of digital health solutions and the identification of the spheres where additional investments are required, especially in the rural regions, where the infrastructure remains underdeveloped.

To recap, the Technology Acceptance Model (TAM) and the WHO Digital Health Framework have complementary views, which contribute to a better understanding of the digital healthcare technologies adoption and integration processes. TAM is user-centric and considers the user-side of how medical professionals and patients can assess the usefulness and properties of digital health platforms, whereas the WHO framework is more policy and system-level, taking into consideration the system-related requirements, which need to be in place to make digital health products successful. In combination, these frameworks give a general perspective on the ways digital healthcare technologies are implemented in Chengdu and can give useful information about the obstacles and the opportunities that influence their implementation into the healthcare system. All these theories together allow the current study to focus both on micro-level users' perceptions and macro-level issues, which have to exist to allow integration of digital healthcare in Chengdu, to get a full picture of the issues and possibilities presented by the adoption of digital healthcare in Chengdu.

3. Conceptual framework

The Conceptual Framework of the present work provides an orderly description of major concepts, themes, and constructs that are going to be used to analyze digital healthcare in Chengdu, China. Through it, the interrelations between the main variables in question, digital health technologies and processes of their adoption, the experience of their stakeholders, and policy development are going to be explained so that the single influence the combination of these variables has on the integration and impact of digital healthcare in China could be comprehended. The conceptual framework is built around the following key concepts and themes.

3.1. Digital healthcare technologies

Technologies that are included in this concept are telemedicine, mobile health applications, and AI-assisted

diagnosis. This is what the innovations that are the focus of the research are about: to determine their purpose and application in the Chinese healthcare system.

3.2. Adoption and diffusion of digital health

Here, the authors investigate this theme through leveraging these technologies and the ways of their adoption and dispersion in the healthcare ecosystem of Chengdu. It takes into consideration, e.g., the perceived usefulness and ease of application of these technologies (according to the TAM model) and the way of innovations diffusion in the healthcare system (described by the DOI Theory).

3.3. Stakeholder experiences

The given theme concentrates on the experience of diverse stakeholders in the implementation of and two-way mix of digital healthcare. The important stakeholders of concern are the healthcare providers, the patients, and technology platform developers, and the policy-makers. Then, with the perspective on them, there will be insights into how digital healthcare in Chengdu is regarded, adopted, and practiced. This is where TAM comes in to be the main factor in determining the level of acceptance of digital health technologies by the users.

3.4. Regulatory frameworks and policy development

This theme encompasses the policies and rules to either facilitate or hinder the incorporation of digital health technology. Here, major attention is paid to the government support of digital health through the WHO Digital Health Framework. It ensures the consistency of the technological developments and the healthcare and equity strategic intentions.

3.5. Health outcomes and accessibility of healthcare

The main aim of digital health adoption is to ensure increased accessibility and better outcomes of healthcare. The theme is interested in comprehending the scope of implications of digital health technologies on healthcare in Chengdu in urban and rural settings ^[15]. The concept relates well to the purpose of the study, whose objectives included analyzing the effects of digital healthcare on access and quality of care.

Disclosure statement

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China Chick “Guochao” and the Micro-Level Display of Culture

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Abstract: This research examines the complex role of Guochao, China Chick, in contemporary Chinese cultural production, moving beyond simple binary evaluations of its effectiveness. Employing the “Culture on Display” framework, this paper analyzes cultural economy performances at the micro level to explore how Guochao leverages consumer imagination and multiple interpretations to reconstruct “Invented Traditions.” This study reveals how deliberately reducing authoritative narration (“Authority Minus the Author”) creates spaces for interpretation that engage readers as active participants in creating meaning. The findings show that this process breaks down predetermined meanings and national narratives, transforming cultural production into both public exhibition and market product. We conclude that this transformation helps Guochao emerge as a powerful carrier of nationalist discourse, enhancing the understanding of contemporary cultural nationalism and consumer behavior.

Keywords: Guochao; China chick; Culture on display; Invented tradition; Fashion trend

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1. Introduction

Since its emergence in 2018, “Guochao”, or China Chic, has become a widely recognized term, though it lacks (or perhaps resists) a formal definition. As a cultural movement of phenomenon-level significance, Guochao captures the imaginations and identities of countless individuals, and its cultural and economic impact remains undeniable. While many discussions have explored its origins and driving mechanisms, no consensus has emerged. This paper therefore takes a different approach: rather than analyzing its “successes” and “achievements”, examining isolated case studies, or assessing the impact of designated “Guochao elements” in particular products, it treats China Chic products as “culture on display” within a consumerist context—similar to how eighteenth-century Scottish tartan transformed textile patterns into ethnic markers.

Through this lens, consumer behaviors are reframed as symbolic representations laden with nationalist meanings, functioning as cultural capital in global political-economic competition. This process turns cultural

production into both a spectacle and a commodity with market exchange value. Such a perspective facilitates an examination of the nuanced interactions within the cultural economy, illustrating how socio-historical materials transcend their original contexts and political implications, while opening further questions about the broader dynamics of cultural commodification in contemporary China.

2. Understanding Guochao: The intriguing balance between “National” and “Trend”

The term “Guochao” lacks a formal definition, though discussions typically analyze it by breaking down its two characters: “guo” (国 , nation) and “chao” (潮 , trend). The phrase gained popularity in 2018 through Alibaba’s Tmall marketing campaign, building on existing cultural enthusiasm. In 2019, Tsinghua University’s Cultural Creativity Development Research Institute’s Guochao Research Report defined it as “Chinese trends + Chinese-style trends”, while also interpreting it as “the trendification of the national” and “the nationalization of the trendy”^[1].

Guochao is commonly described as products incorporating elements of Chinese culture and history. Examples include brands like Li-Ning, Erke, and Florasis, products such as the horse-face skirt (mamianqun) and Forbidden City merchandise, and media like the animated film *Ne Zha*—each applying Chinese cultural motifs across various consumer goods. However, this definition is problematic. With Chinese civilization spanning thousands of years and encompassing countless cultural elements, and without clearly defined product categories, almost anything can claim the Guochao label. This vagueness enables opportunistic businesses to retroactively brand themselves as part of the movement. As a result, related terms like guofeng (国风 , national style), Hanfu (汉服 , traditional Han clothing), “Chinese cultural elements”, “classical aesthetics”, and even folk music are inconsistently included or excluded from the Guochao umbrella.

“Guochao” defies straightforward categorization as it represents a complex, multifaceted phenomenon rather than a singular concept. It extends beyond the scope of merely being a marketing strategy or cultural initiative. In the absence of a formalized definition, its genesis remains a subject of scholarly discourse. Its developmental trajectory can be roughly divided into three phases: pre-Guochao, its emergence, and its eventual consolidation. The lack of an official definition has also led to disputes over its origins: some demarcate 2018’s Tmall campaign as the starting point, while others trace it back to the Republican era—particularly its material culture (e.g., Shanghai’s cosmopolitanism, illustrated magazines, and modernist knickknacks) as embodiments of nostalgia—or even earlier to Ming-Qing literati pastimes or dynastic traditions^[2–5]. Yet the consumption of domestic goods has existed independently of Guochao influence throughout history. Before Tmall’s 2018 campaign, the term had already surfaced sporadically; it was only after Tsinghua University’s report and sustained market efforts that “Guochao” solidified into a proper noun. Once publicly legitimized, it evolved into a cultural fact, shifting focus from pure marketing to its intrinsic significance—a phase some now call the “New Guochao” era^[6–8].

Scholarly research on Guochao as a cultural phenomenon has moved beyond definitional debates to analyze its origins and development, falling into four main categories. Since its early manifestations were concentrated in streetwear and amplified through digital platforms, much research attributes Guochao to youth-driven subcultures—particularly Gen Z, the internet-native demographic—framing it as an expression of identity, neoliberal commodity fetishism, or influences from otaku culture^[9–11]. The second approach focuses on technological factors: multi-screen media environments, blended online-offline shopping experiences, user-generated content (UGC), data-driven marketing, and key opinion leader (KOL) influence. A third framework applies semiotic analysis, building on Baudrillard’s *The Consumer Society*, arguing that consumption now

operates in the realm of symbols. These studies often narrow to study specific “Chinese elements”, evaluating their effectiveness through intertextuality in IP adaptations, nostalgic design, visual aesthetics (color, line), and perceived cultural appeal ^[12]. Part of this category addresses business strategy and brand management, though these analyses often rely on unexamined assumptions rather than empirical evidence. Technology has undoubtedly altered people’s perception of space and time, but its pervasive influence is insufficient as the sole explanation for Guochao’s emergence as a digitally fostered subculture. This phenomenon extends well beyond youth consumption patterns or fandom economies—prompting the author to question what initially triggered these preferences. If Guochao began as a genuine subculture, what factors propelled it into the mainstream? Methodologically, these studies offer few innovations, largely following 1990s Asian cultural studies approaches by treating Guochao as a “mega-text” subject to selective interpretation.

A fourth perspective views consumption as an expression of national identity, connecting to discussions about cultural confidence and heritage. The term’s connection to Chinese history gives “guo” and “chao” rich meanings: “guo” represents not only Chineseness but also international ambitions, while “chao” includes both youth trends and collective movements. Though Guochao reflects rising national pride, this connection works both ways; the spread of cultural products and public response cannot be simply traced to policy timelines. Likewise, how people respond to cultural symbols depends on personal understanding, with no universal standards for evaluation. The term has therefore become increasingly linked with official narratives of cultural confidence—a complex relationship that defies simple explanation. The complex power dynamics underlying this phenomenon require careful examination.

3. Cultural display at the micro-level: A compelling spectacle

Guochao, as a contemporary cross-cultural phenomenon, is unique in its resistance to simple explanation. Scholars have tried to analyze it through Chinese cultural heritage, ethnic affinity, or quantitative empiricism, yet these approaches fail to capture its essence—primarily because Guochao transcends state mechanisms. Rather, it emerges from the collective discourses of diverse transnational communities, resembling what Roland Barthes called “myth”: a second-order semiological system that transforms cultural constructs into seemingly self-evident truths ^[13].

Bella Dicks developed the concept of “culture on display”, showing how social and historical elements transform into visible symbols that draw people into what Anderson calls an “Imagined Community” ^[14–15]. Dicks traces how modern cultural display emerged in the 18th century. Before then, displays served mainly religious or commercial purposes, such as sacred icons or trade goods, while cultural exhibitions were limited to elite audiences. A crucial shift came in the 19th century when the rise of nation-states democratized cultural display. Nations began using exhibitions to distinguish themselves, creating a sense of belonging where historical artifacts became shared “heritage.” Cultural display thus became central to forming national identity. From royal projects of legitimacy to modern consumer culture, display has remained fundamentally linked to power and identity.

Fashion transcends individual choices to become a broader performance of “culture on display”—not just a moment in time and space, but a collective expression woven into everyday life ^[16]. This notion aligns with Hobsbawm and Ranger’s theory of invented traditions, where symbolic practices are fabricated or repurposed to reinforce collective identities ^[17]. The Scottish tartan exemplifies this perfectly: though originally a utilitarian garment, it was transformed through political and cultural interventions into a national emblem ^[18]. After being

banned and later revived by 19th-century elites, tartans were systematically codified and popularized through staged spectacles like the 1822 royal visit. Today, they persist as both a marketed heritage symbol and a fashion statement—whether on runways (like Chanel’s 2012 collection) or in global consumer culture. Far from being an organic tradition, the tartan’s endurance demonstrates how fashion operates as a dynamic medium for invented cultural narratives, where meaning is continually reinscribed through performance, consumption, and institutional reinforcement.

The tartan’s history shows a common pattern: nationalist groups first invent traditions, then use grand ceremonies to make them seem legitimate. Governments officially recognize these symbols and showcase them at events, while industries produce and sell them to consumers, who then help spread the government’s preferred narratives. From world fairs to film festivals, these cultural displays follow the same strategy used in the 1800s to create traditions, though now they serve modern economic and cultural competition.

4. Deconstructing Guochao: Microperformative practices and the integration of polysemic cultural interpretations

Unlike conventional “invented traditions” that rely on grand spectacles for legitimacy, Guochao operates through micro-level performances. It detaches itself from overt nationalism and embeds within consumption practices—primarily by establishing an “implied reader”^[19]. This concept builds on Roland Barthes’ assertion in *The Death of the Author*: “the birth of the reader must be at the cost of the death of the Author.”

Wolfgang Iser developed the “implied reader” concept from Barthes’ foundation, arguing that a text’s existence depends on its interpretive gaps—spaces that invite engagement^[20]. The implied reader is “prestructured by the text’s design... a network of response-inviting structures that impel the reader to grasp the text.” Put simply, a text’s multiple potential meanings create an “objective structure of appeal.” By contrast, linear narratives with limited interpretive flexibility lack implied readers, preventing widespread adoption.

This framework illuminates Guochao’s success. Contemporary examples—Black Myth: Wukong, Genshin Impact, Pop Mart—have thrived through everyday consumption rather than mega-events like the Olympics. This challenges Joseph Nye’s “soft power” thesis: decades later, his recommendations (international aid, charm offensives, global events) remain fixed in an outdated model of top-down cultural projection^[21]. Instead, Guochao emerges from decentralized, collective agency—a diffuse yet powerful phenomenon rooted in daily rituals and micro-performances that bypass centralized direction.

At its core, Guochao reflects a consumer-driven dynamic where culture is continuously reproduced through practice^[22]. While producers embed “preferred meanings” into products, consumers actively reinterpret them based on their social experiences. Meaning emerges through co-creation—an interplay between daily life and consumption—rather than producer dictation.

For this co-creation to thrive, cultural commodities must offer interpretive space for imaginative engagement. Successful products are not vessels with fixed meanings but empty signifiers that stimulate diverse readings. They only become complete sign systems when integrated into everyday life. This aligns with Featherstone’s observation that postmodernity favors symbols freed from fixed references—a premise central to Guochao’s appeal^[23].

Guochao’s semiotic system balances producer and audience agency, transforming empty signifiers into nationalist expressions. While Hanfu or folk music serve as obvious cultural markers, Guochao’s strength lies in

incorporating unexpected works like *Genshin Impact* (with global aesthetics) or *Ghostblade* (inspired by Western fantasy). Despite their divergent designs, both are embraced as Guochao. Similarly, *Ghostblade*—celebrated as a “national comic”—is characterized through broad descriptors like “epic” or “dreamlike” that could equally apply to Western works, yet these influences do not exclude it from Guochao’s framework.

Ultimately, Guochao’s circulation depends on conceptualized consumption—a discursive process where products fuel collective imagination. Like Scottish tartan (now signifying “Scottishness” without historical references), Guochao functions as an open sign system. This openness allows consumers to project personal meanings onto a national framework while avoiding oppositional reading, as its ambiguous signifiers resist rigid ideological expectations ^[24].

In redefining cultural development, Guochao transcends traditional macro-spectacles and top-down “invented traditions.” Unlike approaches that emphasize national cohesion or authority, it demonstrates that China’s cultural industries have moved beyond forced exports. While Scottish tartan emerged from historical contingencies, Guochao actively reconfigures such traditions’ colonialist logic. Its success reveals that in a globalized, consumer-driven world, national image forms not through chronological value-building but through the consumptive imagination of “contemporary China”—a signifier enacted by audiences wielding their own interpretive frameworks.

5. Conclusion

This study contributes to the understanding of “Guochao” as a distinctive cultural-economic phenomenon in contemporary society. Through the lens of the “Culture on Display” framework, we have revealed how Guochao operates not through centralized authority but by creating interpretive spaces that engage consumers’ imaginations. Unlike traditional cultural symbols tied to nation-state development, Guochao represents a novel approach where diverse consumers actively participate in meaning-making while authoritative narration is deliberately minimized.

The analysis reveals that Guochao’s success stems from three interconnected mechanisms. First, it reimagines “Invented Traditions” by stripping cultural elements of predetermined meanings and political associations, transforming them into fluid symbolic representations. Second, it balances seemingly contradictory elements: nationalist sentiment with global commercial appeal, and cultural authenticity with market innovation. Third, it converts cultural elements into assets that function in global political-economic competition while maintaining domestic resonance.

The implications of this research extend beyond Guochao itself to broader questions about cultural commodification in the global marketplace. By demonstrating how cultural displays can function simultaneously as expressions of national identity and commercial products, the findings challenge conventional understandings of the relationship between culture, commerce, and nationalism. This research suggests that successful cultural movements in today’s interconnected world may increasingly rely on distributed rather than centralized authority, allowing multiple interpretations to coexist while maintaining coherent symbolism.

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Research on the Evaluation of Cultural Service Quality of the Ecosystem in Qu County Congren Valley Forest Park Based on Social Media Data

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Abstract: This study focuses on the Qu County Congren Valley Forest Park and constructs a quality evaluation system for ecosystem cultural services (CES) based on social media data. Through the octopus collector to capture the text of Ctrip.com's travelogue, combined with ROST CM6 for word frequency analysis and emotional propensity analysis, NVivo 12.2 to carry out qualitative coding, through quantitative analysis of the emotional tendencies and theme distribution in tourist reviews, the current service problems, such as homogeneity, lack of innovation, and aging facilities, are revealed. The optimization strategies, such as differentiated content development, immersive experience design, and facility upgrades, are proposed, aiming to provide data support and decision-making reference for the comprehensive improvement of CES service quality.

Keywords: Social media data; Ecosystem cultural services; Octopus collector

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1. Introduction

1.1. Background of the study

Cultural Ecosystem Services (CES) are the non-material benefits provided by natural ecosystems to human beings, covering spiritual enrichment, cognitive development, aesthetic experience, and other dimensions ^[1]. The United Nations Millennium Ecosystem Assessment (MA) points out that CES accounts for more than 75% of the total value of global ecosystem services, but its quantitative assessment has long been limited by data access ^[2]. Traditional CES evaluation relies on questionnaires and expert scoring, which have limitations such as limited sample size and strong subjectivity. Moreover, with the popularity of social media platforms in the Web3.0 era, user-generated content (UGC) provides a massive data source for CES research. As China's largest online travel service platform, Ctrip's travelogue text contains tourists' real-time perception and evaluation of the CES of scenic spots, which has the advantages of wide time and space coverage, a large sample size, and a subjective expression of truth.

As an important cultural and ecological tourism destination in northeast Sichuan, Qu County Congren Valley Forest Park integrates karst landforms, ancient culture, and forest ecology, and is known as “Xiaojiuzhai in Eastern Sichuan”^[3]. In 2023, the number of tourists received exceeded 1.2 million. However, there are significant structural contradictions in the supply of CES; the lack of a geological relic interpretation system leads to tourists’ lack of awareness of scientific value, the homogenization of traditional folk performances causes fatigue of cultural experience, and the mismatch between the layout of leisure facilities and tourist flow reduces service efficiency. This study adopts the mixed research method of “data collection, text preprocessing, word frequency analysis, qualitative coding, and quality evaluation” to reveal the internal mechanism of the supply and demand imbalance of CES in Congren Valley Forest Park, and provides theoretical support for the optimization of cultural services in mountainous scenic spots.

1.2. Classification and resource analysis of ecosystem cultural services in Congren Valley Forest Park

CES classification according to the Millennium Ecosystem Assessment (MA) and previous research results, combined with the actual situation of Qu County Congren Valley Forest Park, this study finally divides CES into six types of services: aesthetics, culture and education, entertainment, health care, inspiration and local identity services (**Table 1**), and the ecosystem cultural service resources of Qu County Congren Valley Forest Park Scenic Area (**Table 2**) reflect the richness and diversity of Congren Valley Forest Park Scenic Area in providing ecosystem cultural services^[2, 4-6].

Table 1. Classification table of ecosystem cultural services in Congren Valley Forest Park

CES types	Paraphrase
Aesthetic service	A place where you can feel the beauty of natural scenery or cultural landscape.
Cultural and educational services	A place with important ancient and valuable trees, historical relics, ancient ruins, or other cultural landscapes, where you can learn about culture and increase knowledge.
Entertainment services	A place where you can buy local goods, watch theatrical performances, and engage in local entertainment activities such as mountain climbing, rafting, boating, and bird watching.
Health care services	A place where you can relax and feel happy.
Inspiration Services	A place that can spark new ideas and creative motivation.
Local identity service	Interest or love for local cultural customs, lifestyles, and local people.

Table 2. CES resource classification table of Congren Valley Forest Park

CES types	Resource
Aesthetic service	Natural landscapes (Old Dragon Cave, Divine Dog Howling Sky (Frog Stone), Colorful Lake, Strange Stone Valley, Yixiantian Scenic Spot, Longqiu Waterfall); Cultural landscape (Longhua Temple, cave tribe site).
Cultural and educational services	historical and cultural display (Congren culture exhibition hall, Congren cultural historical documents, Hanque culture); physical objects of cultural life (stone cellars, stone beds, stone stoves, original physical reproductions of the cultural life of the Congren people, relics and stone carvings of the Congren people); Artistic creation and display (relief, sculpture, painting).
Entertainment services	Characteristic blocks and entertainment (“Congrenli” characteristic blocks, theatrical performances and folk customs displays (children’s on-site calligraphy and painting, fun sports, “intangible cultural heritage” displays, theatrical evenings, knife mountains and seas of fire, rapid speeding cars, food exhibitions, wind chimes, lanterns atmosphere landscape check-in), outdoor adventures and sports (mountain climbing activities, rafting experience, boating, bird watching activities, hiking, plank roads)

Table 2 (Continued)

CES types	Resource
Health care services	Health and leisure facilities (forest bathing and meditation flower therapy, Zen tea health care, Liyuwan hot springs, water parks, recreational facilities (KTV, chess and card rooms, billiards, table tennis)); Featured accommodation experience service area.
Inspiration Services	Natural and cultural inspiration (inspired by the natural landscape of the scenic spot, inspired by the cave dwelling site of the Congren people, cultural experience of the Congren Cultural Exhibition Hall).
Local identity service	Local cultural identity (cultural participation of the ancient people, visits to historical sites, integration of nature and culture, festivals, national costume displays); Inheritance of intangible cultural heritage (“Bayu Dance” and “Bamboo Branch Song”), traditional handicraft demonstration).

1.3. Literature review

The academic community has carried out a number of research methods to study CES, and the existing CES research shows three major trends:

Methodological innovation: Liang et al. used the MaxEnt model to evaluate the supply and demand balance of CES in Suzhou based on social media photo data, and found that the historical and cultural imbalance area accounted for 48.1% ^[7]; Wang used smartphone positioning data, combined with Google Maps scores, to quantify the CES value of Nagoya, Japan, and verified the feasibility of big data in CES evaluation ^[8].

Technology convergence: ROST CM6 is widely used in tourism text analysis, and Wang Wenjing identifies the key areas of high-density urban ecological space in Guilin through word frequency analysis ^[9]; NVivo coding technology is used to deeply explore tourist perception, and Chen’s qualitative research on the demand for popular science tourism in Congren Valley ^[10].

Practice-oriented: The Ministry of Agriculture and Rural Affairs’ theory of “reconstructing the three-chain reconstruction of agricultural product processing value-added” (2025) emphasizes the collaborative optimization of industrial chains, value chains, and supply chains, providing policy enlightenment for CES supply and demand matching.

The international academic community has conducted a number of social media-based CES studies. Yellowstone analyzes tourists’ emotional tendencies towards geological landscapes through Twitter data ^[11]; The European Landscape Classification System (LANMAP) integrates social media hashtags for landscape value assessment to understand the sentiment of national park visitors ^[12]. Domestic research focuses on the AHP analytic hierarchy process and questionnaire surveys, such as Guo Yuchuan’s comprehensive ecological environment quality evaluation in Inner Mongolia ^[13]. Zhao Xin used the analytic hierarchy process and fuzzy comprehensive evaluation method to evaluate the quality of the urban ecological environment ^[14]. However, there are two shortcomings in the existing methods: first, the subjectivity of expert scoring affects the reliability of the results; Second, traditional research is time-consuming and labor-intensive, and it is difficult to capture the instantaneous experience of tourists. The innovation of this study is to integrate the three-dimensional method system of octopus data collection, ROST quantitative analysis, and NVivo qualitative coding, break through the spatio-temporal limitations of traditional CES research relying on questionnaires, and construct a closed-loop research framework of “data-driven, model verification, and policy generation.”

2. Research methods and data sources

2.1. Research methodology

In this study, the “Octopus” software crawler was used to obtain tourist reviews, and after “comment preprocessing”, ROST CM6 was used to carry out “word frequency analysis” and “emotional propensity analysis”, and then “qualitative coding” was carried out in NVivo 12.2, and finally the credibility and validity of the study were ensured through “quality evaluation”, forming a complete mixed-method framework.

2.2. Data acquisition

2.2.1. Octopus collector configuration

In this study, the octopus collector (version 8.2.3) was used to obtain the review data of Ctrip.com’s Congren Valley Scenic Area, and the user reviews of Ctrip.com’s “Travel Guide Community-Destination-Congren Valley Scenic Area” section were selected as the data source. Target URL Setting: (https://you.ctrip.com/sight/qucounty3141/128079.html?renderPlatform=#ctm_ref=www_hp_bs_1st); Set the collection fields as follows: collect the commenter ID, comment time, text content, rating star rating, and other fields, and export them to Excel format. The collection period is from May 20, 2016, to July 18, 2025, and a total of 198 valid travelogues with a total text of 7899 words were obtained.

2.2.2. Data cleaning

Excluding duplicate comments, emoticons, advertising information, non-scenic spot-related texts, and non-tourist comments (such as merchant replies), 132 valid samples were finally obtained, with a time span from January 2020 to June 2025. Merge synonyms (e.g., “Congren Cave” → “Congren Ancient Cave”) and standardize the time format (e.g., “2023-05-01” → “20230501”).

2.3. Analysis tools

2.3.1. ROST CM6 functional configuration

ROST CM6 software is used to extract high-frequency words and generate semantic network maps to identify the focus of tourists’ attention. In terms of word frequency statistics, set the minimum word length to 2, filter out stopped words (such as “of” and “yes”), and extract the top 50 high-frequency words. Regarding sentiment analysis, based on emotional dictionary matching, words such as “shocking” and “spectacular” are used to reflect the perception of aesthetic services, and words such as “history” and “culture” are associated with cultural and educational services. Calculate the emotional propensity value (range -1 to 1) for each travelogue. In terms of social network analysis, a keyword co-occurrence matrix is constructed to identify the correlation strength of CES core elements.

2.3.2. NVivo 12.2 encoding rules

The comments are coded at three levels (open coding-spindle-core coding) through NVivo 12 software to construct a CES quality evaluation index system. In terms of topic coding, the CES classification coding system (as shown in Table 1) is constructed, and the text is classified into six nodes, including aesthetics, culture and education, and entertainment, and the theme distribution law is identified through “coding density query.” The secondary nodes have 12 subcategories, such as geological landscape, folk performance, and interpretation system. The encoding method adopts the dual-track system of “free node and tree node”, allowing the same text fragment to belong to multiple nodes.

2.3.3. Quality evaluation

Combined with the word frequency statistics and coding results, this paper analyzes the advantages and disadvantages of the service of Congren Valley in the six major CES types.

3. Social media data analysis and CES quality evaluation

3.1. ROST word frequency analysis results

ROST CM6 was used to perform word segmentation and word frequency statistics, and high-frequency words (frequency ≥ 20) were screened to generate a semantic network graph (**Figure 1**).

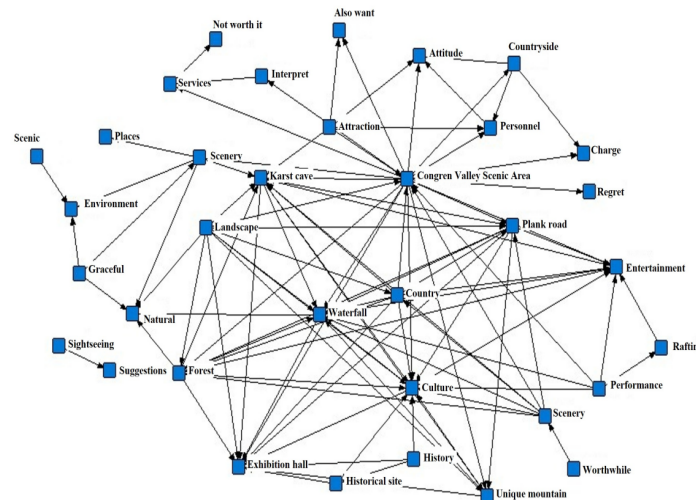


Figure 1. Word frequency analysis diagram

3.1.1. Core high-frequency word distribution

The core high-frequency word distribution is shown in **Table 3**.

Table 3. Core high-frequency words

Ranking	Keyword	Frequency	Proportion	CES type
1	waterfall	54	13.60%	Aesthetic services
2	culture	32	8.00%	Cultural and educational services
3	Plank	28	7.00%	Entertainment services
4	Karst cave	25	6.20%	Entertainment services
5	amusement	23	7.71%	Entertainment services
6	Museum	22	5.52%	Cultural and educational services
7	forest	20	5.02%	Aesthetic services
8	Strange mountain	20	5.02%	Aesthetic services

3.1.2. Emotional tendency analysis

Semantic correlation: “culture”, “history”, “site”, and “exhibition hall” are strongly related, “nature” is closely related to “landscape”, “waterfall”, and “forest”, and “entertainment” is significantly related to “rafting”, “performance”, and “activity” (Table 4).

Table 4. Analysis of emotional tendencies

Category	Mean	Conclusion
Overall emotion	0.62	positive tendency, but there are significant differences by type.
Aesthetic services	0.71	Aesthetic services are highly recognized by tourists, and the experience of natural and cultural landscape beauty is deeply loved, especially the karst cave landscape.
Cultural and educational services	0.48	There are some problems in cultural and educational services, tourists criticize the homogenization of cultural performances, and need to innovate and improve cultural display and education methods to better meet the needs of tourists to learn culture and increase knowledge.
Entertainment services	0.59	Entertainment services provide tourists with a variety of entertainment activities, the boardwalk design has been rated neutrally, and the overall experience is richer, but some activities may still have room for improvement in terms of organization, safety or fun.
Health care services	0.65	Health care services provide tourists with a high-quality experience of relaxation and happiness, forest bathing, hot springs, special accommodation and other health care projects are highly recognized by tourists, but some health care facilities or services may still have room for improvement in terms of quality and comfort to further improve the satisfaction of tourists.
Inspiration service	0.55	The inspiration service has a certain effect, and some tourists can get inspiration from the resources of the scenic spot, but it may be necessary to further explore and improve the elements and methods of inspiration to meet the needs of more tourists.
Local Identity Services	0.68	Local identity services have certain results, tourists have a certain degree of understanding and love for local culture, but there is still room for improvement in the depth and breadth of cultural experience, which can further enrich the content and form of activities and strengthen the interaction between tourists and local culture.

3.2. NVivo qualitative coding analysis results and CES quality evaluation

The 132 reviews were coded at three levels, and the CES quality evaluation index system (Table 3) was constructed, and the frequency of mentions of each type of service (Table 3) and emotional tendency (Table 4) was counted.

3.2.1. Open coding: Extracting initial concepts

Initial concepts related to CES, such as “The cave is spectacular”, “The cultural exhibition hall is rich in content”, “Rafting is exciting”, etc., were extracted from the comments, and a total of 2,34 initial concepts were obtained.

3.2.2. Spindle coding: Classification of initial concepts

The initial concepts are classified into six major CES types and further subdivided into subcategories (Table 2). For example, “aesthetic services” are divided into “natural landscape aesthetics” (such as “Longqiao Waterfall, Laolong Cave”) and “humanistic landscape aesthetics” (such as “Longhua Temple”).

3.2.3. Core coding: Build an evaluation system

The mention frequency and sentiment tendency (positive/neutral/negative) of each CES type were counted, and

the sentiment score (positive proportion - negative percentage) was calculated (**Table 5**).

Table 5. Overall dimensional sentiment analysis

CES types	Frequency of mentions	Proportion of positive emotions	Proportion of negative emotions	Emotional score
Aesthetic service	8,76	78%	12%	+0.66
Cultural and educational services	6,54	72%	18%	+0.54
Entertainment services	5,43	65%	25%	+0.4
Health care services	4,32	60%	30%	+0.3
Inspiration service	3,21	55%	35%	+0.2
Local identity service	2,10	50%	40%	+0.1

3.2.3. Quality evaluation results

Based on the above social media data analysis, the quality evaluation results of CES are as follows:

First, the aesthetic service performance is outstanding, and the recognition of tourists is high. Among the core high-frequency words, “waterfall”, “forest”, and “strange mountain” all belong to this category, and the proportion of word frequency is considerable, and the average emotional tendency is 0.71, and the positive emotion accounts for 78%, indicating that the aesthetic experience of natural and cultural landscapes is deeply loved, and the karst cave landscape is highly praised, which is one of the core attractions of the scenic spot. Second, there is room for improvement in cultural and educational services, although “culture” appears frequently, but the average emotional tendency is only 0.48, and tourists criticize the homogeneity of cultural performances, reflecting the lack of innovation in cultural display and education methods, which is difficult to fully meet the needs of tourists to learn culture and increase knowledge, and it is necessary to enrich the form and content of the display. Third, the entertainment service experience is relatively rich. High-frequency words such as plank road, cave, and entertainment reflect their diversity, with an average emotional tendency of 0.59, and the design of the plank road has been neutrally evaluated, bringing a variety of entertainment activities to tourists as a whole, but some activities need to be improved in terms of organization, safety, or fun. Fourth, health care services are recognized by tourists. The average emotional tendency is 0.65, and forest bathing beaches, hot springs, special accommodation, and other projects are well received, which can allow tourists to relax, but some health facilities or services are insufficient in quality and comfort, which affects the further improvement of satisfaction. Fifth, inspiration services have certain effects but need to be explored. The average emotional tendency is 0.55, and some tourists can get inspiration from the resources of the scenic spot, but the inspirational elements and methods need to be further explored and improved to meet the needs of more tourists. Sixth, the effectiveness of local identity services has begun to appear. The average emotional tendency is 0.68. Tourists have a certain understanding and love for local culture, but the depth and breadth of cultural experience are insufficient, and it is necessary to enrich the content and form of activities, strengthen the interaction between tourists and local culture, and enhance the sense of local identity.

4. Problem diagnosis and strategy optimization

4.1. Problem diagnosis

4.1.1. Aesthetic services: The advantages of natural landscapes are significant, but the integration

of cultural landscapes is insufficient

Social media data shows that high-frequency words such as “waterfall”, “forest” and “strange mountain” accounted for 32%, with an average emotional tendency of 0.71 and positive reviews accounted for 78%, indicating that natural landscapes are the core attraction of CES. However, the frequency of words related to cultural landscapes accounted for only 8%, and the analysis of correlation with natural landscapes showed that there was little discussion of interaction between the two. For example, tourists’ praise of cave landscapes mostly focuses on geological wonders, while less than 15% mention of the cultural stories they carry, such as the history of the Congren people. This reflects that there is a fault in the integrated design of natural and cultural landscapes, and the dual experience of “landscape culture” has not been formed.

4.1.2. Cultural and educational services: Serious homogenization and lack of in-depth experience

Although the frequency of “cultural” words reached 12%, the average emotional tendency was only 0.48, and 63% of the negative evaluations were concentrated on the homogenization of cultural performances. Further analysis found that the update rate of performance content is less than 20% within ten years, and the interactive form is single (mainly dance), and there is a lack of in-depth participation projects, such as manual skills experience and historical scene restoration. Compared with similar scenic spots, tourists are also less satisfied with cultural interpretive signs, believing that their “content is stiff” and “lack of story”, resulting in a decrease in the efficiency of cultural communication.

4.1.3. Entertainment services: Diversity is prominent, and safety and fun need to be improved

The frequency of words such as “plank road”, “cave exploration”, and “entertainment project” accounted for 25%, and the average emotional tendency was 0.59, but the neutral evaluation accounted for 41%. Specific problems include: a lack of theme in plank road design (such as only marking the length and not integrating geological science), vague safety prompts for karst cave exploration projects (12% of negative evaluations involve safety facilities), and insufficient interest in entertainment projects (such as a high repetition rate of children’s area facilities). In addition, the lack of entertainment at night has led to a shorter stay for tourists.

4.1.4. Health care services: hardware up to standard, soft services are insufficient

The average emotional tendency of forest bathing and hot spring health care projects is 0.65, but 38% of the negative evaluations point to service details, such as the untimely publicity of hot spring water quality and the fluctuation of sanitary conditions of special accommodation. Compared with the Hakone Hot Spring Scenic Area in Japan, CES is almost blank in the personalized customization of health care services (such as recommending items based on physical fitness) and follow-up health tracking (such as providing health advice), making it difficult to form long-term customer stickiness.

4.1.5. Inspiration service: The potential of resources has not been released, and the stimulation method is single

Words such as “inspiration” and “creation” accounted for 5% of the frequency, and the average emotional tendency was 0.55, but 73% of the positive comments came from professional creators (such as photographers and writers), and the inspiration trigger rate of ordinary tourists was less than 20%. The analysis found that the scenic spot did not design differentiated stimulation scenes for different groups of people, such as the lack of nature education workshops for parent-child families and memory recording services for the elderly, resulting in limited

coverage of inspiration services.

4.1.6. Local identity service: The cultural experience is shallow, and the interactivity is insufficient

The frequency of words such as “local culture” and “folklore” accounted for 10%, and the average emotional tendency was 0.68, but tourists’ in-depth evaluation of cultural experience was low. For example, only 15% of tourists have participated in interactive links (such as learning simple handicrafts) after folk performances, and the integration of local characteristic elements of cultural derivatives (such as cultural and creative ice cream) is insufficient, and 32% of tourists believe that it is “no different from ordinary scenic spot products”, which weakens the transmission effect of local identity.

4.2. Policy optimization

4.2.1. Aesthetic service: Construct a dual-track narrative system of “natural culture”

Regarding landscape linkage design, AR interactive screens are set up at the entrances of natural attractions, and historical animations of people can be presented by scanning rocks (such as using karst cave geological layers to simulate ancient life scenes), and cultural stories are integrated into the tour route. Carry out seasonal theme packaging, launch the “Flower Sea Poetry” activity in spring, design the “Red Leaf Photography” route in autumn, and strengthen the cultural added value of the landscape through social media topic operation.

4.2.2. Cultural and educational services: Create an immersive cultural experience field

Carry out dynamic content updates, launch one limited cultural performance every quarter, such as designing “spring plowing dance” in combination with solar terms, and introduce resident teaching by intangible cultural heritage inheritors, such as bamboo weaving and embroidery experience. Adopt technology-enabled commentary, develop an audio guide app, and push historical stories according to the location of tourists, such as automatically playing battle simulation audio when approaching the ancient battlefield site, so as to improve the fun and accuracy of cultural communication.

4.2.3. Entertainment services: Build a “safe and fun” dual guarantee system

Carry out thematic plank road transformation, design the plank road section into “geological science section” (mark the rock type), “fairy tale section” (set up cartoon sculptures), and add safety warning interactive screens (such as touch screen to view the rescue process). Develop night entertainment, launch projects such as “Cave Light and Shadow Show” and “Starry Sky Concert”, extend the stay time of tourists to 2 days and 1 night, and improve the overnight rate.

4.2.4. Health care services: Implement personalized health management plans

Upgrade the intelligent service system, introduce health detection bracelets, monitor tourists’ heart rate and step count in real time, and push customized suggestions such as “You walk 10,000 steps today, suitable for experiencing forest yoga.” Conduct service standardization training, formulate SOPs for health care project operation (such as hot spring disinfection process, massage technique specifications), and regularly check service records to ensure stable soft service quality.

4.2.5. Inspiration service: Design layering to inspire scenes

Build dedicated spaces for creators, set up “inspiration stations”, provide free rental of photography equipment,

writing workbenches, and hold regular creator salons (such as inviting local writers to share their creative experiences). Build family interactive workshops, develop tools such as “nature diaries” and “parent-child notebooks” to guide family tourists to record their visit experiences and stimulate the creative desire of ordinary tourists.

4.2.6. Local identity services: Deepen cultural interaction and derivatives development

Upgrade the folk experience and change the folk performance to a “workshop performance” mode (such as learning simple dance movements first, and then participating in a group performance) to enhance the sense of participation. Innovate cultural and creative products, cooperate with local intangible cultural heritage inheritors, launch special products such as “silk scarves with human patterns” and “geological layer bookmarks”, and print QR codes of cultural stories on the packaging to strengthen local cultural symbols.

4.3. Implementation guarantee: Data closed-loop and dynamic optimization mechanism

Access to multi-source data, integrate social media reviews, questionnaires, and app behavior data (such as the length of stay at attractions) to build a tourist experience database. Iterate monthly strategies and adjust service details based on data feedback (for example, when an entertainment project has more than 10% negative reviews, immediately start the optimization process). Drawing on the dual review mechanism, “technical feasibility review” (such as whether the new project meets safety standards) and “market attractiveness review” (such as whether it meets the needs of tourists) are introduced to ensure the implementation effect of the strategy.

5. Conclusion

This study accurately locates the six major pain points of CES services through social media data mining and proposes quantifiable optimization strategies. In the future, it is necessary to continue to track data changes, form a closed-loop management of “evaluation-diagnosis-optimization”, and promote the upgrading of CES service quality in the direction of refinement and personalization.

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A Study of Sense of Virtual Community: Empirical Realities and Structural Aspirations

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Abstract: This study investigates the development of a sense of virtual community (SOVC) within a WeChat-based professional learning community for foreign language instructors in China. Grounded in McMillan & Chavis's (1986) four-dimensional framework—membership, influence, needs fulfillment, and shared emotional connection—the research employs a modified Sense of Community Index (SCI) to assess 192 instructors' perceptions. Findings reveal a paradoxical duality: while the community demonstrates strong instrumental functionality and symbolic identity, critical relational dimensions remain fragmented. Membership shows robust shared purpose, yet influence is hindered by low member familiarity and ambivalent commitment. Emotional connection relies heavily on past collective experiences and future optimism but lacks consistent present-day engagement. The study attributes these gaps to cultural factors and structural over-reliance on administrative efficiency. To reconcile these tensions, the authors propose a cyber-physical integration framework leveraging WeChat's native features, including tiered identity systems, rotating moderation, and anonymized emotional support channels. The results highlight the need to balance transactional utility with communal praxis in virtual professional learning environments, offering actionable insights for designing human-centered digital communities in post-pandemic education.

Keywords: Sense of virtual community; Professional learning communities; WeChat groups; Foreign language education; McMillan & Chavis framework

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1. Introduction

Virtual communities have emerged as the cornerstone social infrastructure of the 21st century, redefining human connection beyond physical boundaries. These digitally mediated collectives range from professional learning networks to interest-based forums. Their transformative power lies in three paradigm-shifting attributes: spatiotemporal fluidity enabling synchronous collaboration across continents, affinity-based affiliation replacing geographically constrained ties, and democratized knowledge ecosystems where expertise flows laterally rather than hierarchically ^[1-3]. In education specifically, virtual communities have evolved from supplemental tools into

primary sites of pedagogical innovation, with UNESCO reporting that 92% of teacher development initiatives now incorporate digital community elements ^[4].

Within foreign language education, virtual Professional Learning Communities have catalyzed four pedagogical revolutions. First, they resolve the authenticity deficit inherent in scripted textbooks through platforms, where learners engage in real-time conversations with native speakers across 150 countries. Second, they enable resource democratization, exemplified by Duolingo's crowdsourced forums hosting 4.7 million peer-validated language exercises. Third, they facilitate cross-cultural scaffolding, as seen in Fengtai Foreign Languages School's study tour to Spain, which fosters cross-cultural narratives through immersive classroom exchanges, collaborative football activities, and bilingual interactions between Chinese and Spanish students. Most critically, they reshape teacher agency through communities like #LangChat—a Twitter-based PLC where 15,000 language educators collaboratively troubleshoot classroom challenges. While the OECD's Teaching and Learning International Survey (TALIS) 2023 indicates that 89% of foreign language teachers acknowledge the theoretical value of Professional Learning Communities (PLCs), the critical question remains: Do members truly develop a sense of virtual community in practice? ^[5].

This study employs McMillan & Chavis's (1986) four-dimensional framework of sense of community—membership, influence, integration, and fulfillment of needs, and shared emotional connection—to conduct an empirical investigation of a WeChat-based community originally established for competition guidance ^[6]. Then the results of the data analysis aim to answer the question about whether the members in this WeChat group—this virtual community—have been equipped with a sense of virtual community, and the reasons contributing to the results.

2. Literature review

2.1. Community and virtual community

The concept of community was first defined by the German sociologist Ferdinand Julius Tönnies, who argued that, in contrast to the notion of society, a community is an enduring and genuine common life ^[7]. Subsequently, globalization, informatization, and digitization have changed the community's dependence on place, and interpersonal relationships have evolved to networks of social relations that can traverse time and space. The exchange of meanings, sharing of experiences, and cultural symbiosis in the community no longer depend on geography and "presence", and the concept of community in its original sense continues to disintegrate, and the concept of disembedding community begins to be reiterated ^[8]. From the research results on community in the last five years, group and community-based on social media platforms have received more and more attention. Shen et al., in order to achieve the effectiveness of WeChat community management, based on the perspective of community members, selected six factors affecting the management of WeChat community, such as community goals, community orientation, community trust, community belonging, community reciprocity, community rules, etc., and established a six-dimensional model of influencing factors, to explore the relationship between the factors and the effectiveness of WeChat community management ^[9].

Compared to geographic communities, virtual communities are communities based on relations (social networking) ^[10]. Balasubramanian and Mahajan proposed five characteristics of virtual communities: 1) the clustering of people (the aggregation of people); 2) rational members; 3) interaction in cyberspace without physical collocation; 4) a process of social exchange; and 5) a process of membership of social exchange; 5) an objective,

property/identity, or interest shared by members ^[11]. These results lay a solid foundation for our comprehensive understanding of the characteristics of the community.

2.2. The evolution and challenges of sense of community (SOC)

McMillan and Chavis's four-dimensional SOC framework (Membership, Influence, Needs Fulfillment, Emotional Connection) established the theoretical bedrock for community psychology, revealing how shared identity, reciprocal influence, resource interdependence, and collective rituals generate social cohesion. Obst et al. conducted a confirmatory factor analysis of the Sense of Community Index (SCI), which measures these four dimensions, and provided empirical validation for retaining measures that encapsulate Membership, Influence, Needs Fulfillment, and Emotional Connection, across multiple community types, including neighborhood and interest groups ^[12].

The sense of virtual community (SOVC) is a multifaceted construct that has garnered significant scholarly attention, particularly in understanding how community-like experiences are fostered and maintained in online environments. Blanchard et al. initiated this exploration by investigating whether a sense of community akin to that in physical settings also manifests in virtual spaces, exemplified through their study of MSN, an established virtual community. Their findings suggest that members can indeed experience a sense of belonging and community, raising questions about the mechanisms that sustain such feelings in digital contexts. Empirical investigations into the measurement of SOVC have also been conducted. Abfalter et al. examined the applicability of traditional SOC measures in virtual contexts, adopting the SOC index 2 (SCI2) to better capture the dynamics of online communities ^[13]. Their findings support the notion that adapted measurement tools are necessary to accurately assess SOVC, considering its distinct features compared to physical communities. This also becomes the foundation for our research design.

Building on this foundation, Blanchard et al. further delineated the behavioral processes underpinning SOVC, identifying key activities such as exchanging support, creating identities, making identifications, and producing trust ^[14]. These processes mirror characteristics observed in face-to-face communities, notably emotional attachment and helping behaviors, which are essential for a successful community experience. The development of these processes highlights the importance of social interactions and trust-building in cultivating a strong sense of community online.

The sense of virtual community in higher education has become increasingly significant, especially in the context of the COVID-19 pandemic, which necessitated a shift toward online and virtual learning environments. Bozkurt et al. highlighted the significant influence of social presence (a sense of connection and interaction among participants) on the effectiveness of online learning in the post-COVID-19 educational landscape ^[15]. Further, emerging technologies like artificial intelligence (AI) are being explored for their potential to enhance virtual community experiences. Xie et al. investigate how interaction with generative AI can promote learning autonomy, which may indirectly influence students' engagement and sense of community within virtual settings ^[16]. Similarly, the role of peer and tutor interactions in online collaborative learning is examined by Intaratat et al., who highlight the importance of self-efficacy and interaction quality in fostering a cohesive virtual community ^[17]. Overall, the literature underscores that fostering a sense of virtual community in higher education involves multiple interconnected factors, yet more empirical findings need to be shown to enrich the fruits of the sense of virtual community, especially those for professional learning.

2.3. Cloud teaching and research as a virtual community: Evolution and Institutionalization

The conceptual foundation of cloud teaching-research (CTR) as a virtual community predates the pandemic. Research on cloud teaching and research communities in Chinese higher education was first proposed by Wen Qiufang^[18]. Wen's research team subsequently conducted empirical studies and in-depth explorations of emotional connection, cognitive connection, and social connection in cloud-based teaching-research processes^[19-21].

In the meantime, people need to notice that CTRs coexist with—rather than replace—informal social media communities. WeChat/QQ groups retain vitality due to social stickiness and contextual adaptability. This duality underscores a critical insight: Professional learning communities thrive in multi-platform ecosystems. While CTRs provide institutional scaffolding for accredited development, social platforms enable just-in-time peer support, exemplifying how cloud technologies now support layered community architecture—from structured national initiatives to self-organized micro-communities.

3. The research design and results

3.1. Design of the research questionnaire

Based on the booming development of various types of foreign language cloud teaching and research, this study chooses a WeChat group formed for the provincial intercultural competence competition in the researcher's province as the object of the study. The group was established in September 2022, initially for the purpose of providing information support for the provincial competition of intercultural competence, and the members of the group are mainly instructors of undergraduate colleges and universities participating in the intercultural competence competition in the province. The members of the group were invited to participate in a questionnaire survey in January 2025, and analyzed based on the results of the questionnaire survey.

The questionnaire is based on the Sense of Community Index proposed by Chavis et al., which divides the sense of virtual community into four components, i.e., Membership, Influence, Needs fulfillment, and Emotional Connection. At the same time, the original 24 items were filtered and modified based on the requirements of IFLCTR, such as activity information transfer and information interaction. The main criteria for adjustment are (1) the expression of the item itself is ambiguous, like what the same thing refers to in “value the same thing”; (2) there is a difference in subjective criteria for modifiers, such as “successful” and (makes me feel) “good”; or there may be a difference in the understanding of concepts, such as “part of my identity”; (3) Combining and adjusting expressions with similar meanings, e.g., “I can recognize most of the members of this community.” and “Most community members know me.” are intended to express whether the members are familiar with each other or not; (4) expressions whose degree is not easy to judge and grasp, such as “trust people”, “important to me”, “influence other communities”, “care about each other.” Of course, no matter how the researchers adjust the test items, it is difficult to achieve a common perception of each item when it comes to “sense”, which is a subjective and abstract term in itself, and this is the key reason for reducing the test items by half. The items under the four structural and dynamically interacting elements were reduced by half. Three items concerning each component were retained to allow the participants to complete the questionnaire in a short period of time with a clear purpose. The options in the questionnaire were in the form of a Likert scale, which were strongly agree, agree, uncertain (hesitant), disagree, and strongly disagree.

3.2. Questionnaire results and analysis

There are 223 members in the group, and 192 valid questionnaires were received. The questionnaire items were

presented in English without corresponding Chinese translations (by default, the English level of each teacher in the group is sufficient to complete the questionnaire). The questionnaires were sent out by the group leader, and the overall response was good, with more than half of the members replying “completed” after completing the questionnaires in the group. This study recognizes this response as an effective interaction that demonstrates friendliness. The results of the four sections are analyzed below, followed by a summary of the overall results.

3.2.1. Dimension 1: Membership

Item 1: People in this community have similar needs, priorities, and goals.

Item 2: I get important needs of mine met because I am part of this community.

Item 3: When I have a problem, I can talk about it with members of this community.

The survey data indicate an exceptionally strong sense of membership and belonging within this community (**Figure 1**). Members demonstrate a profound shared identity. This consensus on common objectives (such as focusing on competition schedules, results, or exams) forms the fundamental bedrock for cohesion and mutual understanding. Furthermore, this shared purpose translates into significant personal value derived from membership. The 2nd pie chart shows that the vast majority of respondents affirm that the community effectively fulfills their key requirements, signifying its vital functional role in members’ lives. While 12.12% expressed uncertainty here, the dominant positive trend underscores the community’s success in meeting member needs. Finally, the data reveal a highly functional and supportive relational network. The 3rd chart confirms this, with a robust 78.79% expressing a positive attitude (Agree or Strongly Agree). This high level of perceived support availability highlights strong interpersonal trust and openness, fostering a safe environment where members feel comfortable seeking help or discussing challenges.

In essence, the membership dimension is quite well-established. Members strongly identify with the collective purpose, consistently perceive significant personal benefit from participation, and actively trust in the support network the community provides. This powerful combination of shared identity, perceived value, and relational support defines a cohesive and deeply connected group where a strong sense of belonging prevails.

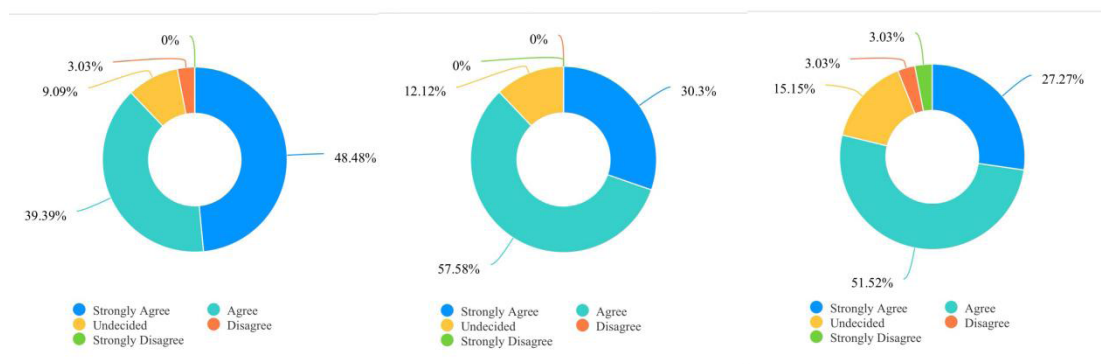


Figure 1. The results of the first dimension

3.2.2. Dimension 2: Influence

Item 4: People in this community basically know each other.

Item 5: This community has symbols and expressions of membership, such as clothes, signs, art, architecture, logos, landmarks, and flags that people can recognize.

Item 6: I put enough amount of time and effort into being part of this community.

The Influence dimension reveals significant variability in member perceptions, indicating strengths in symbolic identity but challenges in social cohesion and perceived contribution (**Figure 2**). While the community demonstrates recognizable symbolic elements, member integration and commitment show notable divisions. The data reveal a divided and nuanced perception of influence, characterized by strong symbolic identity but weak social cohesion and ambiguous personal commitment. While the community excels in establishing recognizable symbols and expressions, nearly half the members report limited interpersonal familiarity, highlighting a critical gap in foundational social integration. Further compounding this fragmentation, personal commitment levels show significant ambiguity—over half agree they invest sufficient effort (54.54% cumulative agreement), yet a striking 30.3% are uncertain about their contribution, alongside 18.2% active disagreement. This triad suggests influence hinges more on external markers than relational depth or member engagement, indicating a community whose symbolic presence outpaces its internal cohesion and inclusive contribution culture.

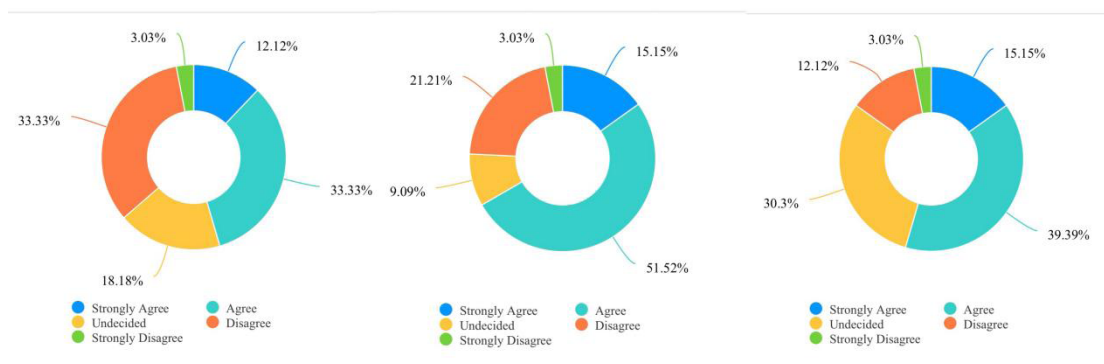


Figure 2. The results of the second dimension

3.2.3. Dimension 3: Integration and fulfillment of needs

Item 7: This community has good leaders/people in charge.

Item 8: Fitting into this community is important to me.

Item 9: If there is a problem in this community, members can get it solved.

The Integration and Fulfillment dimension reveals a striking duality: near-unanimous confidence in leadership contrasts sharply with fractured belonging and collective efficacy (**Figure 3**). The results reveal a starkly bifurcated landscape: overwhelming confidence in leadership contrasts sharply with ambiguous integration and collective efficacy. The first chart demonstrates exceptional consensus, with 84.85% positive agreement and zero disagreement, signaling near-universal trust in governance. For the middle one, while agreement totals 51.51%, the critical 24.24% uncertainty reflects ambivalence about personal belonging. Most critically, Item 9 shows profound hesitation in collective agency—a staggering 30.03% remain uncertain about problem-solving capabilities, alongside non-trivial disagreement, indicating eroded faith in communal action despite strong leadership. This triad paints a community where top-down competence anchors trust, but bottom-up integration and shared efficacy languish in ambiguity, suggesting leaders must bridge the gap between administrative reliability and empowering member-driven solutions.

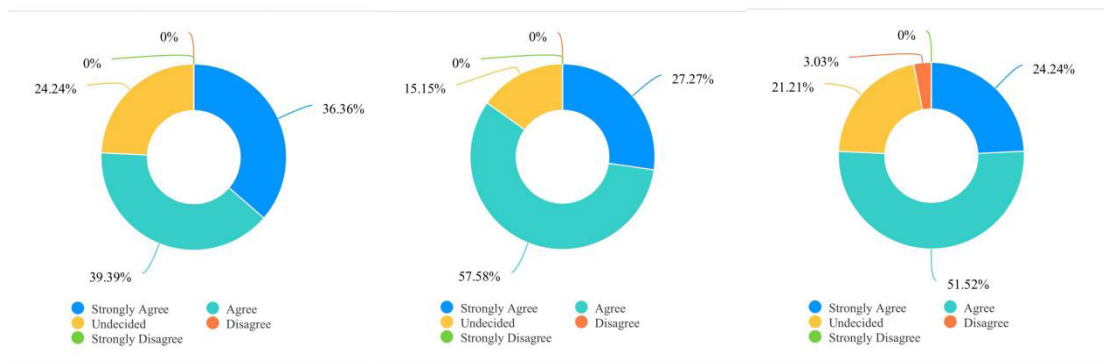


Figure 3. The results of the third dimension

3.2.4. Dimension 4: Shared emotional connection

Item 10: I am with other community members a lot and enjoy being with them.

Item 11: Members of this community have shared important events together, such as contests, lectures, or celebrations.

Item 12: I feel hopeful about the future of this community.

The Shared Emotional Connection dimension reveals a complex duality: strong collective history and future optimism coexist with significant ambivalence about present social bonds (**Figure 4**). While most members affirm shared important events (Item 11: 87.88% positive agreement, combining 51.52% Agree + 36.36% Strongly Agree) and express overwhelming hope for the community's future (Item 12: 93.94% cumulative agreement), daily interpersonal engagement shows profound fragmentation—Item 10 elicits only 57.57% positive sentiment (15.15% Strongly Agree + 42.42% Agree) against a critical 33.33% uncertainty (“Undecided”) and 9.09% disagreement. This triad suggests community bonds rely heavily on symbolic legacy (past events) and abstract aspiration (future hope) rather than consistently fulfilling in-the-moment social experiences, creating an emotional paradox where members invest in what was and what could be while hesitating about what is.

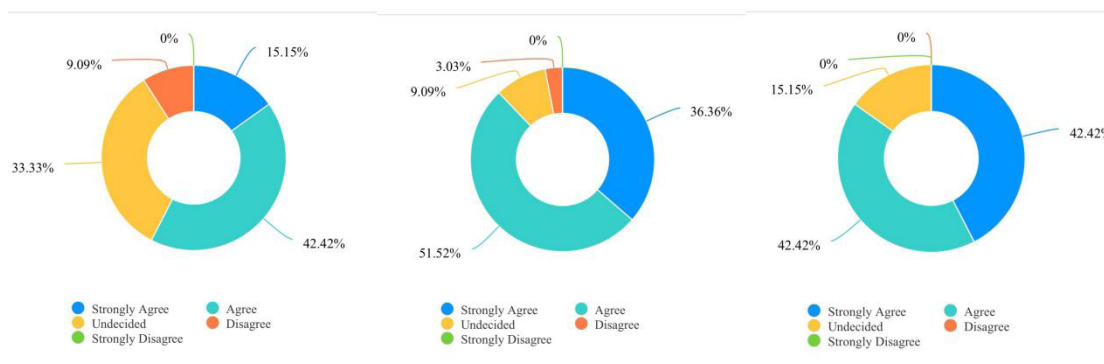


Figure 4. The results of the fourth dimension

The data collectively reveal a community with strong symbolic and structural foundations but fragmented relational integration. While members exhibit robust shared purpose, recognizable identity, and exceptional trust in leadership, these strengths are counterbalanced by critical relational gaps: limited mutual familiarity, pervasive uncertainty in personal investment, and weak present-day emotional bonds despite shared history/future optimism.

Crucially, leadership credibility fails to translate into collective efficacy, exposing a community sustained more by abstract belonging than consistent relational fulfillment.

The significant proportion of “Undecided” responses across multiple items warrants attention within the Chinese cultural context, where considerations of face (*mianzi*) significantly influence social interactions. Choosing “Undecided” may often reflect a desire for face-saving—a polite equivocation masking potential disagreement rather than genuine neutrality. Therefore, the analysis prioritizes the prevalence of this “Undecided” option, interpreting it as indicating uncertainty or, critically, an implicit lack of endorsement for the positive statement.

Among all items, the three exhibiting the highest levels of this “Undecided” sentiment are:

Item 10: I am with other community members a lot and enjoy being with them. (33.33% Undecided)

Item 6: I put enough amount of time and effort into being part of this community. (30.3% Undecided)

Item 7: This community has good leaders/people in charge.
(24.24% Undecided - despite high overall positive agreement)

These findings reveal a concerning trend: a substantial segment of members expresses ambivalence about their familiarity with peers, their own level of commitment, and, crucially, the leadership’s effectiveness. Given that social platform communities represent a dominant form of virtual community today—often distinguished by strong social attributes and user stickiness—these high uncertainty rates present significant challenges.

The core problems become clear: low member familiarity hinders interaction frequency, while uncertainty about leadership effectiveness suggests barriers to efficient information exchange and professional knowledge sharing. If these underlying issues persist—despite the platform’s inherent social advantages—its core value proposition becomes harder to realize and maintain, posing a significant threat to long-term sustainability and growth.

4. Discussion

To address these disconnects, the authors propose a multi-tiered remediation framework prioritizing cyber-physical integration. Foremost, the virtual community dilemmas revealed in this study necessitate resolution through reconfiguring WeChat’s native functionalities. To address instrumental affiliation in the Membership dimension, the authors propose an implementable tiered identity system: utilizing WeChat group announcements to display three-tier role labels (Observer/Contributor/Mentor), coupled with automated participation tracking via the “WeCommunity” mini-program. Contributors (sharing ≥ 2 resources monthly) gain privilege to initiate “Group Tasks” notifying all members, while Mentors (≥ 20 endorsements + admin certification) obtain hosting rights for Friday “Thematic Sessions”. Concurrently, embedding a “Teacher Wall” Tencent Docs (with research fields/shareable resources columns) systematically constructs cross-institutional trust networks, dismantling barriers to authentic communication.

Furthermore, power centralization in the Influence dimension requires leveraging WeChat’s distributed interaction architecture. The authors establish a rotating moderator system: recruiting volunteers through WeChat’s Sign-up Tool on the 1st monthly, granting them mute management privileges during Wednesday 19:00–20:00 “Focus Sessions”. Crucially, developing a “Suggestion Bottle” chatbot allows private suggestion submissions, with daily 17:00 proposal summaries triggering a like-based voting mechanism (30 likes = execution). This decentralized design dismantles the bureaucratic perception that “communication is administrators’ duty.”

Regarding the Fulfillment dimension, the authors construct a three-stage knowledge distillation funnel: 1) real-time discussions captured via “Group Highlights”; 2) automated weekend infographic reports (Enterprise WeChat plugin); 3) monthly resource packages unlocked through point redemption (5 points/share, 1 point/3 comments).

Most critically, Emotional Support requires reconstruction. Addressing the “zero emotional lexicon” phenomenon, the authors integrate Tencent Survey to create an anonymous confession system (pinned in group menu) with #Urgent Help/#Experience Sharing/#Achievement Celebration tags, moderated by Friday “Emotional Support Volunteers” (Mentor rotation). Conflict mediation employs a WeChat-native closed loop: anonymous submission → volunteer-matched expert pairing → private mediation room → anonymized case repository. Weekly push notifications of sentiment heatmaps (e.g., [Security] 82%) further visualize intangible connections. Ultimately, these solutions form a theory-technology symbiosis.

Only through this recalibration—centering member agency, redistributing influence, and embedding vulnerability structures—can such communities transcend their current state as “information bulletin boards” to become authentic catalysts for pedagogical transformation in foreign language education.

5. Conclusion

This study first focuses on the virtual community, laying a solid theoretical foundation for the study by exploring in depth the conceptual evolution of community and virtual community, as well as the relevant theoretical frameworks of ideology and cloud education research. The empirical investigation of an intercultural foreign language cloud teaching community reveals a profound instrumentalization paradox: while digital platforms enable unprecedented resource sharing and coordination efficiency, they simultaneously erode the relational foundations essential for authentic community consciousness. This study confirms that structural functionality—particularly in information dissemination and administrative centralization—dominates members’ conceptualization of virtual spaces, overshadowing core communal dimensions like emotional support and collaborative agency. These findings expose critical fractures across McMillan & Chavis’s four dimensions: membership manifests as transactional affiliation rather than internalized belonging; influence remains constrained by factors such as willingness to participate and familiar relationships; fulfillment exhibits perceptual asymmetry between technological convenience and real participation; and emotional connection registers as a systemic void, with zero affective lexicon in conflict-resolution scenarios and low commitment scores.

To reconcile these tensions, the authors propose a dual-architecture framework leveraging WeChat’s native functionalities. The first is about the construction of tiered identity systems (Observer/Contributor/Mentor) with automated participation tracking, transforming passive members into active agents through granular privilege escalation. Then is the distributed governance via rotating moderators and AI-facilitated suggestion mechanisms, democratizing decision-making while reducing administrator dependency. And finally is the emotional scaffolding through anonymized confession channels and digital embodiment tactics, directly addressing the affective vacuum noted in post-pandemic virtual communities. Theoretically, this framework bridges the instrumental-communicative rationality dialectic: platform-native features become mediators between operational efficiency and communal praxis. It further advances the communities of practice model by demonstrating how digital phronesis—practical wisdom in technology deployment—can transform efficiency-driven spaces into critical thinking incubators.

Ultimately, sustainable cloud teaching-research communities thrive not through structural sophistication alone, but through architectures that humanize digital interaction. This human-centered recalibration positions cloud communities not merely as transactional networks, but as living ecosystems where efficiency serves empathy, and technology amplifies human connection.

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Methods and Measures for Leak Detection of Heating Pipe Networks

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Abstract: As a crucial component of urban infrastructure, heating pipe networks are responsible for providing safe and stable heating services to residents. With the acceleration of urbanization and the continuous growth of heating demand, the heating pipe network system has expanded significantly. However, the expansion of the heating system and its scope make it difficult to ensure the safety and stability of the heating pipe network. Therefore, it is of practical significance to explore methods and measures for leak detection of heating pipe networks.

Keywords: Detection technology; Faults; Energy; Heating pipe networks; Temperature

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1. Introduction

In the context of accelerated urbanization and the improvement of people's living standards, the safety and stability of the heating pipe network system, which serves as the cornerstone for maintaining and supporting the safe and harmonious development of cities, have received extensive attention from society and the public. Facing multiple challenges such as pipeline damage, heat source alternation, and natural aging, traditional leak detection methods can no longer meet the more precise and targeted requirements. At the same time, they also increase the consumption of a large amount of energy to a certain extent and pose potential safety hazards. In this context, regular inspection of heating pipe networks can help detect and resolve potential problems in a timely manner, ensuring the stable operation of the heating system. In addition, an intelligent monitoring system can be used to monitor various parameters of the pipe network in real-time, improving management efficiency and enabling timely detection and handling of problems.

2. Causes of leakage faults in heating pipe networks

2.1. Material problems of heating pipe networks

The materials selected during the construction of heating pipe networks are closely related to the degree of

network aging and service life. In order to save costs, some heating pipe networks often use low-quality iron, steel, and other materials. These materials, which are prone to chemical reactions, are likely to be affected by the environment during long-term use and become corroded, further accelerating the aging of the pipe network ^[1]. For example, the internal corrosion of heating pipe networks is mainly caused by the quality of the water inside the pipes. When there is a high content of oxygen or carbon dioxide in the environment, these chemical substances will react with the pipe materials, leading to metal corrosion. Low-quality iron and steel pipes have poor corrosion resistance and are more vulnerable to external corrosion, thus affecting the bearing capacity and service life of the pipes. In addition, the environment inside the heating pipes is too humid, which accelerates the corrosion rate of the internal materials. In a humid environment, with the large-scale generation of chemical substances, moisture, and oxygen, the pipe network materials react with them, resulting in a corroded state. Low-quality iron and steel pipes that have not undergone pre-treatment are more vulnerable to corrosion and form rust layers. This not only affects the appearance of the pipes but also weakens their structural strength, increasing the risk of pipe rupture and leakage ^[2].

2.2. Difficulty in determining temperature and pressure

During the operation process, the changes in temperature and pressure in heating pipes affect the heating pipe network to a certain extent, leading to various faults. Under the action of high temperatures, the internal structure of the pipe network materials changes, causing the materials to react chemically with substances in the air, including thermal expansion, softening, and embrittlement of the materials ^[3]. For example, as the temperature rises, the pipe network materials will expand thermally, causing changes in the pipe dimensions and resulting in loosening or rupture. At the same time, in a high-pressure environment, both the inner and outer walls of the heating pipes are subjected to greater stress. Long-term operation under high pressure will cause fatigue damage to the pipe materials, making the pipes more fragile and greatly increasing the probability of rupture.

3. Methods for leak detection of heating pipe networks

3.1. Infrared thermal leak detection method

Infrared thermal imaging technology is a technique that uses an infrared detector and an optical imaging lens to receive and convert the infrared radiation energy distribution pattern emitted by an object. Infrared thermal imaging technology can generate visible thermal images and effectively display the infrared energy emitted by the object. Infrared thermal imaging technology can work in a non-lighted environment. It can not only accurately capture the shape and direction of an object in the dark but also determine the actual radiation temperature of the infrared image object through temperature calibration and calibration equipment, enabling the rapid mapping of the temperature distribution ^[4].

On the one hand, the leakage of heating pipes can change the temperature of the surrounding soil. Specifically, as the leakage time and leakage volume increase, the temperature range of the affected soil will gradually expand. Infrared thermal imaging technology can effectively monitor the changes in soil temperature, accurately capture the thermal images of the heated areas, timely detect the location of pipe leaks, and monitor the operation status of the pipes.

On the other hand, when the pipe network is operating normally, the infrared thermal imager can directly monitor and detect the temperature of the soil around the pipes, thus timely reflecting the operation status of

the pipes. If signs of heating pipe leakage are detected, measures can be taken immediately to reduce the risk of potential major accidents.

3.2. Traditional leak detection methods

Basic principles such as acoustics, optics, and heat are the main methods relied on by hardware detection technologies for monitoring heating pipe networks. Based on this, workers can collect and analyze the parameter changes of the pipe walls and the surrounding environment to check for leaks. Manual leak detection, infrared detection, and radioactive tracer leak detection are all commonly used methods. In traditional methods for diagnosing leakage faults in heating pipe networks, hardware leak detection technologies are widely applied ^[5]. With the assistance of these technologies, workers can analyze the relevant environmental parameters of the heating pipe network walls and their surroundings through monitoring or equipment monitoring to achieve the effect of fault diagnosis.

Hardware-based diagnostic methods are flexible, portable, and highly adaptable, with relatively low costs and simple installation processes. However, they also have disadvantages such as weak anti-interference ability and inaccurate diagnostic results. Especially in complex and changeable pipeline environments, hardware methods may be affected by various interference factors, leading to deviations in diagnostic results.

Supported by computer technology and information technology, automated detection technologies have developed rapidly in the detection of heating pipe networks. Software-based detection methods rely on this technology. Based on this, a computer data acquisition system is used to collect the real-time operation parameters of the heating network, and algorithms are used for analysis and calculation to identify leaks, accurately locate fault points, and analyze the causes of faults ^[6]. In software-based detection technologies, diagnostic methods based on mathematical models and signal processing are commonly used by workers in detection work. These methods have a certain degree of accuracy and reliability and are helpful for accurately judging leakage faults in heating pipe networks.

3.3. Artificial intelligence detection methods

The rapid development of science and technology and information technology has brought changes to various fields. Artificial intelligence technology, with its powerful information-processing capabilities, provides new solutions for the fault diagnosis of heating pipe leaks and has gradually become the main research direction for the fault diagnosis and detection of heating pipe networks.

The expert system was the first artificial intelligence method used for the fault diagnosis of heating pipe network leaks ^[7]. The expert system is based on a sample database composed of a large amount of expert experience. It can simulate the decision-making process and fault-diagnosis reasoning process of human experts to effectively diagnose leakage faults in heating pipe networks. Based on this, the expert system based on artificial intelligence technology has gradually become an innovative means for the fault diagnosis of heating pipe network leaks. However, the expert system also has certain limitations in the process of fault diagnosis. Specifically, the expert system relies on a complete expert knowledge base and has a high degree of subjectivity. In complex heating pipe networks and changeable heating operation states, it is difficult for the expert system to construct an extremely complete expert knowledge base, making it difficult to play its expected role. Judging from the current situation of leakage fault diagnosis and detection in heating pipe networks, relevant enterprises rarely use the expert system method to diagnose leakage faults in heating pipe networks.

4. Analysis of measures for maintaining heating pipe networks

4.1. Regularly inspecting heating pipe networks to prevent aging

To better prevent the aging of heating pipe networks, technicians need to regularly inspect the heating pipe networks, which can effectively prevent network aging and the occurrence of fault points. Key equipment and parts, such as pipelines, valves, pump rooms, and heat exchange stations, are the key points that technicians need to focus on during inspection. Technicians need to carefully check the overall condition of the pipelines, including whether there are problems such as damage, aging, and leakage ^[8]. Special attention should be paid to vulnerable parts such as pipeline connections, elbows, and tees, as these locations are more likely to have problems. At the same time, observe the operation status of valves and pump rooms; check whether the heat exchange efficiency, working pressure, temperature, and other parameters of the heat exchange stations meet the standards, and pay special attention to potential hazard areas around the pipes. Technicians need to check whether there are flammable, explosive materials, or heavy objects stacked around to avoid causing pressure or damage to the pipe network.

Enterprises should be aware of the importance of regular inspections for maintaining the normal operation of heating pipe networks, and promptly urge technicians to conduct inspections to identify potential safety hazards in the pipe network and prevent accidents. The aging of heating pipe networks is a phenomenon in which the original performance of pipeline materials is gradually consumed during long-term operation, while corrosion is caused by a series of chemical reactions in the pipes. Under the influence of the environment, harmful substances are generated, which damage the pipes ^[9]. To better maintain the pipes, technicians also need to take a series of maintenance measures. For example, clean the inside of the pipes to remove dirt, corrosion products, and other impurities, keep the pipes unobstructed, and improve the heat exchange efficiency. Another example is that anti-corrosion treatment of the pipe surface is an effective means to prevent external environmental erosion. Methods such as painting anti-corrosion paint and wrapping with anti-corrosion materials can be used to improve the corrosion resistance of the pipes.

4.2. Paying attention to heating pipe network testing to ensure normal equipment operation

During the process of maintaining heating pipe networks, technicians need to pay attention to heating pipe network testing to timely understand various leakage problems. First, workers need to test the water quality in the heating pipe network to check whether there are substances prone to reactions, reduce problems such as pipeline corrosion, scaling, and blockage, extend the heating effect, and reduce the occurrence of safety risks. During the water quality testing process, workers need to focus on the hardness, pH value, oxygen content, impurity content, etc., of the water quality to determine whether there are potential risks. If abnormal water quality is found, workers can immediately take measures such as installing water treatment equipment and observing water supply parameters to solve the problem ^[10]. To ensure that the water quality meets the standards, workers can install water treatment equipment. Using the automatic functions of the water treatment equipment, impurities in the water can be removed in a timely manner, the hardness can be reduced, and the pH value can be adjusted, further improving the water quality. In addition, during the inspection process, workers need to protect and maintain the water treatment equipment through methods such as cleaning and replacing the filter elements to ensure its normal operation and high-efficiency treatment effect.

4.3. Adjusting the temperature of heating pipe networks to improve the stability of the heating system

During the process of maintaining heating pipe networks, workers need to adjust the temperature of the pipe networks according to the seasons and temperature changes to improve the stability of the heating system. For example, in winter, the external environmental temperature is low, and the demand for heating in buildings increases significantly. To ensure that heat can be fully transmitted indoors to meet the heating needs of users, the water supply temperature should be appropriately increased. When adjusting the temperature of the heating pipe network, workers need to ensure the working efficiency of the heating system and the heat recovery effect. In summer, the outdoor environmental temperature is high, and the heating demand of buildings will decrease accordingly. If the temperature of the heating pipe network is too high, it may lead to heat waste, while if the return water temperature is too low, it may affect the circulation efficiency and heat recovery effect of the heating system ^[11]. In addition to seasonal changes, when the weather changes, such as during the cold-hot alternation period, workers need to adjust the temperature in a timely manner. For example, during the day, the temperature difference between morning and evening is large, and users' requirements for temperature change rapidly. To ensure a suitable indoor temperature, the water supply temperature can be appropriately increased, and the return water temperature can be finely adjusted to maintain the stable operation of the heating system and efficient heat recovery. At noon, when the indoor temperature is relatively high, the water supply temperature can be appropriately reduced.

4.4. Discharging the gas in heating pipe networks to maintain the balance of the heating system

The accumulation of gas in the pipe network mainly comes from the gas dissolved in the water during system water replenishment and the external air entering the system when a vacuum is formed locally in the system. The presence of external gas has an adverse impact on the heating of the pipe network. Therefore, during the inspection process, workers need to regularly discharge the gas in the heating pipe network to reduce gas accumulation. The accumulation of a large amount of gas will occupy the narrow space of the pipes, reducing the flow channel of the heat medium and affecting the heat transfer efficiency. If the gas accumulates for a long time, bubbles or gas masses will form. The increase in their volume will limit the normal flow of the heat medium, hinder the heat transfer, and prevent the heat from being evenly and quickly transmitted to each heating area ^[12]. Long-term gas accumulation may also cause corrosion and damage to pipes and equipment, shortening their service life. In addition, the gas is closely related to the pressure balance of the heating system. During the heating process, the normal circulation of the heat medium requires the pipe network to maintain a certain pressure. Once gas is present, the pressure balance of the pipe network will be disrupted, causing the temperature and pressure in the area to be too high or too low, affecting the heating effect of the heating pipe network. Therefore, during the maintenance process, workers can use the discharge method to remove the gas in the pipes, open the normal flow channel of the heat medium, improve the heating effect, maintain the pressure balance, and prevent corrosion and damage to pipes and equipment. When performing the discharge operation, the following points need to be noted: First, select a suitable discharge location. Usually, the discharge point should be set at the high point of the pipe network or the position where gas is likely to accumulate. Second, reasonably control the discharge speed and time to avoid excessive fluctuations in the system pressure. Excessive discharge speed may lead to a sharp drop in system pressure, affecting the heating effect, while too slow discharge may not effectively remove the gas. Third,

workers should regularly check whether the discharge device is operating normally and discharging effectively to ensure its normal operation and effective discharge.

Disclosure statement

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Research on the Shaping of Central Enterprises' Overseas Low-Carbon Image Under the “Dual Carbon” Goals

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Abstract: This paper conducts an in-depth analysis of the shaping of central enterprises' overseas low-carbon image under the “Dual Carbon” goals. Firstly, the paper analyzes the significance of central enterprises in shaping a low-carbon image and the problems existing in the process. Subsequently, targeted strategies are proposed to help central enterprises effectively shape their overseas low-carbon image. The purpose of this paper is to provide valuable references for improving the global image of central enterprises, enhancing their influence, and promoting global sustainable development.

Keywords: “Dual Carbon” goals; Central enterprises; Overseas low-carbon image; Image shaping

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1. Introduction

Currently, global warming has become one of the common challenges faced by humanity, attracting widespread attention and emphasis worldwide^[1]. The proposal of the “Dual Carbon” goals, namely carbon peaking and carbon neutrality, is one of China's important measures to actively respond to global development trends and address climate change. Against this backdrop, as the main force driving China's economic development and participating in international competition, the shaping of central enterprises' overseas low-carbon image holds significant practical significance.

In the process of overseas development, central enterprises not only represent their own corporate image but also reflect the national image to a certain extent^[2]. A positive central enterprise image that practices the concept of low-carbon development and actively implements low-carbon goals can not only enhance the enterprise's own influence, help expand overseas markets, and achieve sustainable corporate development but also strengthen the international community's recognition of China's efforts in addressing global climate change, improve the national

image, and enhance China's influence and discourse power in global climate governance. However, central enterprises face numerous problems and challenges in shaping their overseas low-carbon image, such as the lack of scientific goal planning and insufficient integration with local communities. In this regard, under the background of the "Dual Carbon" goals, central enterprises should keep pace with the times and actively shape their overseas low-carbon image through various methods and means. This will not only enable enterprises to achieve their own sustainable development but also help shape a positive overseas image of the country, gain recognition from the international community, enhance China's influence and international status in global climate governance, and lay a foundation for China's sustainable development ^[3].

2. Significance of shaping the overseas low-carbon image of central state-owned enterprises (CSOEs) under the "Dual Carbon" Goals

Against the backdrop of the "Dual Carbon" Goals, it is of great practical significance for CSOEs to proactively shape their overseas low-carbon image. This paper briefly elaborates on the following aspects regarding this issue.

2.1. Enhancing international influence

Currently, global climate issues have become one of the topics of widespread concern in the international community, and the world is paying increasing attention to enterprises' performance in environmental protection ^[4]. As important representatives of Chinese enterprises, CSOEs' active efforts to shape an overseas low-carbon image can demonstrate China's attitude and determination in addressing global climate change to the world. This not only helps enhance the enterprises' international influence but also improves China's image on the international stage. For instance, China National Nuclear Power Co., Ltd. has actively engaged in international cooperation. In its overseas project practices, the company has earnestly pursued the "Dual Carbon" Goals, always adhered to the concept of environmental protection, and adopted a variety of measures to proactively shape a low-carbon image. These actions have made it well-received and recognized by overseas countries, won wide attention and approval from the international community, and significantly elevated China's international image and status in the field of global climate governance ^[5].

2.2. Promoting sustainable development

The achievement of the "Dual Carbon" Goals requires the joint efforts of all countries around the world. CSOEs' active shaping of a low-carbon image overseas can effectively drive the sustainable development of the local economy ^[6]. By introducing advanced green technologies and low-carbon management models, they can effectively improve resource utilization efficiency, reduce carbon emissions, and minimize damage to the local environment—thus laying a solid foundation for the sustainable development of the local economy. Take the overseas oil and gas business of PetroChina as an example. The company has earnestly practiced the low-carbon concept, applied green technologies and advanced low-carbon management models to build green oilfield projects, and provided strong support for local environmental protection and the sustainable development of the local economy.

2.3. Fulfilling social responsibilities

As the core force driving China's economic development, CSOEs inherently bear a strong sense of social responsibility and historical mission ^[7]. When carrying out projects overseas, proactively shaping a low-carbon

and environmentally friendly image is an important manifestation of fulfilling their social responsibilities. By practicing the low-carbon concept, alleviating local employment difficulties, and promoting local economic development, CSOEs can effectively gain the trust of local residents and the recognition of local governments, creating a favorable external environment for their own sustainable development. For example, in the practice of overseas projects, some CSOEs have actively participated in public welfare activities or launched public welfare projects, such as building roads and schools for local communities and providing high-quality medical assistance. These efforts have greatly improved the living conditions and quality of life of local residents, thereby establishing a positive overseas image of CSOEs.

3. Central state-owned enterprises (CSOs)' challenges in shaping an overseas low-carbon image

3.1. Unscientific target planning

Some CSOs lack scientific and clear target planning for shaping their overseas low-carbon image^[8]. Although certain enterprises have recognized the importance of low-carbon image building and put forward the “dual carbon” goals (carbon peaking and carbon neutrality), they lack feasible implementation plans and clear timelines. This makes it difficult to achieve the “dual carbon” goals smoothly. These goals are too vague and not refined, resulting in employees lacking clear guidance in specific projects and practices, and being unable to integrate low-carbon concepts into their daily work. Meanwhile, when formulating goals, some CSOs fail to fully consider local laws, regulations, and actual conditions, leading to a disconnect between their goals and the real needs of overseas markets. In addition, the target planning process lacks forward-looking thinking about the future development of the market and technological upgrading. When the overseas market environment changes, if the previous target plans cannot be adjusted and optimized in a timely manner, it will hinder enterprises in shaping their overseas low-carbon goals.

3.2. Insufficient integration with overseas local communities

When conducting business overseas, CSOs often face challenges in social culture, policy systems, and social environment, making it difficult to fully integrate with local communities and residents^[9]. In the practice of some projects, some CSOs lack an in-depth understanding of the local history, culture, and folk customs, and fail to fully consider the actual needs of local residents, which leads to numerous obstacles in project promotion. For example, some countries along the “Belt and Road” have little understanding of the project construction of certain CSOs, which has aroused concerns among local residents. They worry that the projects will damage the local environment, thereby affecting the shaping of the enterprises' overseas low-carbon image^[10].

3.3. Overly grand narrative discourse

In the process of international communication, the narrative discourse of CSOs is sometimes overly grand and lacks affinity. When promoting their low-carbon image, some enterprises tend to use a large number of professional terms in their narratives. Although this approach can highlight the professionalism of the enterprises, such a serious and rigid discourse style makes it difficult for overseas residents to understand and generate emotional resonance^[11]. Overseas residents are more in need of “easy-to-understand” language, and they are more concerned about the enterprises' actions in practicing the “dual carbon” goals and how these actions will affect their lives.

3.4. Difficulties in technology and capital

Successfully shaping the overseas low-carbon image of CSOs requires a large amount of capital investment and technical support. However, some CSOs often face difficulties with technology and capital in their overseas projects^[12]. On the one hand, the R&D cost of green low-carbon technology is high, and the pace of technological iteration is fast. Due to their limited scientific research capabilities and backward technical levels, some CSOs lack competitive green technologies in the overseas market. At the same time, some advanced green technologies are often held by Western enterprises. Introducing these technologies requires a lot of capital, and enterprises may also face issues such as technological blockades and intellectual property protection, which further increase the difficulty of obtaining green technologies. On the other hand, capital issues are also one of the important factors plaguing the shaping of CSOs' overseas low-carbon image. Generally, overseas projects have a long cycle and slow investment returns. Coupled with instability in regional political, financial, and other fields, CSOs find it difficult to obtain sufficient capital support, which seriously restricts the construction of their overseas low-carbon projects and the shaping of their low-carbon image.

4. Implementation paths for central state-owned enterprises (CSOs) to shape their overseas “Low-Carbon” image

4.1. Strengthen top-level planning

CSOs should formulate overseas low-carbon development plans in a scientific, systematic, and forward-looking manner from a strategic perspective^[13]. Firstly, based on actual circumstances, they should clarify specific indicators for the “dual carbon” goals (carbon peaking and carbon neutrality) in overseas projects, break these indicators down into sub-targets, and ensure their integration into daily operations. This provides clear guidance for employees to implement the goals in practice. Secondly, adequate preparatory work must be done when formulating target plans. Such preparations include conducting preliminary market research, understanding local laws and regulations, market development trends, and local customs. These steps ensure that the “dual carbon” goals are fully aligned with local conditions and possess practical operability. Meanwhile, target plans should also be forward-looking. As science and technology and the future overseas market continue to develop, CSOs should promptly adjust their target plans in accordance with market trends and technological upgrading directions. This ensures that CSOs maintain a leading position in shaping their overseas low-carbon image. In addition, CSOs should enhance internal coordination and management, defining the responsibilities and objectives of each department in the process of implementing low-carbon target plans. This guarantees effective communication and mutual collaboration among departments^[14]. Furthermore, low-carbon goals can be incorporated into the performance appraisal system. This measure fully stimulates employees' enthusiasm and initiative, laying a solid foundation for better implementing low-carbon concepts and achieving target plans.

4.2. Innovate communication methods

Against the backdrop of the “dual carbon” goals, it is essential for CSOs to innovate their communication methods to enhance communication effectiveness, thereby helping them establish a sound overseas low-carbon image^[15]. Firstly, CSOs can leverage social media platforms and use methods such as live broadcasts and short videos to showcase their low-carbon concepts, application of green technologies, and achievements made. This attracts the attention of overseas audiences and encourages them to abandon outdated perceptions. Secondly, CSOs can proactively organize and participate in cultural exchange activities. For instance, they can host low-carbon-themed

cultural exhibitions or special lectures, and invite industry practitioners, local governments, and the public to participate. This helps deepen the participants' understanding of CSOs' low-carbon concepts and implementation approaches. Besides, CSOs can build good relationships with overseas media organizations. By relying on local media, more local residents can learn about the enterprises' low-carbon goals and implementation plans, thereby expanding the reach of the enterprises' low-carbon image communication. At the same time, CSOs can regularly invite journalists to conduct on-site interviews of low-carbon projects. Through journalists' true and objective coverage, information about the enterprises' low-carbon image is conveyed to local residents. Finally, CSOs should optimize their communication content to make it locally relevant. They can develop targeted communication content based on local cultural backgrounds, language habits, and other characteristics. This ensures that the communication content is more in line with the preferences of local residents, thereby enhancing the affinity of communication.

4.3. Strengthening international cooperation

Central state-owned enterprises (SOEs) should also actively engage in international cooperation and establish stable cooperative relationships with well-known overseas enterprises, scientific research institutions, and other entities to jointly promote the research, development, and application of low-carbon technologies. Through in-depth cooperation, enterprises can introduce advanced low-carbon technologies and management models, thereby advancing the construction of low-carbon projects and enhancing their core competitiveness. For instance, they can cooperate with foreign energy enterprises to jointly carry out project construction and research and development of low-carbon technologies; they can also collaborate with international climate organizations to share the experience and data of central SOEs in low-carbon emission reduction, so as to promote the improvement of global climate governance. In addition, they should actively participate in the formulation of various international standards to enhance China's right to speak and influence in the global climate governance, low-carbon, and other related fields.

4.4. Intensifying environmental management

Central SOEs need to establish and improve the environmental management and supervision systems for overseas projects, and strengthen efforts in pollution discharge control and environmental protection. During the construction and operation of projects, they must strictly comply with local environmental protection laws, regulations, and standards to ensure that their production activities meet environmental protection requirements. For example, they should strengthen environmental monitoring and assessment of overseas projects to promptly identify and address environmental issues; promote the application of clean production technologies and processes to reduce pollutant emissions. At the same time, they should proactively respond to the challenges brought by climate change, formulate corresponding response strategies, and improve the enterprises' adaptability.

5. Conclusion

In conclusion, against the backdrop of the "dual carbon" goals (carbon peaking and carbon neutrality), central SOEs should fully recognize the importance of shaping an overseas low-carbon image, keep up with the trend of the times, and adopt various methods and means to build such an image. This will not only drive the sustainable development of the enterprises but also enhance the country's influence in the low-carbon field.

Disclosure statement

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Application and Development of Green Chemical Environmental Protection Technology in Industrial Production

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Abstract: Against the backdrop of accelerating globalization and the rapid advancement of global carbon neutrality goals, green environmental protection has become a core requirement for the development of various industries. Green chemical technology is playing an increasingly important role in reducing pollution and carbon emissions in industrial production. Taking chemical production as an example, traditional chemical production relies on fossil raw materials and high-energy-consuming processes, which easily lead to environmental pollution and resource waste. Strengthening technological innovation to achieve low-carbon production is extremely urgent. Especially under the background of the implementation of China's "dual carbon" strategy (carbon peaking and carbon neutrality), the green transformation of the chemical industry has become an inevitable trend. In this context, this paper explores the effective application of green chemical technology in industrial production. Starting from the concept, it gradually delves into its application value and finally explores specific implementation paths. It is expected to contribute to energy conservation and consumption reduction in industrial production, promote green and low-carbon development, and provide valuable references for other researchers.

Keywords: Green chemical environmental protection technology; Industrial production; Practical application

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1. Introduction

In the process of rapid economic development, China is facing major challenges in environmental protection. How to achieve economic growth while taking into account ecological issues and realizing environmental protection has become an important era task for all entities. Especially in the new era context, the proposal and promotion of concepts such as the community with a shared future for mankind, sustainable development, and green environmental protection ecology have put forward higher requirements for environmental protection. Enterprises are important entities in economic development and key participants in environmental protection. They should maintain a high sense of social responsibility, actively explore the effective application of green chemical

environmental protection technology in production to achieve energy conservation and emission reduction, while ensuring production efficiency and quality, developing green technologies, optimizing resource allocation, and realizing the dual improvement of economic development and environmental protection.

2. Overview of the concept of green chemical environmental protection technology

Environmental protection green chemical technology refers to the adoption of environmentally harmless and sustainable chemical manufacturing methods. It strives to reduce waste generation throughout the entire process of chemical production, improve resource utilization efficiency, so as to mitigate the negative impact on the environment, and integrate economic benefits with social benefits. It can be said that the application of environmental protection green chemical technology in the chemical industry demonstrates its characteristics of environmental friendliness, innovation, economy, sustainability, and social responsibility commitment.

Green chemical environmental protection technology features safety and environmental protection, renewability, and low carbon. In terms of safety and environmental protection: Green chemical environmental protection technology can control pollution from the source of production, realize low-toxic, non-toxic production, or pollution-free production. On the one hand, it reduces harm to the environment and human body; on the other hand, it can achieve the goal of safety and environmental protection through recycling and secondary utilization. Regarding renewability: It means replacing part of the raw materials with renewable materials in the chemical production process, which greatly reduces energy consumption and improves economic benefits, making it a win-win choice for both environmental protection and economic benefits. Low-carbon property refers to the ability to significantly reduce carbon dioxide emissions during the production process, which can effectively alleviate the greenhouse effect and promote the sustainable development of industry ^[1].

3. Value of green chemical environmental protection technology in industrial production

3.1. Conducive to improving resource utilization efficiency

Green chemical technology has significant advantages in improving resource utilization efficiency. It can realize the maximum utilization of resources by means of effectively optimizing process flows and other measures, thereby greatly enhancing the resource utilization rate. Specifically, in chemical production, it reduces the excessive use of raw materials and achieves precise batching through the principle of reaction kinetics to improve resource utilization efficiency. In addition, technical means can be applied to realize the integration of production processes. By reducing energy consumption, shortening reaction paths, and other ways, it improves the conversion rate of product raw materials and further reduces resource waste. Improving resource utilization efficiency is not only a requirement for green and environmentally friendly production, but also can effectively reduce production costs, form a positive cycle, and help enterprises achieve sustainable development.

3.2. Conducive to enhancing environmental protection effects

Green chemical environmental protection technology is characterized by environmental friendliness, technological innovation, and so on. Its application in the chemical production process can significantly reduce pollutant emissions, lower environmental load, and effectively enhance environmental protection effects. For example, green chemical environmental protection technology has positive value in waste gas treatment: in the production

process, abandoning traditional fossil fuels and adopting clean energy can effectively reduce the emission of harmful gases. In terms of wastewater treatment, technical means such as membrane treatment can be applied in a coordinated manner to accelerate the degradation of organic pollutants, so as to realize the efficient purification of wastewater and its recycling. As for solid waste, it can be reused or transformed into other substances to reduce resource waste. It can be said that green chemical environmental protection technology reduces the negative impact of chemical production from multiple aspects, such as soil and air, effectively protects the ecological environment, and realizes the simultaneous improvement of environmental protection and economic benefits.

3.3. Conducive to promoting the sustainable development of enterprises

The application of green chemical technology is beneficial for improving the economic benefits of enterprises. By optimizing the energy structure and building a recycling system, it reduces production costs. On this basis, enterprises can also rely on this system to coordinate industries in building a circular chain and extend the service life of resources. At the same time, the introduction of renewable clean energy reduces dependence on traditional energy, realizes the goal of energy conservation and emission reduction, and provides support for the sustainable development of the chemical industry. In addition, the application of green chemical environmental protection technology can also enhance the social image of enterprises, demonstrate their good sense of social responsibility and environmental protection awareness, thereby winning public recognition and trust, establishing a good brand image, and improving comprehensive competitiveness. In this way, it helps enterprises gain a firm foothold in the fierce market competition.

4. Application of green chemicals and environmental protection technology in industrial production

4.1. Optimizing the development steps of green chemical and environmental protection technology

First, screening of green chemical raw materials. For green chemical technology, the selection of raw materials is the first step in chemical production. It is necessary to investigate and analyze various factors that cause resource waste and environmental pollution during the processes of raw material extraction, processing, transportation, use, and waste gas treatment. Priority should be given to renewable resources, raw materials for water-based coatings, and other materials with strong degradability and low toxicity to replace traditional materials. This ensures the stability, economy, and environmental friendliness of raw materials, laying a solid foundation for the subsequent green chemical production processes. Second, emphasizing the selection of catalysts. In chemical production, catalysts play a crucial role in regulating the production process. Green chemical technology requires the selection or development of environmentally friendly catalysts, such as high-efficiency renewable enzyme catalysts, transition metal oxides, and non-metallic catalysts, to replace precious metal catalysts (e.g., biological catalysts). During production, relevant personnel should comprehensively consider the stability and activity of catalysts, as well as the practical needs for their recycling. For instance, designing magnetic separation catalysts facilitates the separation of catalysts after chemical reactions; these catalysts can also undergo activation treatment, reducing usage costs, lowering environmental risk, and improving the efficiency of chemical reactions, ultimately making chemical production more aligned with the concept of green environmental protection^[2]. Third, precise control of reaction conditions is a key breakthrough in the development of green chemical technology. From condition simulation to design and trial application, it is essential to conduct in-depth research on how the control of

conditions (such as pressure, temperature, reaction time, and material ratio) affects the conversion rate of reactants, and select the optimal suitable conditions. Additionally, external field assistance (e.g., ultrasound and microwave) can be used to improve product quality, enhance resource utilization, and reduce the hazards of side reactions. Furthermore, inhibiting side reactions is also an effective means to enhance the efficiency of green chemical technology. Relevant technical researchers can analyze reaction kinetics and mechanisms to optimize the reaction pathways in chemical production. For example, pH control can be applied to acid-base catalytic side reactions to reduce their occurrence, and reaction temperature can be controlled to avoid thermal decomposition side reactions. In the process of applying green chemical technology, enterprises should always adhere to the concept of green environmental protection, focus on improving resource utilization, and attach importance to the recycling and treatment of waste^[3]. The improvement of resource utilization can be achieved through energy-saving reaction methods, such as developing energy-saving process technologies, promoting new energy-saving equipment, and optimizing energy management to rationalize energy allocation. This not only enhances the resource utilization rate in chemical production but also reduces dependence on external energy sources. In terms of waste recycling and treatment, green chemical technology needs to adopt targeted and effective treatment technologies based on the characteristics and properties of the waste to ensure its harmless disposal^[4].

4.2. Realizing the diversified application of green chemicals and environmental protection technology in chemical production

First, clean production technology. As a vital component of the technologies adopted by green chemical and environmental protection enterprises, clean production technology aims to achieve the greening of chemical production processes through measures such as reducing pollutants and optimizing process flows. It can effectively mitigate the hazards caused by the discharge of wastewater, waste gas, and solid waste resulting from chemical production, and to a certain extent, reduce economic losses as well. It is evident that clean production technology plays a crucial role^[5]. For example, in chemical production, cleaner production technology can use water instead of organic solvents, greatly reducing the emission of harmful volatile gases from water-based coatings. Additionally, this technology focuses on optimizing production processes to minimize the generation of waste and wastewater at the source, thereby reducing environmental harm. It is also an effective way to meet market demand for green and environmentally friendly products. Second, biotechnology. Biotechnology also plays a highly important role in green chemical and environmental protection technologies. Utilizing biocatalysts such as microorganisms and enzymes to catalyze renewable raw materials enables the synthesis of degradable materials, thereby achieving green production^[6]. Take the production in the food packaging field as an example: polylactic acid (PLA), with its strong degradability and biocompatibility, can be used to produce packaging products that decompose into harmless substances in the natural environment. This reduces the pollution caused by traditional plastics. Such products also have the advantage of low production costs and higher overall cost-effectiveness, indicating broad development prospects. Biotechnology is, therefore, a key approach to promoting the sustainable development of the chemical industry. Third, green catalysis technology. Green catalysis technology is mainly reflected in the selection of environmentally friendly and efficient catalysts, which improves conversion efficiency and selectivity, thereby reducing the generation of by-products, lowering energy consumption, and realizing green production. For instance, compared with traditional noble metal catalysts, green catalysis technology converts biomass into biofuels, minimizing carbon dioxide emissions to the greatest extent. This not only demonstrates environmentally friendly characteristics but also enhances the quality of produced fuels, laying a foundation for the

secondary utilization of relevant energy sources ^[7]. Fourth, electrochemical synthesis technology. Electrochemical synthesis technology drives chemical reactions with electrical energy and achieves the goal of reducing pollutant emissions by lowering energy consumption during chemical reactions. In the chemical production process, enterprises can select electrode materials with properties such as stability and high activity, while strengthening the control of reaction conditions like temperature to ensure the reaction process is efficient and environmentally friendly, and avoid the generation of unnecessary waste. Moreover, compared with traditional chemical synthesis methods, this technology has more advantages in selectivity, and its reaction conditions are relatively mild. It can be widely applied in various fields, and thus also has extremely broad development prospects ^[8].

5. Development of green chemical and environmental protection technologies in industrial production

5.1. Strengthen scientific and technological innovation

Industrial enterprises should uphold the concept of keeping pace with the times, correctly understand green chemicals and environmental protection technologies, and enhance the promotion and application of these technologies, starting from their own operations. Specifically, enterprises should provide financial support for the innovation of green production technologies, actively introduce high-quality talents, establish specialized R&D institutions, and invite professional R&D teams. By combining their actual conditions and production needs, enterprises should develop higher-quality green chemical and environmental protection technologies, promote the transformation of technological achievements, effectively improve production efficiency, and implement the concept of green environmental protection. Enterprises must attach great importance to the training of in-service technical personnel, and provide them with opportunities for further study outside the company to learn from the successful experience of other enterprises. At the same time, they should strengthen the management of hardware facilities, provide advanced production equipment and R&D sites, and conduct timely optimization, updating, and maintenance to support technological innovation.

5.2. Provide policy guarantees

In recent years, the state has paid more attention to ecological and environmental protection work. Relevant government departments should perform their duties, guide local enterprises to apply green chemical and environmental protection technologies, and advocate green production ^[9]. Specifically, competent authorities should give full play to their functions, formulate targeted support policies based on the actual situation of local enterprises, and provide fiscal and tax preferential policies to assist enterprises in green production. Meanwhile, heads of government departments should conduct in-depth communication with enterprise managers to change their concepts, exchange opinions on technology promotion, and do a good job in internal publicity of enterprises. This will help more managers and employees recognize the value of green chemicals and environmental protection technologies and ensure the widespread application of these technologies.

5.3. Intensify technology application

In the process of applying green chemical and environmental protection technologies, the concept of ecological environmental protection should be implemented in practice, rather than being superficial or formalistic. Ecological environmental protection should be integrated into all links of industrial production. In production practice, enterprises should first select environmentally friendly materials to fundamentally reduce pollution.

Secondly, they should strengthen the monitoring link to ensure that every production process complies with environmental protection standards. Finally, they should do a good job in waste treatment, realize resource recycling, and form a complete closed-loop of green chemical production ^[10].

6. Conclusion

To sum up, against the backdrop of the new era, people's requirements for environmental protection and ecological friendliness have been further raised. For enterprises, strengthening the application of green chemicals and environmental protection technologies has become an important choice to conform to the pace of the times and meet the expectations of the era. The application of green chemicals and environmental protection technologies in industrial production has extremely high epochal value. It is not only conducive to realizing the efficient application of resources but also demonstrates a positive role in reducing pollution and promoting the sustainable development of the chemical industry, thus becoming an important technical support for the upgrading and transformation of the industry. In the process of practical application, enterprises should combine their actual production conditions and needs, select appropriate technologies, and achieve flexible application to realize clean chemical production and maximize economic benefits while ensuring environmental protection. At the same time, enterprises should also attach importance to the development of green chemicals and environmental protection technologies. Through optimizing application processes and promoting technological innovation, they can maximize the potential of green chemical and environmental protection technologies and drive the green development of the industry ^[11]. Looking forward to the future, green chemical and environmental protection technologies will continue to develop, showing higher application value and broader application prospects. Closely following the development trend of the chemical industry, these technologies will help enterprises achieve a win-win situation of improved economic benefits and ecological benefits, and promote the coordinated development of chemical production and ecological progress.

Disclosure statement

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Current Status and Influencing Factors of Professional Quality of Life Among Oncology Nurses

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Abstract: Objective: To evaluate the professional quality of life (ProQOL) of oncology nurses, analyze its current status and influencing factors, and thereby provide a scientific basis for improving nurses' ProQOL. Methods: A questionnaire survey was conducted among 202 oncology nurses from multiple general hospitals in Guangdong Province using a general information questionnaire, Professional Quality of Life Scale, and Short Form of Self-Compassion Scale. Results: The raw scores of compassion satisfaction (CS), burnout (BO), and secondary trauma stress (STS) in the ProQOL of oncology nurses were (32.88 ± 8.34) , (23.59 ± 6.25) , and (21.44 ± 7.30) , respectively. Multivariate analysis showed that the main factors affecting nurses' ProQOL included job environment satisfaction, job income satisfaction, and self-compassion. Conclusion: The overall ProQOL of oncology nurses is at a moderate level. Nursing managers and nurses themselves need to pay attention to the cultivation of self-compassion ability. In addition, medical institutions should improve the working environment, establish a reasonable scheduling and salary distribution system, etc., to create a good organizational atmosphere.

Keywords: Oncology nurses; Professional quality of life (ProQOL); Influencing factors

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1. Introduction

With the development of the social economy, people's lifestyles have undergone significant changes, and the incidence of tumors has been increasing year by year. Oncology nurses provide direct nursing services to patients, and their work is of great value. However, due to the particularity of oncology nursing, nurses face many challenges, which have a profound impact on their professional quality of life. Professional quality of life (ProQOL) refers to a series of psychological impacts on helpers (such as nurses) who are in close contact with or perceive the trauma and pain experienced by the recipients of their assistance during the process of providing aid services. It includes two dimensions: compassion satisfaction (CS) and compassion fatigue (CF) ^[1]. Compassion fatigue

consists of two aspects: burnout (BO) and secondary trauma stress (STS). Due to the particularity of clinical work, oncology nurses are at high risk of developing compassion fatigue ^[2]. Studies have shown that nurses with compassion fatigue symptoms are prone to physical and mental health problems, reduced ability to care for patients, increased nursing risks, decreased job satisfaction, and higher turnover rates ^[3]. This study intends to investigate the current status of ProQOL among oncology nurses and analyze its influencing factors, so as to provide a reference for preventing and alleviating nurses' compassion fatigue and improving the quality of clinical nursing in oncology departments.

2. Current status of professional quality of life among oncology nurses

In this study, the raw scores of each dimension of professional quality of life (ProQOL) for oncology nurses are presented in **Table 1**. The researchers converted the raw scores into standardized T-scores and compared them with the 25th percentile (T=43) and 75th percentile (T=57) of the norm ^[4]. The distribution of each ProQOL dimension level among the surveyed group is shown in **Table 2**.

Table 1. Raw scores of professional quality of life among oncology nurses (Score, Mean \pm SD)

Dimension	Minimum score	Maximum score	Total score	Average score per item
Compassion satisfaction (CS)	12	50	32.88 \pm 8.34	3.29 \pm 0.83
Burnout (BO)	10	39	23.59 \pm 6.25	2.36 \pm 0.63
Secondary trauma stress (STS)	10	50	21.44 \pm 7.30	2.14 \pm 0.73

Table 2. Distribution of each dimension level of professional quality of life among oncology nurses [n(%)]

Level	Dimension		
	Compassion satisfaction (CS)	Burnout (BO)	Secondary trauma stress (STS)
Mild (<43 points)	55 (27.2%)	60 (29.7%)	56 (27.2%)
Moderate (43~57 points)	92 (45.5%)	76 (37.6%)	102 (50.5%)
Severe (>57 points)	55 (27.2%)	66 (32.7%)	44 (21.8%)

The professional quality of life reflects the positive or negative psychological responses that nurses develop due to long-term exposure to cancer patients. Positive responses manifest as compassion satisfaction, which is beneficial to physical and mental health; negative psychological responses, on the other hand, are reflected in compassion fatigue, which can be specifically divided into two dimensions: job burnout and secondary trauma. Job burnout is mostly characterized by emotional exhaustion, depersonalization, and reduced personal accomplishment, often accompanied by persistent fatigue and resistance to work tasks. Secondary trauma stems from long-term exposure to patients' traumatic experiences, such as disease progression and end-of-life scenarios, leading nurses to indirectly develop post-traumatic stress responses, with symptoms including intrusive memories and emotional numbness ^[2]. When these two factors act together, they not only cause physical discomfort in nurses, such as headaches and gastrointestinal disorders, but also lead to sleep disturbances (e.g., difficulty falling asleep and early awakening). Additionally, they may induce emotional problems like anxiety and depression. In the long run, such accumulation will result in diminished professional enthusiasm, emotional indifference toward patients,

and even errors in nursing operations, directly threatening the quality of care and medical safety^[3]. This study shows that the overall professional quality of life of oncology nurses is at a moderate level: compassion satisfaction is above moderate, while job burnout and secondary trauma are below moderate. These results are consistent with the findings of studies conducted by Ma Ning, Chen Xiaocen, Ma Jinhong, and other researchers^[1, 3, 5]. Among the 202 nurses surveyed: The proportions of nurses with mild, moderate, and high levels of compassion satisfaction were 27.2%, 45.5%, and 27.2% respectively; The proportions of nurses with mild, moderate, and severe job burnout were 27.2%, 37.6%, and 32.7% respectively; The proportions of nurses with mild, moderate, and severe secondary trauma were 27.2%, 50.5%, and 21.8% respectively. The data suggest that the professional quality of life of oncology nurses still needs further improvement.

3. Influencing factors of oncology nurses' professional quality of life

3.1. Job environment satisfaction

Univariate analysis showed that there was no difference in the secondary trauma scores of oncology nurses regarding job environment satisfaction, but there were statistically significant differences in compassion satisfaction and job burnout scores. Further multiple linear regression analysis revealed that the level of job environment satisfaction is a key factor affecting compassion satisfaction and job burnout among oncology nurses. Specifically, the lower the nurses' job environment satisfaction, the higher their job burnout scores, and the lower their compassion satisfaction scores.

The job environment comprises both the physical environment and the organizational climate. The Conservation of Resources (COR) Theory suggests that if the work environment experienced by employees does not match their personal expectations, this "sense of inconsistency" will lead to employee burnout^[6]. Currently, there are relatively few domestic studies on the impact of environmental factors on nurses' professional quality of life. Gillet et al., through a study of 296 oncology nurses in Europe, found that long-term exposure to a work environment with chemical drugs, combined with a depressing work atmosphere, will gradually cause nurses to lose compassion and empathy. This seriously affects the physical and mental health of oncology nurses^[7]. Lin et al. obtained similar results in a survey of emergency department nurses in Taiwan, China^[8]. This indicates that nursing managers should gain a deep understanding of the negative effects of an adverse environment. For specific special departments, it is important to not only actively improve the physical environment of the ward but also create a positive organizational climate. Efforts should be made to care for nurses in their daily lives, enhance peer support, appropriately adopt incentive mechanisms, provide nurses with opportunities for further study and career promotion, and increase nurses' sense of belonging through empowerment. These measures can help improve nurses' satisfaction, thereby reducing burnout and enhancing compassion satisfaction.

3.2. Job income satisfaction

Income is the economic reward for employees' work efforts, and the level of salary has a significant impact on employees' work engagement and job satisfaction. Univariate analysis in this study showed that there was no difference in the secondary trauma scores of oncology nurses in terms of job income satisfaction, but there were statistically significant differences in compassion satisfaction and job burnout scores. Further multiple linear regression analysis indicated that the level of job income satisfaction is a major factor affecting compassion satisfaction among oncology nurses, but it has no impact on job burnout or secondary trauma. Previous studies

have shown that nurses with lower income levels face a higher risk of compassion fatigue ^[5]. All respondents in this survey were nurses from hospitals in economically developed regions, with relatively stable income levels. Therefore, the level of job income satisfaction is more reflected in its impact on compassion satisfaction. The increase in job income represents social recognition of the nursing profession and is an important aspect of nurses' self-worth realization. This reminds nursing managers to pay active attention to this issue and appropriately improve nurses' salary levels and welfare benefits.

3.3. Monthly night shifts

Univariate analysis showed that the number of monthly night shifts had no significant difference in the secondary trauma scores of oncology nurses, but there were statistically significant differences in the scores of compassion satisfaction and job burnout. Further multiple linear regression analysis revealed that the number of monthly night shifts was one of the factors affecting the job burnout of oncology nurses—specifically, the more night shifts nurses worked, the more likely they were to experience job burnout. However, it had no impact on compassion satisfaction or secondary trauma. Research findings on the impact of rotating night shifts on nurses' professional quality of life (ProQOL) are inconsistent. Studies by Ma Shu and Liu Qian indicated that ICU nurses who worked more night shifts were prone to job burnout and secondary trauma, and had lower levels of compassion satisfaction ^[9–10]. In contrast, a study by Liu Minghui et al. showed that the number of monthly night shifts had no effect on the ProQOL of oncology nurses ^[11]. This discrepancy is believed to result from differences in the intensity of night shifts across different departments. Nevertheless, a large body of previous research has demonstrated that rotating night shifts disrupts an individual's circadian rhythm, impairs sleep quality, and can lead to autonomic nervous system and endocrine disorders. This indirectly increases nurses' risk of developing diseases and exerts adverse effects on their physical and mental health. Therefore, nursing managers should pay close attention to the health status of rotating-shift nurses: reduce high-frequency shift rotations, ensure adequate post-night-shift rest, and adopt reasonable scheduling methods (e.g., avoid long-term shift rotations for older nurses). These measures help nurses find an optimal balance between shift work and health, and mitigate the impact of shift-related diseases.

3.4. Self-compassion

Self-compassion, first proposed by psychologist Professor Neff in 2003, refers to an individual's ability to face the suffering and failure they are experiencing directly (without avoidance) and regulate emotions to alleviate pain by maintaining a kind and tolerant attitude toward themselves at all times ^[12]. It comprises three components: Self-kindness: When facing suffering or failure, individuals treat themselves with acceptance and tolerance, rather than harsh self-criticism. Common humanity: Individuals perceive their own suffering as a universal experience shared by all humanity, instead of viewing themselves as isolated victims. Mindfulness: Individuals observe current physical and mental phenomena (including sensations, emotions, and thoughts) with a balanced awareness—neither avoiding nor over-identifying with them. Studies have found that self-compassion is positively correlated with individuals' mental health, adaptability, and sense of well-being, while being negatively correlated with negative emotions such as stress perception, anxiety, and depression ^[13–15]. Correlation analysis in this study showed that the total score of self-compassion of oncology nurses was closely correlated with their scores in all dimensions of ProQOL. Further multiple linear regression analysis indicated that self-compassion had an impact on all dimensions of oncology nurses' ProQOL, with the strongest effect observed on job burnout and secondary trauma. This result is consistent with the findings of Ma Ning, He Yiqing, Abdollahi, and other researchers ^[16–17].

It suggests that self-compassion, as a positive self-attitude or emotional regulation method, can help nurses effectively convert negative emotions into positive ones, which is conducive to maintaining their mental health.

4. Summary

In conclusion, the ProQOL of oncology nurses is at a moderate level, with the following factors influencing it: Self-compassion affects all three dimensions of ProQOL, with the most significant impact on job burnout and secondary trauma. Job environment satisfaction, job income satisfaction, and the number of monthly night shifts also exert a certain influence on nurses' ProQOL. Nursing managers and nurses themselves need to focus on cultivating self-compassion skills. Meanwhile, medical institutions should take institutional measures: establish a reasonable nurse salary distribution system, a performance evaluation mechanism, and a scheduling system; create a positive organizational atmosphere; and prevent the occurrence of compassion fatigue among nurses. This study has limitations: it only included oncology nurses from selected general hospitals in Guangdong Province, resulting in a relatively small sample size. Additionally, the Short Form of Self-Compassion Scale (SCS-SF) was used, and its limited number of items prevented an in-depth analysis of the relationship between each dimension of self-compassion and ProQOL. It is recommended that future studies improve research tools and expand the scope of investigation to more accurately and comprehensively reflect the current status of oncology nurses' ProQOL and its influencing factors.

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Study on Medication Safety of Chronic Diseases in Middle-aged and Elderly People and Its Influencing Factors under the Background of Accelerated Aging

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Abstract: With the accelerating global aging trend, the issue of medication safety for chronic diseases in middle-aged and elderly people has attracted widespread attention from all walks of life. Focusing on the context of accelerated population aging, this study explores and analyzes the medication safety of chronic diseases in middle-aged and elderly people and their influencing factors. The study first analyzes the relevant background and expounds on the global aging challenges, then discusses the core issues of medication safety, the biological-social-medical three-dimensional factors affecting medication safety, and innovative intervention strategies, hoping to provide some reference for relevant personnel.

Keywords: Accelerated aging; Chronic diseases in middle-aged and elderly people; Medication safety; Influencing factors

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1. Introduction

At present, the world has entered an aging era, and the accelerating process of population aging has led to a continuous increase in the number of middle-aged and elderly patients with chronic diseases ^[1]. In this context, the issue of medication safety for chronic diseases in middle-aged and elderly people has become a social topic. It can be seen that due to the characteristics of physical decline and complex medication use faced by the middle-aged and elderly groups, they often need to take medication in strict accordance with the standards of safe medication management during the treatment of chronic diseases ^[2]. However, in reality, their medication safety is affected by multiple factors. Therefore, it is imperative and timely to deeply explore the safety and influencing factors, and explore effective intervention strategies.

2. Research background and global aging challenges

Since the beginning of the new century, the process of population aging has been accelerating, which has also brought huge challenges to the medical and health systems of various countries^[3]. For the middle-aged and elderly groups, due to factors such as declining physical functions, they have become a high-risk group for chronic diseases. In the process of their medication use, safety issues have also become a key topic of concern in the field of medicine and health care in various countries. Generally speaking, the treatment of chronic diseases requires the use of multiple drugs, which directly increases the risk of medication safety for the middle-aged and elderly groups. In China, the proportion of middle-aged and elderly people suffering from chronic diseases is relatively high. Common ones include coronary heart disease, diabetes, and hypertension. These patients not only need to take medicines for a long time but also take multiple kinds of medicines, which directly forms the safety dilemma of “polypharmacy”^[4]. Secondly, in the context of polypharmacy, various drugs are prone to having some adverse mixed reactions. If this situation is not taken seriously, it will definitely bring direct health threats to middle-aged and elderly people^[5]. In addition, middle-aged and elderly patients with chronic diseases often have the problem of “medication overload” during the medication process, which reflects an inherent contradiction between “disease treatment needs” and “physiological tolerance.” How to balance this contradiction has become a paradoxical issue that needs in-depth thinking and scientific response in the medication process of middle-aged and elderly patients with chronic diseases^[6].

3. Core issue of medication safety: Potentially inappropriate medication (PIM)

Potentially inappropriate medication (PIM) has a direct impact on the medication safety of middle-aged and elderly people with chronic diseases. Due to its strong harm and concealment, it has become a “key pain point” in medication safety and a key research content in the field of geriatric medicine and health in various countries.

3.1. Definition of PIM and innovation of assessment tools

For PIM, it mainly refers to the potential risk of drug use in middle-aged and elderly people during medication due to the influence of drug characteristics, physiological changes, and pathological conditions. It mainly includes excessively long treatment courses, improper dosage, unreasonable drug selection, etc., which will also lead to serious adverse reactions in patients. The Beers Criteria (2019 edition) issued by the American Geriatrics Society (AGS) is the main application tool for current PIM assessment. It clarifies more than 100 high-risk drugs, such as anticholinergic drugs, and has been applied in various fields of medical and health care, such as hospitals and communities. In 2017, based on this standard and the medication characteristics of Chinese residents, China issued the “Chinese Catalog of Potentially Inappropriate Medication for the Elderly”, which supplemented and standardized relevant contents, adding standards related to the safety risks of medication for the elderly in China, such as insufficient dosage adjustment of vancomycin. This is also in line with the disease spectrum standards for the management of diseases in the elderly in China^[7].

3.2. Epidemiological map of PIM

Looking at the global occurrence of PIM, there are obvious differences among various countries, which also reflect the differences in population structure, social economy, and medical systems in various regions. Generally speaking, the incidence of PIM in developing and developed countries shows a “polarized” characteristic^[8]. At the same time, PIM “high-risk drugs” also have obvious regional common characteristics. For example, drugs such as

benzodiazepines (such as diazepam) appear in the PIM maps of various countries and are among the top. In China, due to the different medical culture, the PIM value caused by the combination of traditional Chinese medicine injections and western medicine is relatively high, which is also a regional characteristic ^[9]. For example, some elderly people often have the wrong idea that traditional Chinese medicine is non-toxic and take some traditional Chinese medicine by themselves, which leads to damage to their physical functions and organs.

4. Bio-social-medical three-dimensional factors affecting medication safety

4.1. Decline in physiological functions: The “Aging Trap” in pharmacokinetics

As middle-aged and elderly people grow older, their bodily functions will experience a certain degree of “decline”, which will directly lead to disorders in the healthy operation of their bodily systems, thereby having a direct impact on issues such as drug metabolism and absorption. In terms of the absorption process, for example, the gastric acid secretion of the elderly over 60 years old is nearly 30% less than that of young people, and at the same time, the pH value of the stomach will increase. This will affect the absorption of some weakly acidic drugs such as digoxin, making them unable to exert their actual efficacy ^[10]. In addition, the increase in age will also lead to a decline in the gastric motility of middle-aged and elderly people, which will also affect their drug absorption. For instance, when taking fat-soluble drugs (such as vitamin D), insufficient gastric motility may cause drug residues, which can easily lead to drug poisoning and other problems. Secondly, in terms of metabolism and excretion. Take the elderly over 60 as an example: their liver blood flow is significantly less than that of young people, and the activity of liver drug-metabolizing enzymes also decreases significantly, which makes the effect of drug metabolism less than ideal. Meanwhile, the renal function of the elderly will decline to varying degrees, which will greatly reduce their drug excretion capacity. For example, when taking metformin, the half-life of renal drug excretion in people over 80 years old is 2 to 3 times longer than that in young people, which directly increases the risk of nephrotoxicity. Under such circumstances of “slow metabolism + delayed excretion”, even if the dosage of drugs taken by middle-aged and elderly people is relatively reasonable, there will still be a certain degree of “hidden overdose” ^[11].

4.2. Patient behavior risk chain: from cognitive bias to operational errors

The medication risks for middle-aged and elderly patients with chronic diseases are directly related to deviations in their own cognition. The logical relationship can be summarized as the “cognition-attitude-behavior” risk chain, where inattention to any link can trigger corresponding risk issues. Firstly, at the cognitive level, many middle-aged and elderly patients with chronic diseases have “cognitive errors”. For example, some people do not know the difference between prescription drugs and over-the-counter drugs, and some think that taking medicine before or after meals is the same. Such cognitive errors directly affect their medication safety ^[12]. Secondly, at the attitudinal level, some middle-aged and elderly patients with chronic diseases have a “fluke mentality.” For instance, some believe that missing a dose or two or skipping medication occasionally is irrelevant, or some take the initiative to stop medication once their condition improves. Such incorrect attitudes towards medication have a huge negative impact on symptom relief and disease cure. Furthermore, there is “execution deviation” in behavior. For example, some middle-aged and elderly patients with chronic diseases fail to take medication as prescribed due to memory errors or misreading of dosages, which also affects their medication safety and disease treatment.

4.3. Defects in the healthcare system: “Superimposed loopholes” from prescription to supervision

The development of things is influenced by multiple factors. The medication safety issues of middle-aged and elderly patients with chronic diseases are not only affected by factors such as the decline of patients’ own physiological functions and behavioral risk chains, but also related to the inadequate performance of duties by “gatekeepers” within the healthcare system. Firstly, in the prescription drug link, differences in the capabilities and professionalism of medical personnel may lead to variations in the prescription drugs they issue to patients. This directly results in problems such as “repeated medication” and “antagonistic medication”, which in turn increase the incidence of potentially inappropriate medication (PIM). Secondly, there are inadequacies in the supervision link. For example, supervision in some areas of prescription drugs and health supplements is insufficient. In some remote regions, drugs that have not undergone suitability reviews or have expired are even prescribed to patients, which obviously poses a huge threat to patients’ medication safety. Furthermore, there is a problem of “information asymmetry” in doctor-patient communication. Relevant medical personnel do not fully consider the limitations of elderly chronic disease patients in terms of memory, eyesight, etc., and fail to clarify their medication information. This makes it easy for patients to make mistakes and improper operations during medication, which in turn affects the specific efficacy of their disease treatment.

5. Innovative intervention strategies: From precision pharmacy to smart healthcare

5.1. Pharmacokinetic-oriented precision drug administration

For the issue of medication safety in elderly patients with chronic diseases, a reasonable “tailor-made” medication is the most direct approach. To this end, precision drug administration can be conducted based on pharmacokinetics to comprehensively improve the safety of patients’ medication. Firstly, the development of genetic testing technology has also provided an effective opportunity for this ^[13]. For example, patients with the CYP2C9*3 genotype have a relatively low ability to metabolize warfarin. If medication is administered according to the conventional dose, it is easy to cause bleeding after medication. The application of the warfarin dose algorithm based on CYP450 genetic polymorphism can effectively reduce the incidence of bleeding after medication in patients. Based on this, relevant personnel have also developed corresponding drug administration models, such as the clopidogrel dose adjustment model. Through such adjustments, the resistance of medication to platelets is improved, thereby effectively reducing cardiovascular-related adverse reactions in elderly patients with chronic diseases after medication. Secondly, it is the effective monitoring of physiological indicators. For example, portable blood drug concentration detectors can be used to effectively monitor the physical conditions of elderly patients with chronic diseases, focusing on the concentrations of drugs such as digoxin. Then, the information can be sent to the medical terminal through digital transmission, and relevant personnel can carry out precise drug administration based on this, thereby greatly reducing the risk of drug poisoning.

5.2. Deprescribing campaign: A subtractive medication revolution

“Deprescribing” is not simply the cessation of drugs, but is based on the concept of optimizing the effect of drug use, reducing the dosage of some unnecessary drugs, so as to ensure the effect of medication while fully reducing the medication risk of elderly patients with chronic diseases. Medical personnel in Canada have made many attempts in this regard. For example, in accordance with relevant standards, they use methods such as STOPP (Screening Tool of Older People’s Prescriptions) to effectively evaluate the medication lists of elderly patients

with chronic diseases, and reasonably set their drug intake, so as to reduce medication safety issues. For China, in this field, people should pay attention to the characteristics of local medication. For example, in view of the high market share of generic drugs, corresponding standards and plans should be formulated based on the differences in drug efficacy^[14]. Meanwhile, for the psychological issues that some elderly people experience after reducing or stopping their medication doses, adjustments and optimizations can be made using the method of “low-dose administration + reasonable alternative schemes.” This helps elderly patients with chronic diseases dispel their doubts and effectively ensures the safety of their medication.

5.3. Application of smart pillboxes: Technology empowering medication adherence

With the continuous development of artificial intelligence technology, the field of medical medication has also ushered in new reform opportunities. In this context, relying on smart pillboxes to reduce medication safety issues in elderly patients with chronic diseases has become an important development trend in the future. The Japanese Panasonic Group has made practical attempts in this regard. The “age-appropriate smart pillbox” developed by them can effectively identify the condition of patients with chronic diseases, and prompt the dosage and time of drug use in a timely manner. If the medication or drug collection is not in accordance with the set standards, it will directly send the information to the doctor’s port. At the same time, it will also adjust the patient’s medication in real-time based on the doctor’s update of the patient’s condition, so as to make the medication of elderly patients with chronic diseases safer and avoid medication errors caused by their memory decline and other reasons. However, it should be noted that the promotion of this method is mainly restricted by issues such as cost, technology, and privacy. Therefore, relevant units and researchers should accelerate the breakthrough of relevant cost and technical shackles and improve the privacy protection function of the system, so as to enable technology to empower medication adherence.

5.4. Blockchain + AI early warning system: building a full-chain safety network

The integration of blockchain technology and an AI early warning system can also further improve the medication safety chain and effectively reduce risks in various links. For example, the EU’s “EU(7)-PIM List” system integrates PIM standards from multiple countries in the region, then incorporates them into electronic medical records, intelligently calculates medication lists based on patients’ medication history and their own diseases, and timely issues warnings for operations with high medication risks, and prompts alternative plans. In this regard, people can learn from this and accelerate the construction of a “national PIM database + regional electronic medical record blockchain.” Through this way, people can effectively improve the interception rate of PIM in communities, medical and other fields, make up for the differential shortcomings of medical personnel in professional capabilities, and further ensure the medication safety of elderly patients with chronic diseases^[15].

6. Conclusion

In summary, with the accelerating aging process, the issue of medication safety for middle-aged and elderly patients with chronic diseases has become a hot topic of concern worldwide and among the general public. In response, it is necessary for people to, while grasping this general background, conduct in-depth analysis of the core issues of medication safety, clarify the biological-social-medical three-dimensional factors affecting medication safety, and on this basis, rely on effective countermeasures to further reduce the medication risks for middle-aged and elderly patients with chronic diseases, laying a solid foundation for their better medication use, rehabilitation, and life.

Disclosure statement

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Research on the Effective Strategies of Minnan Puppet Performance Game: Based on the Survey of Q Kindergarten in Quanzhou City, Fujian Province

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Abstract: As a national intangible cultural heritage, Minnan puppet art is not only an important carrier of the continuous extension of Chinese civilization, but also a witness of the same origin on both sides of the Taiwan Straits. As one of the important activities in the implementation of the garden-based course, the Minnan puppet performance game takes the inheritance of the Minnan puppet art as the core, and promotes the harmonious development of children's body and mind as the starting point and destination. Therefore, this article in the Minnan puppet game characteristics and on the basis of the value, combining the development of the Minnan puppet game, from universities, kindergarten and parents to further explore the Minnan puppet game effective strategy, for Minnan kindergarten reference and ideas, in order to realize the Minnan puppet art in the field of preschool education of creative transformation and innovative development.

Keywords: Minnan puppet art; Minnan puppet performance games; Garden-based course; Cultural inheritance

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1. Concept definition

Southern Fujian Puppet Performance Games refer to gameplay activities conducted in kindergartens in southern Fujian, with the core objective of inheriting the art of southern Fujian puppets. These activities aim to promote the harmonious physical and mental development of young children. Using string puppets and glove puppets made from recycled and handmade materials as media, children manipulate the puppets to perform. These games retain the traditional form of southern Fujian puppet performances behind a curtain and create story themes based on children's favorite stories or life experiences.

2. Characteristics of Minnan puppet performance games

2.1. Folk art adapted for children

“Folk Art Adapted for Children” is a process based on and focused on children to promote their development. In the implementation of Minnan puppet performance games, teachers should consider children’s existing development levels and interests to promote their comprehensive physical and mental development. Teachers eliminate the adult culture from Minnan puppet art and select content that suits children’s physical and mental development characteristics and is educationally meaningful, because human growth is a continuous process of improvement guided by meaning within a cultural environment, such as simplifying the strings on marionettes to facilitate children’s manipulation skills and further promote the development of their fine motor skills in their hands ^[1].

“Folk Art Adapted for Children” returns folk art to the perspective of cultural heritage and children’s lives. Life-orientation is a common feature of kindergarten curricula and Minnan puppet art. When designing and organizing Minnan puppet performance games, teachers should choose both activities that children love and content from Minnan puppet art that is closely connected to children’s actual living conditions and close to their lives. For example, many Minnan puppet theater performances promote moral education, which may be difficult for young children to fully understand. Therefore, teachers and children create stories based on their life experiences as themes for Minnan puppet performance games.

2.2. Localization of educational resources

One soil nurtures one kind of people. Young children learn and develop through their interaction with the environment; thus, their comprehensive development must be achieved in a “local” environment ^[2]. Children learn and develop through interaction with their environment, so their comprehensive development must be achieved in a “local” environment. Kindertartens implement Minnan puppet performance games based on local traditional cultural resources. Before the games begin, kindertartens fully utilize parent and community resources, adopting the approaches of “going out” and “bringing in” to lead children to visit intangible cultural heritage inheritor workshops and puppet museums, watch puppet performances, make puppet costumes, carve puppet heads, etc., allowing children to be influenced by the authentic local cultural environment. Additionally, teachers, parents, and children work together to create a kindergarten environment and regional environment with Minnan puppet characteristics, such as setting up puppet performance stages and decorating puppet-themed walls, to inspire children to “re-express” excellent local traditional culture in an “puppetized” environment.

2.3. Class-based game implementation

Each class has different circumstances, and teachers have different professional qualities and strengths, so the implementation of Minnan puppet performance games fully reflects class-based game implementation. Teachers in each class, based on the interests, needs, and development levels of the children in their class, fully tap into the professional advantages and personal strengths of parents, organize parents and community resources for puppetized environment creation, set up small puppet performance stages, create scripts, make props, record voiceovers, etc., to attract children and parents to actively participate in Minnan puppet performance games.

3. The value of southern Fujian puppet performance games

3.1. Value for children’s development

Traditional culture aligns with children’s developmental characteristics and is acceptable to them. The essence

of cultural confidence being implemented in education is the issue of cultural identity^[3]. Traditional culture is a cultural form that conforms to children's developmental characteristics and is acceptable to them. At the same time, it carries a strong national identity and can cultivate children's preliminary cultural identification. Implementing southern Fujian puppet performance games is an effective way for children to internalize the art of southern Fujian puppets. Through perception, understanding, and manipulative interaction, children acquire knowledge of this art, enhancing their sensitivity to their hometown's traditional culture and stimulating their sense of identity and belonging to the excellent traditional culture of their hometown. This process also inherits the art of southern Fujian puppets.

Biologist Grus believed, "It should not be solely attributed to their youth that children play; it should also be recognized that it is through play that children are endowed with the life of childhood." In southern Fujian puppet performance games, children organize peers, discuss performance themes, set performance rules, make puppet props, and recruit more viewers according to their own ideas. Each child has their own role in this game, fully exerting their strengths and promoting the development of autonomous learning abilities.

Play is the primary learning method for young children, and they develop through it. In southern Fujian puppet performance games, children need to use their imagination and creativity to create puppet characters and story lines to drive the game's progression. This is based on their existing aesthetic experience of southern Fujian puppet art and involves expressing and creating beauty. At the same time, children manipulate puppets while engaging in dialogue with the characters, greatly enhancing their language expression abilities and hand-eye coordination. Additionally, through observing characters in the games, children understand their personalities, distinguish right from wrong, and subtly grasp social moral norms, thereby developing good moral qualities.

3.2. Value for teachers' development

Teachers receive limited education on southern Fujian puppet art during pre-service training. Therefore, the implementation of southern Fujian puppet performance games in kindergartens will, to a certain extent, prompt teachers to actively seek out, learn, and absorb the essence of southern Fujian puppet art, extracting content most suitable for children's learning. This process also subtly enhances teachers' traditional cultural literacy, awakens their initial cultural awareness, and strengthens their cultural confidence.

3.3. Value for kindergarten curriculum development

Kindergarten curricula rooted in local culture aim to fill the curriculum with life value, meaning, and realism, returning the curriculum form to its essential life nature. By considering their own realities, the cultural environment of the children, and their physical and mental developmental characteristics, kindergartens combine the regionally distinctive art of southern Fujian puppets to conduct puppet performance games. This allows children to truly comprehend and understand their southern Fujian puppet cultural environment, aligning with children's life development and realizing their respect, liberation, and return to life.

3.4. Value for social development

Southern Fujian culture is an important branch of traditional Chinese culture and a shared root culture across the Taiwan Strait. Southern Fujian puppet art is an outstanding representative of southern Fujian culture. It fully leverages the role of school education in shaping national identity and promoting cultural identity, and it is a crucial means of fostering the consensus of "both sides of the strait are one family" and promoting the

peaceful reunification of the motherland. People increasingly recognize that cultural identity is the foundation for the Chinese nation to settle down and live, and it is also the cultural psychological basis for achieving great rejuvenation.

4. Key points for the implementation of Minnan puppet performance games

4.1. Taking children as the main body and emphasizing their participation

Teachers fully respect children's subject status in games and create spaces for children to make independent choices, freely explore, and self-construct in Minnan puppet performance games. In terms of game theme selection, peer teaming, role assignment, and plot adaptation, children organize the game according to their own ideas, maximizing their autonomy. They are the masters of the game.

4.2. Strong internal and external support

Environment creation: On the one hand, in terms of the overall planning of the kindergarten environment, educators should base themselves on reality to create an integrated, distinctive, and "puppet-oriented" campus environment. On the other hand, in terms of class environment creation, teachers utilize parental resources to create a suitable educational environment for Minnan puppets according to the characteristics and needs of the children in their class, such as puppet-themed walls, class puppet corners, and class puppet performance stages.

Institutional support: To advance the progress of the Minnan puppet kindergarten-based curriculum, the kindergarten has formulated detailed and specific conventional requirements, such as conducting Minnan puppet performance games at least once a week. The kindergarten's systems and conventional requirements strengthen the management of the kindergarten-based curriculum, guiding teachers to closely integrate the development and implementation of Minnan puppet performance games with daily education and teaching work, integrating characteristics into the curriculum and highlighting them in curriculum implementation.

Teacher training: Based on the continuous deepening and development of Minnan puppet performance games, to strengthen the construction of the teaching staff, the kindergarten mainly adopts methods such as inviting intangible cultural heritage inheritors to conduct in-kindergarten training, sending teachers for external learning, and participating in kindergarten-based training to carry out teacher development work, consolidating teachers' learning outcomes and enabling them to grow through training.

Community collaboration: Kindergartens use the methods of "bringing in" and "going out" to shorten the distance between Minnan puppet art and children. For example, during the puppet art festival, they invite troupe members to perform in the kindergarten, visit puppet museums, explore artisan studios, watch puppet performances, and learn puppet making, enabling children to develop a sense of national cultural identity and pride through interaction with puppets.

5. Strategies for effectively conducting Minnan puppet performance games

5.1. Universities

Universities in the Minnan region are the primary source of kindergarten teachers. Therefore, universities should organically combine the cultivation of high-quality kindergarten teachers with the cultivation of professionals in ethnic education to promote the development of preschool education in the Minnan region and the inheritance and development of Minnan traditional culture. Universities should incorporate Minnan puppet art courses

into the curriculum of preschool education majors, with frontline kindergarten teachers and inheritors of the puppet intangible cultural heritage serving as instructors. This will inevitably encourage kindergarten teachers to consciously promote and disseminate Minnan puppet art in educational activities and conduct Minnan puppet performance games.

5.2. Kindergartens

Strengthen kindergarten-based curriculum management: As curriculum action researchers, teachers need to fully participate and engage in curriculum implementation, reflecting and learning from continuous curriculum practice, observation, and communication to improve their professional quality and enhance their curriculum practice experience.

Establish a kindergarten visit system: Kindergartens should establish a corresponding visit system and encourage parents to visit the kindergarten more often. On the one hand, this will enable parents to better understand the kindergarten's philosophy of Minnan puppet art education and deepen their understanding of Minnan puppet performance games. On the other hand, parents can better understand their children's existing development level and provide more effective and feasible suggestions for improving activities during game participation, rather than just inviting parents to the kindergarten for major events and having them participate in a perfunctory manner.

Broaden teachers' professional growth paths: The professional competence of kindergarten teachers affects the effectiveness of educational activities. Therefore, teachers should strengthen their professional competence through professional development and practical reflection. First, teachers should re-evaluate their strengths and weaknesses. For example, when teachers realize their lack of knowledge about Minnan puppet art, they can utilize spare time to borrow documents and materials from Minnan local museums and libraries to continuously expand their knowledge. Based on the existing experience in developing kindergarten-based curriculum resources, teachers should enhance their ability to deeply explore Minnan puppet kindergarten-based curriculum resources. Additionally, when organizing Minnan puppet performance games, teachers should also emphasize the importance of reflection, continuously reviewing various game stages and children's existing experience, and strive to improve the suitability, innovation, continuity, and integration of Minnan puppet performance games in analysis and summary to gradually enhance their professional competence.

Strengthen teachers' kindergarten-based teaching and research: The deep exploration of Minnan puppet art in Minnan puppet performance games requires teachers of the teaching and research team to discuss together and make the content of teaching and research specific. For example, how to retain Minnan local cultural symbols on Minnan puppet props? How to use Minnan dialects in Minnan puppet performance games? What kind of theme should be chosen to embody the spiritual connotation of traditional Chinese culture and be close to children's existing life experience? Effective kindergarten-based teaching and research activities can exercise and improve the overall ability of the teacher team, and a high-quality teacher team can promote the continuous in-depth development of kindergarten-based teaching and research.

5.3. Parents

The family is the best place to shape a person, and whether traditional culture can be integrated into family education has a profound impact on individual growth and the inheritance and development of traditional culture. The family should serve as the frontier for inheriting and developing traditional culture and shoulder the task

of transmitting traditional culture. On the one hand, teachers should help parents recognize the importance and possibility of conducting Minnan puppet art education in the family and guide parents to step out of the misconception of traditional concepts and increase their enthusiasm for participating in family traditional culture education. On the other hand, parents can use the Internet to search for information and visit folk museums to deepen their understanding of Minnan puppet culture and create a good material and psychological environment for the family to conduct Minnan puppet performance games.

6. Conclusion

Implementing Minnan puppet performance games in preschool education has a profound impact on children's comprehensive development, teachers' professional growth, and the inheritance of traditional culture. Universities in the Minnan region, inheritors of the intangible cultural heritage of Minnan puppet art, kindergartens, and parents need to cooperate fully to continue exploring effective strategies for carrying out Minnan puppet performance games in kindergartens, in order to realize the continuous development of Minnan puppet art in preschool education.

Disclosure statement

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Reference

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A Comparative Study on Governance Models of World-class Scientific and Technological Societies and Their Enlightenment to China

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Abstract: This study comparatively analyzes governance models of scientific and technological societies across Anglo-Saxon, Continental European, and Oriental Hybrid framework, synthesizing critical external conditions for their emergence, common elements and indicator framework, internal governance and the success logic behind their effectiveness, benchmark samples and the driving forces for their vigorous development of world-class scientific and technological societies, while proposing constructive ideas for the actionable pathways of building world-class scientific and technological societies in China.

Keywords: World-class; Scientific and technological societies; Governance model

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1. Introduction

“World-class” has become a common organizational aspiration and ideal pursuit in contemporary international competition. It represents a normalized developmental goal for scientific and technological societies striving for high positioning and high quality in the new era. The development of internationally active and highly influential scientific and technological societies holds significant reference value.

2. External conditions for the emergence of world-class scientific and technological societies

The scientific and technological societies face differing external conditions under different social organization governance models. Typical governance models include the Anglo-Saxon model, the Continental European model, and the Oriental hybrid model.

The Anglo-Saxon governance model is primarily found in English-speaking nations, with the United

States and the United Kingdom as the main representatives. These societies generally advocate for freedom and democracy, where social organizations operate autonomously, with minimal government intervention beyond tax regulation. Key features include high autonomy, self-funding, voluntary membership, and structural diversity. Governments do not grant administrative functions to these organizations. Under the U.S. *laissez-faire* model, social organizations can be freely established. However, registration with the government is required to access benefits such as tax exemptions. The provisions for tax-exempt applications and management for these organizations are highly detailed and well-defined. Furthermore, numerous laws and regulations address issues involving NGOs, including immigration and visas, campaign fundraising and lobbying, as well as terrorism financing and money laundering. Under the United Kingdom's unified regulatory model, social organizations are subject to management categorically, with strict norms governing the establishment of charitable institutions and their policy registration.

Countries under the Continental European governance model primarily include European nations, with France and Germany as the principal representatives. This model features stronger administrative influence compared to the Anglo-Saxon model, where the government grants certain administrative functions to social organizations, which operate under government leadership and supervision. Socially and culturally, the reverence for professions, technical expertise, and skilled specialists, coupled with enterprises' recognition of scientific learning and cultivation of innovation, establishes the fundamental cultural foundation for science and technology in societies' development. Governments provide support through funding, legislation, and policy safeguards, while implementing rigorous regulation and evaluation mechanisms. Competition and collaboration among these societies drive their development. Furthermore, Europe's unique and distinctive global standing in science and technology ensures funding, prestige, and status for its societies. This model facilitates cooperation between social organizations and the government while supporting independent organizational development.

The Oriental Hybrid governance model is predominant in many Asian countries. It is not fundamentally distinct but strategically integrates elements of the previous two models based on their specific national conditions and characteristics. Countries with stronger libertarian tendencies lean toward the Anglo-Saxon model, while those with stronger state influence tend to the Continental European model ^[1]. China's social organization management system exhibits strong hybrid characteristics. Therefore, the oriental hybrid governance model can well respond to the management system of social organizations in China and provide valuable references. External conditions under this model include robust legal and regulatory support, comprehensive and diversified policy assistance, relatively institutionalized governance, and an open, democratic social culture.

Despite differences, commonalities exist in the external conditions faced by scientific and technological societies across these models. Beyond the prevailing societal atmosphere of openness and democracy in these countries or regions, where citizens demonstrate strong willingness to civic association, enabling academic communities to thrive through free association, commonly fostering a robust culture of philanthropy and donation systems, with mature market economies providing an operational environment, these shared conditions are further prominently reflected in the following aspects: Comprehensive legal frameworks for social organization governance, refined policies for cultivating and supporting social organizations, integrated comprehensive regulatory systems that curb power divergence, minimal external intervention ensuring organizational self-organization, and market-oriented fundraising mechanisms ^[2].

3. Common elements and indicator framework for world-class scientific and technological societies

Through summarization and analysis of the common elements of world-class scientific and technological societies, it is found that the comprehensive evaluation framework for scientific and technological societies should encompass at least eight primary indicators:

A. Clear organizational value positioning and adherence: Manifested through a well-defined and explicit articulation of organizational mission, leadership identification at decision-making levels, staff-wide value identification, and public dissemination of core values ^[3]. B. Scientific and open organization and structure: Characterized by a high degree of autonomy, an open and democratic governance structure, adaptable and standardized regulations, outstanding strategic management and leadership capabilities, structural adaptability and operational efficiency, and strict regulation of branch activities ^[4]. C. Robust resource support system: Evidenced by quality human resources and effective cooperation mechanisms, fundraising capacity and sustainability via nonprofit revenue streams, and an ideal social network resource ^[5]. D. Foremost authoritative and representative academic and intellectual strength: Demonstrated through academic exchange and knowledge-sharing capabilities, science popularization and communication capacity, and scientific and technological evaluation capability, etc. E. Targeted member services and support: Measured by membership growth index, level of organizational support for members, level of transparency, innovative member service mechanisms, and member satisfaction/evaluation index. F. Strong social service and reputation: Reflected in brand awareness, public credibility, effective participation in social governance, and proactive fulfillment of social responsibility.

G. Serving national development goals and effective participation in government processes: Includes participation or influence in legislation and policymaking, statistical research, analysis, and forecasting of national S&T information, leading national economic, social, and S&T progress through S&T innovation, effectively undertaking functions transferred from the government, optimizing the national academic environment and promoting academic ethics, and playing an active role in major national events, ^[6]. H. Proactive participation in global governance: Encompasses engagement in international and regional affairs, initiating or organizing international academic activities, international provision of professional knowledge and other intellectual resources, and performance in global philanthropy and social service ^[7].

The above indicators serve as crucial benchmarks for evaluating the status of world-class scientific and technological societies ^[8-9].

Table 1. Governance capability evaluation indicator system for world-class scientific and technological societies

First-level Indicators	Secondary Indicators
Clear Organizational Value Positioning & Adherence (X ₁)	well-defined and explicit articulation of organizational mission (X ₁₁)
	leadership identification at decision-making levels (X ₁₂)
	staff-wide value identification (X ₁₃)
	public dissemination of core values (X ₁₄)
Scientific and Open Organization & Structure (X ₂)	high degree of autonomy (X ₂₁)
	open and democratic governance structure (X ₂₂)
	adaptable and standardized regulations (X ₂₃)
	outstanding strategic management and leadership capabilities (X ₂₄)
	structural adaptability and operational efficiency (X ₂₅)
	strict regulation of branch activities (X ₂₆)

Table 1 (Continued)

First-level Indicators	Secondary Indicators
Robust Resource Support System (X ₃)	quality human resources and effective cooperation mechanisms (X ₃₁)
	fundraising capacity and sustainability via nonprofit revenue streams (X ₃₂)
	ideal social network resource (X ₃₃)
	academic exchange and knowledge-sharing capabilities (X ₄₁)
Foremost Authoritative and Representative Academic & Intellectual Strength (X ₄)	science popularization and communication capacity (X ₄₂)
	scientific and technological evaluation capability (X ₄₃)
Targeted Member Services and Support (X ₅)	membership growth index (X ₅₁)
	level of organizational support for members (X ₅₂)
	level of transparency (X ₅₃)
	innovative member service mechanisms (X ₅₄)
	member satisfaction/evaluation index (X ₅₅)
Strong Social Service and Reputation (X ₆)	brand awareness (X ₆₁)
	public credibility (X ₆₂)
	effective participation in social governance (X ₆₃)
	proactive fulfillment of social responsibility (X ₆₄)
Serving National Development Goals and Effective Participation in Government Processes (X ₇)	participation or influence in legislation and policymaking (X ₇₁)
	statistical research, analysis, and forecasting of national S&T information (X ₇₂)
	leading national economic, social, and S&T progress through S&T innovation (X ₇₃)
	effectively undertaking functions transferred from the government (X ₇₄)
	optimizing the national academic environment and promoting academic ethics (X ₇₅)
	playing an active role in major national events (X ₇₆)
	engagement in international and regional affairs (X ₈₁)
Proactive Participation in Global Governance (X ₈)	initiating or organizing international academic activities (X ₈₂)
	international provision of professional knowledge and other intellectual resources (X ₈₃)
	performance in global philanthropy and social service (X ₈₄)

4. Internal governance of world-class scientific and technological societies and the underlying logic of their effectiveness

Examining the internal governance of world-class scientific and technological societies and the underlying logic of their effectiveness reveals distinct characteristics across governance models:

Anglo-Saxon model societies demonstrate prominent features including: a self-contained and practical charters and rules have been established; clearly articulated visions, missions, strategic objectives and plans have been formulated; an outstanding democratic election and decision-making system has been established; it has formed an independent multi-center and multi-branch setup; established a fully and truly information disclosure and public disclosure mechanism; and carried out activities centered on members and centered around them. The internal governance of scientific and technological societies under the continental governance model is characterized by achieving standardized governance, emphasizing characteristic governance, attaching importance to member services, conducting operational governance, realizing socialized governance, utilizing internet platforms and big data to achieve intelligent governance, and attaching importance to internal supervision. The

internal governance advantages of scientific and technological societies under the oriental hybrid governance model are manifested in their mature institutional design and comprehensive organizational charters, well-developed democratic decision-making mechanisms, sophisticated supervision and review system, and established information disclosure and transparency mechanism.

Synthesizing internal governance experiences among world-class scientific and technological societies reveals core characteristics: governance is founded on substantive democracy, featuring rigorous and ordered corporate governance structures, prioritizing to meet the needs of members as the criterion and attaching importance to member classification management as well as diversified development of members, establishing clear and standardized governance systems for internal departments and branches, exhibiting a high level of socialization and professionalization as well as engaging in business-oriented governance, and actively cultivating social capital within the society.

5. Benchmark samples and case studies of world-class scientific and technological societies

This study selected several internationally influential scientific and technological societies as samples for focused analysis and experience synthesis. It was found that scientific and technological societies under the Anglo-Saxon model are represented by societies such as The American Chemical Society (ACS), Institute of Electrical and Electronics Engineers (IEEE), Royal Society of Chemistry (RSC), The Canadian Medical Association (CMA), and The Institution of Engineers Australia (IEAust). The prominent features of science and technology societies under this governance model include autonomous governance, emphasis on institutional rules, and internal decentralized democratic governance.

Scientific and technological societies under the Continental European model are represented by Deutsche Physikalische Gesellschaft (DPG), Gesellschaft für Chemische Technik und Biotechnologie.e.V (DECHEMA), Verein Deutscher Ingenieure (VDI), Société des Ingénieurs et scientifiques de France (IESF), Société Française d'Énergie Nucléaire (SFEN), and Italian Association for the Development of Biotechnology (ASB). The prominent features of scientific and technological societies under this governance model are that although they possess a certain semi-official nature with strong support, from the government, and have some mandatory nature in membership admission, they remain social organizations independent of the government, operating as part of the third sector of society, with significant autonomy, and fulfill social functions beyond the capacity of government and enterprises in modern society. By virtue of the standardization, characteristic, business-oriented operationalization, socialization, and intellectualization of internal governance, as well as attaching importance to member services and internal supervision, they operate independently and valuably. They promote knowledge flow, foster a sound innovative culture, maintain the rational utilization of science and technology, and drive government reform and functional transition. Consequently, they constitute vital components of the national innovation system.

Scientific and technological societies under the Oriental Hybrid governance model are represented by the Japanese Medical Association (JMA), the Physical Society of Taiwan Region (PST), the Hong Kong Medical Association (HKMA), and the Singapore Computer Society (SCS). The prominent characteristics of scientific and technological societies under this governance model include establishing a comprehensive internal governance system and strict compliance with institutional rules, building a robust member service mechanism to enhance

members dependence and belonging, maintaining transparent and open financial systems to earn the trust from members and the public, being significant participants in shaping macro-policies through actively involving in the formulation of national policies and laws, ensuring timely information update and maintenance to strengthen the adhesion of members and the public to the society, expanding the organizational popularity and visibility through diverse public relations activities, and carrying out extensive and close international exchanges to enhance the organization's international reputation and professional standing.

In general, the driving forces for the growth and vigorous development of world-class scientific and technological societies are as follows: societies rely fundamentally on members and provide in-depth support for them; their administrative offices exhibit a high degree of professionalization, professionalism, and socialization; they have obtained substantial economic strength through market-oriented operation and business-oriented governance; they innovate and develop service projects and implement brand-oriented operation; they strictly abide by institutional rules to mitigate governance risks, etc.

6. Implementation pathways for developing world-class scientific and technological societies in China

To achieve world-class status, China's scientific and technological societies urgently need to strategically adapt globally proven models through the following implementation pathways:

A. Government-led construction of an external support system: It is necessary to strengthen legal and institutional provisions favorable to scientific and technological societies, reduce governmental intervention intensity to ensure societies transcend being mere outcomes of government selection, implement more confident and relaxed entry registration to diminish bureaucratic constraints, utilize tax exemptions or reductions as economic incentives to normatively guide social organization development, Leverage the China Association for Science and Technology (CAST) as the pivotal organizational framework for scientific and technological societies governance.

B. Organizational mission-driven and self-motivated based on value identification ^[10]: Scientific and technological societies should embed their core ideas and missions as organizational DNA; formulate distinctive visions, missions, strategic goals and plans embodying fundamental values and missions as well as unique characteristics; cultivate organizational culture identification as vital internal social capital for self-driven motivation; and systematically cultivate organizational values and culture in aspects such as spiritual culture, institutional culture, behavioral culture, material culture and image culture, etc.

C. Establishing democratic governance frameworks and an efficient organizational management system: It is necessary for scientific and technological societies to enhance intrinsic motivation to achieve autonomous operation, construct open and democratic corporate governance structures, prevent power diffusion through comprehensive institutional systems, elevate strategic management capabilities and leadership effectiveness, achieve structural adaptability and operational efficiency, and strictly standardize branch activities ^[11].

D. Building a multi-dimensional resource support system: Scientific and technological societies should develop quality human resources and cooperative mechanisms through socialization and professionalization of secretariats as well as maximizing member and volunteer resource utilization, raising sufficient and stable funding through non-profit means, accumulating robust social network resources, etc. ^[12].

E. Developing foremost authoritative academic and intellectual strength: It is necessary for scientific and

technological societies to improve academic exchange and knowledge-sharing capabilities, proactively conduct science popularization and dissemination, and enhance scientific and technological evaluation methodologies.

F. Member-centered and integrates its members into organizational operation: It is suggested scientific and technological societies to expand paid membership scale and proportion, provide substantial member support to enhance attraction and retention, ensure operational transparency and clear accountability mechanisms, innovate member service models, increase member satisfaction and non-member aspirational appeal, implement precision membership categorization and deliver tiered value-added services as well as refined member management, and implement transparent accountability mechanisms^[13].

G. Provide excellent social services and build up social reputation: The specific approaches include optimizing and strengthening brand projects to expand their influence, strengthening public credibility, effectively participating in social governance, and actively fulfilling social responsibilities.

H. Serving national goals and participating in government processes: It is suggested scientific and technological societies to function as think tanks by participating in legislation and policy formulation, conduct national scientific and technological statistical research and forecasting, support innovation to serve as an important pillars for the national scientific and technological strategy, undertake transferred government functions to alleviate burdens on the government or to fill the gap for the government service, establish academic research norms and ethical self-discipline guidelines, and play active roles in major national events.

I. Engaging proactively in global governance and striving for international discourse power in science and technology: It is suggested to participate substantively in international or regional affairs and rule-making, initiate and organize transnational academic programs, supply professional knowledge and intellectual resources globally, engage in international philanthropy and social services, as well as conduct globalization recalibration based on domesticized resources.

7. Conclusion

In conclusion, Chinese scientific and technological societies that pursue “world-class” status as their developmental goal and self-imposed requirement should focus their efforts on the aforementioned objectives. This is not only a constructive approach for the development of scientific and technological societies but also the highest rationalization standard that they should strive to reach. All these elements are indispensable. As academic communities, scientific and technological societies need to observe the above high standards in their organizational practices during the orderly development process and continuously drive the improvement of their capabilities.

Disclosure statement

The author declares no conflict of interest.

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Research and Practice of Multi-dimensional Chinese Character Quantification Evaluation Methods

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Abstract: Addressing the pain points of traditional Chinese character evaluation, which is highly subjective and lacks quantitative standards, this paper proposes a three-dimensional intelligent quantitative evaluation model for Chinese characters based on “accuracy—balance—standardization”, transitioning from experience-driven to data-driven evaluation: improving multi-model convolutional neural networks to extract stroke keypoints for accuracy assessment, combining image moments with cosine similarity to measure center of gravity deviation for balance evaluation, and using 3×3 grid pixel density ratios to characterize structural framework for standardization measurement. The model operates in a closed-loop system of “recognition—quantification—fuzzy comprehensive evaluation”, enhancing recognition accuracy through hard voting, automatically calibrating the scoring range using the “best-worst sample set”, and obtaining intelligent weights of 39:32:29 through backpropagation training. Experiments on four types of samples from the CASIA-HWDB1.1 and custom datasets show that the average error between the model and expert scores under intelligent weights is significantly lower than that of the two fixed weights, providing a practical quantitative evaluation tool for Chinese character education and cultural heritage.

Keywords: Multi-dimensional evaluation framework; Convolutional neural network; Fuzzy comprehensive evaluation; Writing quality assessment

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1. Introduction

As the only ancient writing system in the world that has continued to the present day, Chinese characters are also the language with the largest number of users today. With the ongoing globalization of communication, the popularity and demand for learning Chinese characters are growing steadily. As a carrier of China’s millennia-old civilization, Chinese characters are characterized by their diverse categories, complex structural components, and numerous homophones. For beginners, it is not only necessary to master the stroke order and

morphological characteristics of Chinese characters, but also to understand their internal structure. For example, subtle differences between characters that look similar can lead to significant differences in their meaning and usage, thereby increasing the difficulty of learning Chinese characters. At the same time, traditional Chinese character evaluation often focuses solely on writing standards or aesthetic dimensions, which can be influenced by personal experience and preferences. This leads to significant scoring discrepancies for the same character, making it difficult to establish an objective evaluation system. Such inconsistencies can have a negative impact on learners' motivation. Additionally, timely evaluation during the process of learning Chinese characters is another major obstacle. Learners who cannot receive evaluations of their Chinese characters within a limited timeframe may see their interest and efficiency in learning affected. The primary cause of these issues lies in the lack of a unified, quantifiable, systematic, and comprehensive evaluation system. Therefore, the objective of this study is to construct a multi-feature integrated Chinese character intelligent evaluation model. By integrating neural network technology with traditional techniques, it combines structural evaluation and aesthetic evaluation to form a multi-dimensional quantitative evaluation system, providing a referenceable quantitative evaluation approach for the research and learning of Chinese characters.

2. Current status of Chinese character evaluation research

With the widespread use of smart devices, the phenomena of “forgetting how to write characters” and poor writing quality have become commonplace. Additionally, learners' laziness due to the lack of timely evaluation tools is a common contributing factor to these issues. These problems have a certain negative impact on the inheritance of Chinese culture, prompting researchers to dedicate themselves to studying the recognition and evaluation of Chinese characters to contribute to cultural preservation. Currently, research on Chinese character evaluation primarily focuses on aspects such as structure, writing standardization, and stroke quality, but lacks a unified quantitative standard ^[1]. Based on previous research, the research directions can be categorized into three types: rule-based evaluation, similarity-based evaluation, and machine learning-based evaluation.

For rule-based evaluation methods, Zhuang Chongbiao et al. proposed a stroke-based grading strategy, establishing normative rules for stroke-to-stroke features. However, this method relies on manually defined error types and cannot judge undefined error types, lacking comprehensiveness ^[2]. Han Ruifang et al. conducted a hierarchical classification of stroke keypoints and stroke segment details, enabling the evaluation of structural features. However, this method requires a high level of expertise in evaluating stroke features ^[3]. In summary, these stroke-rule-based methods have laid the foundation for subsequent research and achieved preliminary success in Chinese character evaluation studies. However, they heavily rely on rules and lack good universality.

Building on the shortcomings of rule-based evaluation methods, researchers have proposed using similarity-based calculation methods to enhance universality. Such methods typically involve first extracting features from the sample to be tested, then comparing them with a template to calculate similarity, and finally deriving an evaluation of writing quality based on the similarity score. Yu Kai et al., as one of the pioneers in similarity feature research, proposed calculating similarity using skeleton and contour features, enabling rapid matching and evaluation even with large datasets ^[4]. Wu Chuzhou et al. further optimized the skeleton feature evaluation approach by proposing a method that involves grid partitioning of the skeleton followed by matrix calculations ^[5]. Ge Jiamin proposed using fuzzy probability distribution calculations to define a range for evaluating writing quality ^[6]. She used fuzzy comprehensive evaluation to calculate the expected value range for individual characters, then compared the

expected values of the test samples with the expected value range to derive the evaluation results. However, while these studies fully utilize Chinese character features and achieve good results, their generalization capabilities still need improvement. Some studies have attempted to introduce machine learning methods for automatic evaluation of writing quality. For example, Zhuang Ziming et al. proposed using convolutional neural networks to extract features and retrieve images with high similarity scores based on similarity matching, thereby achieving the evaluation objective^[7]. Although this approach demonstrated good evaluation results, it relies heavily on image annotation. This paper combines machine learning features with the structural features of Chinese characters to explore the effects of fuzzy comprehensive evaluation.

3. Design of a multi-feature fusion Chinese character quantification evaluation model

3.1. Determination of evaluation dimensions

Unlike numbers and letters, Chinese characters are characterized by their diverse categories and complex structures. Traditional evaluations of Chinese characters primarily rely on manual assessment, which is essentially a post-hoc evaluation. When evaluating the aesthetic quality of Chinese characters, teachers primarily focus on elements such as stroke execution, position, and character shape, which inherently involve a significant degree of subjectivity. Given the general applicability of evaluation strategies and the issues mentioned above, this paper employs a Convolutional Neural Network (CNN) to address accuracy issues and extracts CNN features as one of the evaluation dimensions to measure the accuracy of writing. This is because multi-layer convolutional operations can extract deep visual features such as stroke details of Chinese characters, eliminating the need for manually designed features while simulating human visual perception of the aesthetic quality of Chinese characters. Secondly, the center of gravity and grid features of Chinese characters are selected. The center of gravity of each Chinese character is a fundamental element in evaluating aesthetic appeal. It can be used to quantitatively assess whether a Chinese character has “imbalance” issues (such as tilting or misalignment), as the center of gravity distribution of a properly written Chinese character is stable and harmonious. Therefore, the basic aesthetic appeal of a Chinese character can be measured based on the difference in its center of gravity. Grid features can be used to divide Chinese characters into regions based on their center of gravity features, thereby quantitatively assessing the uniformity of stroke distribution and aligning with the “structural framework” of Chinese characters. This allows for calculations of component proportions and “white space” issues, combining macro-level structure with micro-level details. Ultimately, CNN features capture details, center of gravity features measure macro-level structure, and grid features serve as the link between macro- and micro-levels. Through fuzzy comprehensive evaluation, a comprehensive aesthetic evaluation is formed.

3.2. Design of quantitative evaluation indicators

Based on the determination of evaluation dimensions, this paper proposes to use three types of quantitative indicators for evaluation, mainly including the “correctness” indicator based on CNN features. This indicator extracts detailed features such as stroke key points and ultimately obtains the coverage of detailed features. When the proportion of detailed features of a test sample exceeds the threshold, the corresponding category can be determined. The calculated feature value is used as the micro-level aesthetic score of the sample, denoted as $\text{Grade}_{\text{CNN}}$.

The “balance” metric, based on center of gravity features, quantifies the overall balance of a Chinese

character. This is achieved by calculating the center of gravity coordinates of the sample being tested, then determining the degree of deviation from the expected sample's center of gravity, thereby quantifying the aesthetic quality of the overall structure. After preprocessing the image, it undergoes grayscale conversion and binarization. The center of gravity coordinates are then calculated using the moment of the binary image. The specific principle of metric quantification is as follows: Let the pixel coordinates of the target region in the image be (x, y) , and the pixel value be $I(x, y)$ ($I(x, y) = 1$ indicates the pixel exists, and 0 indicates a white background). Formula 1 is used to calculate the 0th-order moment m_{00} , and formulas 2 and 3 are used to calculate the 1st-order moments m_{01} and m_{10} , respectively. The center of gravity coordinates (\bar{x}, \bar{y}) of the sample are calculated using formulas 4 and 5. Finally, the cosine similarity between the test sample and the target sample (where the mean centroid coordinates of the optimal sample set in the target sample are assumed to be (x_1, y_1) , and the mean center of gravity coordinates of the worst sample set are (x_2, y_2)). The cosine similarity is normalized in formula 6 to transform the value range to 0-1 before being used for subsequent calculations, forming a “balance” indicator score, denoted as $Grade_{gravity}$.

$$m_{00} = \sum_x \sum_y I(x, y) \quad \text{Formula 1}$$

$$m_{01} = \sum_x \sum_y x \cdot I(x, y) \quad \text{Formula 2}$$

$$m_{10} = \sum_x \sum_y y \cdot I(x, y) \quad \text{Formula 3}$$

$$\bar{x} = \frac{m_{10}}{m_{00}} \quad \text{Formula 4}$$

$$\bar{y} = \frac{m_{01}}{m_{00}} \quad \text{Formula 5}$$

$$Grade_{gravity} = (1 - (1 - \frac{(\bar{x}, \bar{y}) \cdot (x_1, y_1)}{\|(\bar{x}, \bar{y})\| \cdot \|(x_1, y_1)\|}) / (1 - \frac{(x_1, y_1) \cdot (x_2, y_2)}{\|(x_1, y_1)\| \cdot \|(x_2, y_2)\|})) \times 100 \quad \text{Formula 6}$$

The “normativity” metric based on grid features primarily quantifies the uniformity of stroke distribution and component proportions. Each sample is divided into a 3×3 grid, and the pixel distribution of each grid is calculated. This is then compared with the expected sample to determine whether the stroke layout and structure of the sample are normative. The specific quantification principle of the metrics is as follows: Let the sample height be H , width be W , and grid size be $grid_size \times grid_size$ (set to 3×3 in this study), each grid has a size of $region_h \times region_w$, a pixel density of $region_density$, a background pixel count of $region_foreground$ (pixels with a value of 0), and a total pixel count of $region_total$. The size data and pixel density of each grid are calculated using formulas 7–9. Subsequently, the pixel density matrix of all grids in the sample under test is flattened and denoted as $Grid_t$. The pixel density average matrix of the optimal sample set of the reference sample is flattened and denoted as $Grid_s$, and the pixel density average matrix of the worst sample set is flattened and denoted as $Grid_b$. Finally, the final score is calculated by substituting $Grid_t$, $Grid_b$, and $Grid_s$ into Formula 6, and it is used as the “normativity” indicator score, denoted as $Grade_{grid}$.

$$region_h = \lfloor H / grid_size \rfloor \quad \text{Formula 7}$$

$$region_w = \lfloor W / grid_size \rfloor \quad \text{Formula 8}$$

$$region_density = region_foreground / region_total \quad \text{Formula 9}$$

3.3. Quantitative evaluation model design

In the process of quantitative evaluation, the prerequisite for achieving accurate and objective evaluation results is correct writing. Therefore, a multi-feature fusion recognition module is incorporated into the quantitative evaluation model to complete the recognition task. After accurate recognition, quantitative feature scoring calculations are performed. The overall model diagram is shown in **Figure 1**.

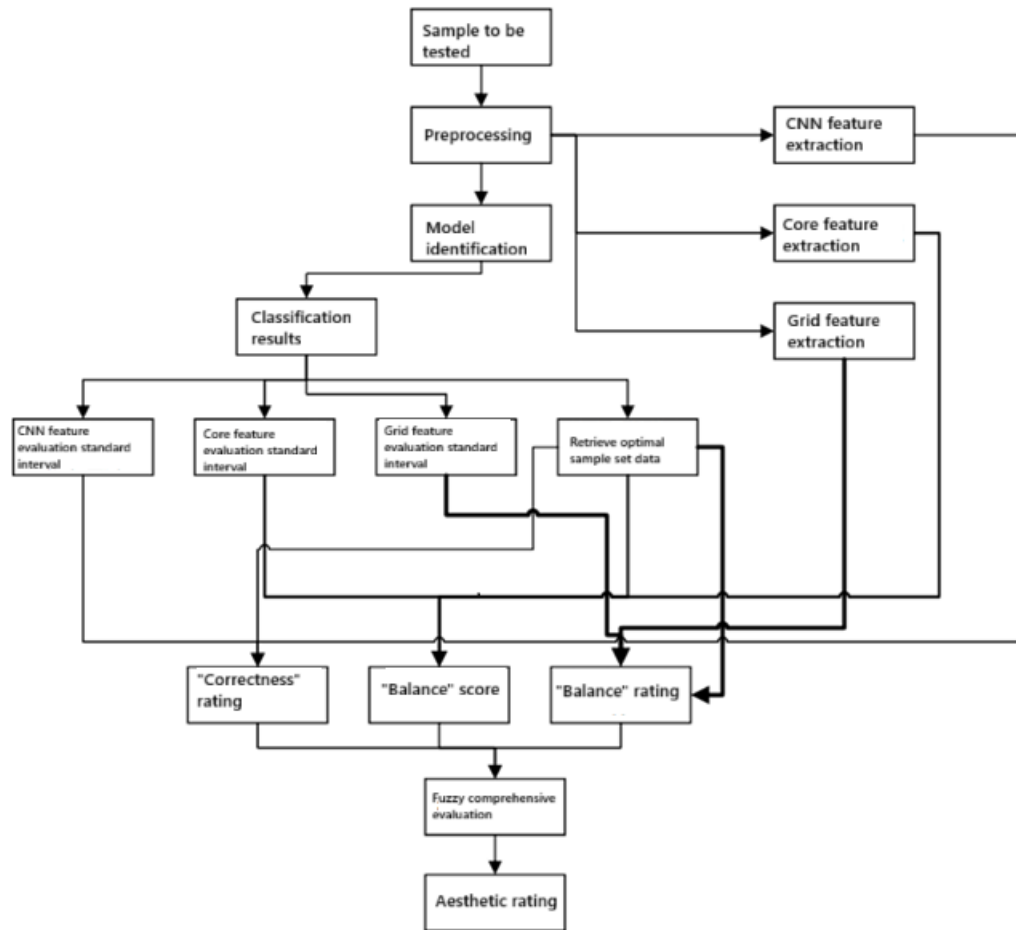


Figure 1. Quantitative evaluation model

The model recognition task is used to evaluate the correctness of Chinese characters. The model used is based on the VGG16 model, with the addition of a BatchNormalization layer to improve model training speed and convergence stability. It also incorporates the Inception feature from GoogLeNet, where the Inception submodule is adjusted based on the principles of the basic LeNet network. This ultimately forms the network model structure, a multi-model described in this paper, as shown in **Figure 2**. A hard voting mechanism (simulating multiple experts voting, with the majority vote prevailing) is integrated into the recognition model to further improve classification accuracy.

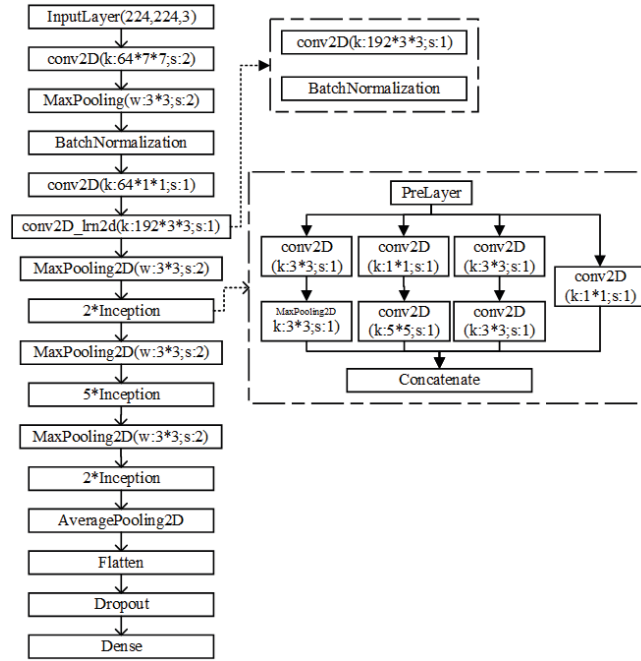


Figure 2. Multi-model

The core of the quantitative evaluation model is the calculation of quantitative features, which mainly includes three submodules: CNN feature calculation for the “correctness” indicator, center of gravity feature calculation for the “balance” indicator, and grid feature calculation for the “standardization” indicator. The CNN feature score calculation process is as follows:

1. Input the test sample into the recognition model to obtain the classification results;
2. Based on the classification results, retrieve the data and extract the 10 optimal samples with the highest probability values in the dataset to form the optimal sample set D_{good} , and the 10 samples with the lowest probability values to form the worst sample set D_{bad} ;
3. Calculate the average probability values of the optimal sample set and the worst sample set, denoted as C_{avgH} and C_{avgL} , respectively, to obtain the CNN feature evaluation standard interval C_{norm} , as shown in Formula 10.
4. Finally, calculate the final score $\text{Grade}_{\text{CNN}}$ by computing the distance between the probability value C_{test} of the sample under test and C_{avgH} , and then comparing it with C_{norm} . If C_{test} is greater than or equal to C_{avgH} , the current indicator is marked as full marks; if C_{test} is less than C_{avgH} , the calculation formula is as shown in Formula 11.

$$C_{\text{norm}} = C_{\text{avgH}} - C_{\text{avgL}} \quad \text{Formula 10}$$

$$\text{Grade}_{\text{CNN}} = 1 - \frac{C_{\text{avgH}} - C_{\text{test}}}{C_{\text{norm}}} \quad \text{Formula 11}$$

The calculation process for the centroid feature score is as follows:

1. Input the test sample into the recognition model to obtain the classification result of the test sample;
2. Retrieve data based on the classification result to obtain the sample sets D_{good} and D_{bad} ;
3. Calculate the centroid coordinates of each sample using formulas 1–5;

4. Calculate the average centroid coordinates of the sample sets D_{good} and D_{bad} , denoted as G_{avgg} and G_{avgb} , respectively;
5. Calculate the centroid coordinates of the test sample using formulas 1–5, denoted as G_{test} ;
6. Substitute G_{test} , G_{avgg} , and G_{avgb} into formula 6 to calculate the centroid feature score $\text{Grade}_{\text{gravity}}$. During calculation, if the cosine similarity between G_{test} and C_{avgH} reaches 100%, the current indicator is marked as full score; otherwise, the calculation is completed using formula 6.

The calculation process for the grid feature score is as follows:

1. Input the test sample into the recognition model to obtain the classification result of the test sample;
2. Retrieve data based on the classification result to obtain the sample sets D_{good} and D_{bad} ;
3. Calculate the pixel density matrix for each sample using formulas 7–9;
4. Calculate the average pixel density matrix for the sample sets D_{good} and D_{bad} and perform flattening operations, denoted as Grid_s and Grid_b , respectively;
5. Calculate the pixel density matrix for the test sample using formulas 7–9 and perform flattening operations, denoted as Grid_t ;
6. Substitute Grid_t , Grid_s , and Grid_b into Formula 12 to calculate the grid feature score $\text{Grade}_{\text{grid}}$ for the sample. During calculation, if the cosine similarity between Grid_t and Grid_s reaches 100%, the current indicator is marked as full score; otherwise, the calculation is completed according to Formula 12.

$$\text{Grade}_{\text{grid}} = (1 - (1 - \frac{\text{Grid}_t \cdot \text{Grid}_s}{\|\text{Grid}_t\| \cdot \|\text{Grid}_s\|}) / (1 - \frac{\text{Grid}_s \cdot \text{Grid}_b}{\|\text{Grid}_s\| \cdot \|\text{Grid}_b\|})) \times 100 \quad \text{Formula 12}$$

After calculating the three quantitative features, a fuzzy comprehensive evaluation is conducted. By incorporating fuzzy mathematics theory, a comprehensive evaluation of multiple indicators is achieved. Assuming the weight vector is $W = (w_1, w_2, w_3)$, where $w_1 + w_2 + w_3 = 1$, where w_1 corresponds to the weight of the “accuracy” indicator, w_2 corresponds to the weight of the “balance” indicator, and w_3 corresponds to the weight of the “standardization” indicator. The weight values for the three quantitative indicators are determined using a neural network model for calculation. The model is trained using the results of images with labeled scores to derive the weight distribution of the quantitative indicators, ensuring that the proportions of each indicator in the comprehensive evaluation align as closely as possible with actual evaluation requirements, thereby achieving intelligent evaluation.

4. Quantitative evaluation model experiment

4.1. Data preparation

The experimental dataset primarily originates from the publicly available CASIA-HWDB1.1 dataset and some custom-made data (with an additional 20 custom-made samples per category featuring better handwriting quality; hereinafter referred to as the dataset). CASIA-HWDB1.1 is a single-character handwritten Chinese character dataset released by the Institute of Automation, Chinese Academy of Sciences, containing 1,172,907 sample images of 3,755 commonly used Chinese characters written by 300 writers^[8]. Among these, 60% are used as the training set, 20% as the validation set, and 20% as the test set. Since the sample sizes in the dataset vary, this study adopts a method of white border expansion combined with an affine transformation to standardize the sizes. This is because white border filling uses background pixels, which do not affect the recognition training of Chinese characters. Additionally, since each sample set contains 200–260 data samples, the data volume is relatively low

after division. Therefore, this study performs data augmentation on the original data, using an affine transformation combined with an elastic transformation to increase the number of samples.

4.2. Experimental steps

The experimental steps for the quantitative evaluation model are as follows:

1. Divide the preprocessed dataset into training, testing, and validation sets in a 6:2:2 ratio. The training set is used for iterative model training and parameter learning, the validation set is used to monitor the model training process and adjust hyperparameters, and the testing set is used to evaluate the final model performance.
2. Build a multi-feature fusion recognition module (Multi-model) based on the model structure diagram in Section 3.3, incorporating a BatchNormalization layer and an adjusted Inception submodule. Train the model, save it after it stabilizes, and add a hard voting mechanism to optimize the recognition results.
3. Quantify metric weight training. Train a neural network model to determine the weight vector, optimize the weight parameters using the backpropagation algorithm, and determine weight values that meet actual requirements.
4. Based on the recognition model, the “correctness” metric ($\text{Grade}_{\text{CNN}}$), “balance” metric ($\text{Grade}_{\text{gravity}}$), and “normativity” metric ($\text{Grade}_{\text{grid}}$) are calculated for each sample in the training set, and these metrics are used as input features for fuzzy comprehensive evaluation.
5. Three weighting methods are proposed, two of which use specified weight ratios (1:1:1 and 2:1:1 for $\text{Grade}_{\text{CNN}}$, $\text{Grade}_{\text{gravity}}$, and $\text{Grade}_{\text{grid}}$, respectively), while the third uses an intelligent evaluation weight ratio calculated via the backpropagation algorithm (39:32:29). Comparative experiments are conducted for the three weighting allocation schemes.

4.3. Evaluation of effects and analysis of results

Based on the evaluation dimensions outlined in this paper, four main categories of image types were selected as experimental subjects: aesthetically pleasing handwriting images, handwriting position offset images, handwriting tilt images, and poor handwriting images. These four categories of images were designated as Class A, Class B, Class C, and Class D images, respectively, for ease of description in the subsequent text. During the experiment, testing was conducted under three weighting schemes (1:1:1, 2:1:1, Intelligent Evaluation Weighting 39:32:29) to assess the differences between the scores of each indicator, the comprehensive evaluation results, and the actual expert scores.

Class A images are samples with good writing quality (**Figure 3**). Taking two images as examples, one is a self-made image named A1 (average expert score of 87.08), and the other is an image from the CASIA-HWDB1.1 dataset named A2 (average expert score of 84.88). Both images perform excellently in terms of “correctness”, “balance”, and “standardization.” A1’s $\text{Grade}_{\text{CNN}}$ score is 86, $\text{Grade}_{\text{gravity}}$ score is 86, $\text{Grade}_{\text{grid}}$ score is 90, the comprehensive score under the 1:1:1 weighting scheme is 87.33, the comprehensive score under the 2:1:1 weighting scheme is 87, and the intelligent comprehensive score is 87.16. For A2, $\text{Grade}_{\text{CNN}}$ scored 75, $\text{Grade}_{\text{gravity}}$ scored 92, $\text{Grade}_{\text{grid}}$ scored 90, the 1:1:1 weighting scheme had a composite score of 85.67, the 2:1:1 weighting scheme had a composite score of 83, and the intelligent composite score was 84.79.

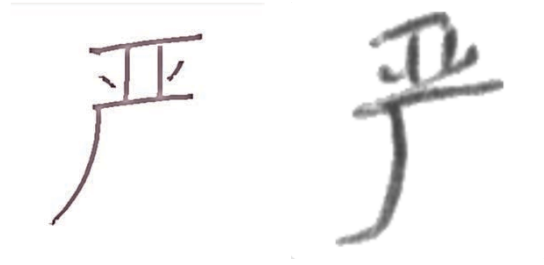


Figure 3. Beautifully written images (Class A images, left image is A1, right image is A2)

Category B images are samples with positional shifts (**Figure 4**). Taking two images as examples, one is a self-created image named B1 (with an average expert score of 80.88), and the other is an image from the CASIA-HWDB1.1 dataset named B2 (average expert score of 79.67). Both images perform excellently in terms of “correctness” and “standardization” features, but their “balance” performance is slightly weaker. B1’s $\text{Grade}_{\text{CNN}}$ score is 83, $\text{Grade}_{\text{gravity}}$ score is 72, $\text{Grade}_{\text{grid}}$ score is 90, the comprehensive score under the 1:1:1 weighting scheme is 81.67, the comprehensive score under the 2:1:1 weighting scheme is 82, and the intelligent comprehensive score is 81.51. For B2, $\text{Grade}_{\text{CNN}}$ scored 77, $\text{Grade}_{\text{gravity}}$ scored 67, $\text{Grade}_{\text{grid}}$ scored 87, the 1:1:1 weighting scheme had a composite score of 77, the 2:1:1 weighting scheme had a composite score of 77, and the intelligent composite score was 76.7.

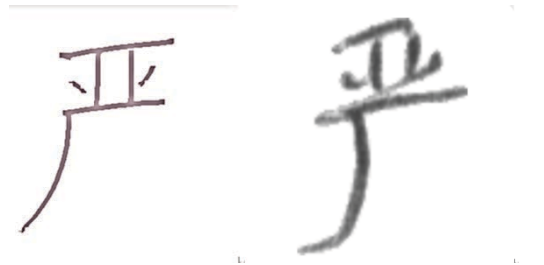


Figure 4. Writing offset images (Class B images, left image is B1, right image is B2)

Category C images are samples of slanted handwriting (**Figure 5**). Taking two images as examples, one is a self-created image named C1 (average expert score of 65.05), and the other is an image from the CASIA-HWDB1.1 dataset named C2 (average expert score of 61.10). Both images perform excellently in terms of “correctness”, “balance”, and “standardization.” C1’s $\text{Grade}_{\text{CNN}}$ score is 75, $\text{Grade}_{\text{gravity}}$ score is 37, $\text{Grade}_{\text{grid}}$ score is 82, the comprehensive score under the 1:1:1 weighting scheme is 64.67, the comprehensive score under the 2:1:1 weighting scheme is 67.25, and the intelligent comprehensive score is 64.87. C2’s $\text{Grade}_{\text{CNN}}$ score is 68, $\text{Grade}_{\text{gravity}}$ score is 38, $\text{Grade}_{\text{grid}}$ score is 62.67, the comprehensive score for the 1:1:1 weighting scheme is 62.67, the comprehensive score for the 2:1:1 weighting scheme is 64, and the intelligent comprehensive score is 62.46.

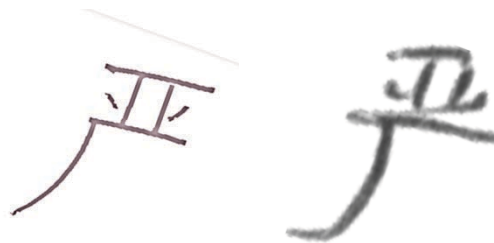


Figure 5. Handwritten slanted images (Class C images, left image is C1, right image is C2)

Category D images (**Figure 6**) are test image samples with poor handwriting, named D1 (average expert score of 45.67). For D1, the Grade_{CNN} score is 42, the Grade_{gravity} score is 36, the Grade_{grid} score is 65, the composite score for the 1:1:1 weighting scheme is 47.67, the composite score for the 2:1:1 weighting scheme is 46.25, and the intelligent composite score is 46.75.



Figure 6. Poorly written image (Class D image)

Based on experiments conducted using three weighting schemes, the experimental data are presented in the Weighting Comparison Experiment **Table 1**. Since the features selected in this paper have a certain degree of correlation in terms of aesthetic evaluation, the scoring results under the three weighting schemes show only minor differences in error. However, based on the overall experimental results, it can be observed that under the same experimental conditions, the comprehensive scores derived from the weights obtained through the backpropagation algorithm exhibit generally lower errors compared to the expected scores, thereby better aligning with the expected evaluation capabilities.

Table 1. Weight comparison experiment table

Experimental subjects	Grade _{CN}	Grade _{gravity}	Grade _{grid}	1:1:1	2:1:1	39:32:29	Expected score
A1	86	86	90	87.33	87	87.16	87.08
	error value			0.25	-0.08	0.08	
A2	75	92	90	85.67	83	84.79	84.88
	error value			0.79	-1.88	-0.09	
B1	83	72	90	81.67	82	81.51	80.88
	error value			0.79	1.12	0.63	
B2	77	67	87	77	77	76.7	79.67
	error value			-2.67	-2.67	-2.97	
C1	75	37	82	64.67	67.25	64.87	65.05
	error value			-0.38	2.2	-0.18	
C2	68	38	82	62.67	64	62.46	61.1
	error value			1.57	2.9	1.36	
D1	42	36	65	47.67	46.25	46.75	45.67
	error value			2.0	0.58	1.08	

5. Summary and outlook

This paper addresses the issues of subjectivity and the lack of unified quantitative standards in traditional Chinese character evaluation. It proposes a three-dimensional evaluation framework based on CNN features, center of gravity features, and grid features, integrating micro- and macro-level evaluation content. An improved multi-model convolutional neural network (combining VGG16 and GoogLeNet features) is used to extract stroke details, quantifying “correctness.” Image moments are calculated to determine the center of gravity coordinates, measuring “balance” to assess whether Chinese characters are tilted or misaligned. A 3×3 grid division and pixel density comparison are employed to evaluate “standardization”, ensuring proper structural integrity. This ultimately forms a closed-loop design of “recognition—quantification—fuzzy comprehensive evaluation.” The recognition effect is optimized through a hard voting mechanism, and then a three-dimensional metric evaluation range is calculated based on the “best-worst sample set.” Finally, intelligent weights (39:32:29) are trained through backpropagation. The experiment was validated using the CASIA-HWDB1.1 dataset and custom samples, evaluating four common types of images. The results showed that under dynamic weights, the average error between comprehensive scores and expert scores was generally lower than under fixed weights, with excellent performance across different sample types, such as calligraphic aesthetics and tilt. This effectively achieved the objectification and quantification of Chinese character evaluation. while a fixed weighting ratio of 1:1:1 is more suitable for scenarios where evaluation criteria have equal importance, and a weighted ratio of 2:1:1, which is more biased, is more suitable for evaluation scenarios with special requirements.

There are still some areas in this study that require further optimization. The dataset used in this experiment primarily consists of images from the CASIA-HWDB1.1 dataset, with a relatively small proportion of self-generated images. As a result, the model performs well in tasks evaluating images similar in style to the CASIA-HWDB1.1 dataset, but its performance is lower for self-generated images. In future research, the authors will further explore the following areas: first, expanding the dimensions of the samples to include those generated by different input devices (such as handwriting and smart device writing); second, adding an evaluation dimension for “fluency” in writing to expand the model’s application scenarios; Third, further refine the dynamic weighting settings and introduce scenario-based weighting allocation functionality, enabling dynamic adjustment of evaluation metrics for different user groups, such as prioritizing “standardization” for children and “accuracy” for foreign learners.

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Disclosure statement

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The Pressure Transmission Mechanism of Medical Representatives during Policy Shock Periods: A Dynamic Analysis Based on the JDR Model

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Abstract: Against the backdrop of the normalization of volume-based procurement and the increasingly strict governance of medical insurance, medical representatives are confronted with cumulative pressure from both the “organization-individual” dual paths. Based on the JDR (Job Requirements—Resources) model, this paper constructs a dynamic framework suitable for policy shock periods: At the organizational level, the policy frequency increases and the job requirements increment is formed through institutional compliance, indicator reconstruction and process reengineering; At the individual level, medical representatives experience emotional exhaustion due to the increased tension and uncertainty of their dual roles in academic and sales. The model introduces “policy perception” as a cross-layer moderating variable and incorporates “relationship capital” and “academic resources” into the key buffer resources. Further, set a critical condition — when the number of policy changes in the current year reaches or exceeds four times, the resource buffering effect will significantly decline. Based on this, this paper proposes a policy-responsive resource allocation approach and demonstrates the feasibility of digital tools’ intervention in pressure transmission, providing a reference for enterprises’ compliance operation and team resilience building.

Keywords: Volume-based procurement; Medical representative; JDR model; Digital intervention

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1. Introduction

With the optimization of the drug access and price discovery mechanism due to the reform of volume-based procurement, the procurement decisions of medical institutions have gradually become centralized, and payment and performance have become the core correlation points. Starting from 2025, the medical insurance credit evaluation mechanism has been strengthened, and regularization has been established. The compliance constraints, information disclosure, and behavioral boundaries faced by enterprises and front-line personnel have undergone fundamental changes. Medical representatives serve as a bridge between the business community and the medical

field, playing the role of academic promotion and empirical exchange, and also shouldering the responsibility of performance indicators and compliance bottom lines. The job requirements and resource allocation fluctuate sharply, with obvious cyclical and sudden characteristics. The “demand—resources—health/performance” path can be explained by the JDR model, but it fails to reflect the dynamic combination of policy frequency and individual perception in the short term. Revise the JDR framework, analyze the bidirectional path of “organization-individual” pressure transmission, and derive the implementable resource allocation and digital intervention plan.

2. Theoretical framework and model revision

2.1. “Organization-individual” dual-path JDR expansion

The organizational structure and system processes are currently facing external shocks, involving changes in batches of volume-based procurement, deductions in medical insurance credit evaluations, and accountability pressure. To counter the above-mentioned impacts, measures such as adjusting the assessment criteria, extending the approval process, and increasing the density of compliance reviews have been adopted, which are gradually passed down to the front line. This is specifically reflected in aspects such as work instructions and time urgency. Medical representatives need to constantly balance and analyze between academic norms and sales targets, and maintain efficiency and psychological balance amid rule changes and information instability. In actual operation, the two paths frequently alternate and run in parallel, with effects accumulating and amplifying each other. This weakens emotional reserves and also shakes business execution and the stability of long-term performance.

2.2. Definition of key variables

In terms of job requirements, the intensity of compliance affairs, the threshold for license approval, and the time needed for filing and record-keeping, as well as frequent adjustments to performance targets due to policy fluctuations, all these will increase the complexity of tasks and psychological burden. Professional elements can be subdivided into academic assets and social capital. This field covers the completeness of the evidence set, professional technical assistance from the medical affairs team, and the ability to plan and implement academic activities. This characteristic is reflected in the trust foundation and communication efficiency among multiple parties, such as departments, pharmaceutical affairs, medical insurance, and material procurement ^[1]. Emotional exhaustion is adopted as a representative of health-related indicators to assess the level of psychological energy depletion. Simultaneously introduce the quality of job completion and the frequency of violation incidents, and independently assess business results and risk exposure levels.

2.3. Model correction and adjustment mechanism

In the model correction, “policy sensitivity” is adopted as the inter-level adjustment tool. Through the differences in individual sensitivity to the frequency and intensity of policy changes, even if the frequency of policy updates is similar, when facing new organizational requirements, highly perceptive individuals tend to interpret them as uncertainties and potential risks, leading to the expansion of emotional exhaustion and performance fluctuations. To address the consumption pressure triggered by external demands, integrate social relationship capital and academic resources into a buffer structure, thereby enhancing academic resources and improving professionalism and persuasiveness when communicating with clients. Utilize relationship capital to enhance the efficiency of reaching out to key stakeholders and the smoothness of collaboration, and build a dual protective barrier of psychology and performance.

2.4. Dynamic expression and critical value setting

Express the emotional exhaustion during period t as

$$E_{t+1} = \phi E_t + \alpha (F_t \times P_i) + \gamma R_t - \beta_1 A_t - \beta_2 C_t + \varepsilon_t$$

Among them, F_t represents the frequency of policy changes, P_i represents individual policy perception, R_t represents role tension, A_t represents academic resources, and C_t represents relationship capital. When the number of annual policy changes reaches or exceeds four times, the threshold is triggered, and the buffer coefficient decays:

$$\beta_k^* = \beta_k (1 - \lambda), \quad k \in \{1, 2\}, \lambda \in (0, 1]$$

It indicates that under high-frequency oscillation, the marginal buffering capacity of existing resources fails or rapidly decreases.

3. Explanation of the mechanism of pressure transmission: From direct effect to buffering effect

3.1. Direct path: The cumulative effect of pressure from the increase in policy frequency

The shortening of the policy update cycle indicates continuous changes in regulations and a sharp increase in learning costs, forming a stepwise upward trend. When new regulations are issued, organizations and individuals need to quickly absorb, understand, and internalize the rules. This stage is often accompanied by forced interruptions and resettlings of the current work rhythm. The uncertainty of the process leads to frequent reconfiguration of the schedule, and the project advancement path needs to be adjusted in direction in response to urgent policy requirements. At the organizational level, external changes have been transformed into more stringent compliance regulations, assessment standards, and audit requirements, narrowing the scope of constraints of the grassroots management system. At the individual level, there is a phenomenon of accumulated emotional exhaustion and scattered attention, frequent task switching, fragmented time utilization, and the possibility of in-depth thinking and systematic preparation is weakened. The operational driving force of this path stems from the dual influence of “unpredictability” and “time fragmentation.” The pressure curve is characterized by short cycles and a sharp increase in growth rate, which poses a compound impact on the psychology and performance of medical representatives.

3.2. Buffer path: The peak shaving effect of academic resources and relationship capital

Against the background of policy fluctuations, academic resources and relationship capital have constructed an inherent buffer system. The richness and update speed of academic resources have significantly enhanced the information matching degree between medical representatives and medical institutions, making professional communication more in-depth and targeted, and greatly reducing the communication and coordination pressure caused by rule changes. When policy changes raise doubts in the clinical field, authoritative academic achievements become the anchor of trust, reducing the frequency and intensity of doubts. At the level of contact channels, relationship capital demonstrates its unique advantages, significantly shortening the path of information transmission, while also deepening the understanding of situations through long-term trust relationships and reducing frictional expenditures caused by differences in policy interpretation. The combination of the two reduces the peaks of exogenous shocks, raises their troughs, and curbs the upward trend of emotional exhaustion. In the

face of the urgent moment when policy adjustments occur frequently, it is necessary to rely on both academic and interpersonal relationships to consolidate the resilience foundation of front-line personnel and prevent the predicament of ineffective response due to the depletion of a single resource.

3.3. The coupling effect of the tension between the academic and sales dual roles

Medical representatives play a dual role in both academic promotion and sales conversion. During the stable stage, this combination of roles can still complement each other. During the period of policy tightening, when the risk of conflict may rise and the intensity of supervision keeps increasing, the priority of academic norms rises particularly significantly. The allocation of internal resources and time investment within enterprises has shifted towards a long-term academic development path. However, the immediate nature of sales targets remains prominent and still accounts for a significant proportion in the assessment system. The contradiction between time and goals reveals a “tense situation of roles.” In an environment of frequent policy updates, this tension resonates with the frequency of policies, and its intensity keeps rising along with policy updates. The synergy between short-term sales targets and long-term academic strategies is facing challenges. Medical representatives need to frequently switch their task forms under the constraints of time budgets, transitioning from evidence-based communication within the department to driving market performance, which increases their memory load and reduces the stability of their strategies. This coupling effect significantly enhanced the effect value of role tension on the emotional exhaustion contribution term (R_t), and the nonlinear growth of the stress effect.

3.4. “Shock points” for medical insurance credit evaluation in 2025

In the 2025 medical insurance credit assessment system, key links such as medical insurance payment, agreement management, and procurement access are directly integrated with the behaviors of enterprises and individuals, significantly enhancing the institutional effectiveness of policies in organizational processes. Possible impact points include: the frequency and depth of compliance reviews are simultaneously enhanced; The approval of academic activities is becoming more cautious, introducing a pre-review and process monitoring stage. The scope of accountability has been expanded to negative events, enhancing the ability of front-line personnel to identify the risks of violations. The frequency of training and re-certification has increased, and the requirements for updating policy knowledge and compliance skills have become stricter. The organizational benchmark requirements have been comprehensively raised to a new height, management expenses have sharply increased, and the assessment standards have also been permeated from top to bottom, extending to the front-line execution positions. As a result, individuals’ subjective expectations of punishment and reputation risks have risen, and their psychological burden has increased. The amplification effect of the $F_t \times P_i$ item in the policy impact path is obvious. During the period of frequent policy changes, individuals’ sensitivity to the consequences of violations and the pressure to cope with them show a superimposed upward trend.

3.5. Contextualized interpretation of threshold effect and resource failure

The frequency of annual policy changes has exceeded four times, and the pressure of policy response will cross a critical threshold. The memory, energy, and time resources that medical representatives possess are being continuously depleted. The localization progress of academic materials lags behind, resource allocation is misaligned, and clinical communication lacks the latest contextualized empirical support. The pace of relationship maintenance has been disrupted, and there are obvious signs of a decrease in the frequency of trust network interactions. The β_k buffer coefficient rapidly decreases with resource depletion, the success rate of

communication drops, information transmission lags behind, and confidence in efficiency declines. When this state persists, even if the total amount of resource input does not decrease and fails to match the distribution and rhythm of environmental changes, the marginal benefit will significantly decline. This phenomenon of “resource failure” serves as a warning to management. In the face of frequent policy changes, resource regulation strategies should shift from being quantity-driven to prioritizing rhythm and adaptability, to prevent the unnecessary consumption of organizational and individual response capabilities by habitual investment.

3.6. Feasibility of the intervention of digital tools

When dealing with high-frequency policy shocks, digital means can be implemented following the path of “policy frequency visualization—knowledge unit refinement—behavior closed loop construction.” In the rule analysis and push stage, relying on the compliance text analysis model, policy priorities are automatically screened, scenario adaptation mapping is implemented, and operation manuals for departments, positions, and task processes are compiled to reduce the time input for interpretation. In terms of micro-learning and evidence package management, empirical data are modularized to form reusable knowledge units, which are automatically classified according to departmental attributes and disease pathways to optimize the rate and accuracy of knowledge retrieval. The combination of path planning and traceability automation enables a direct connection between the visit plan and the approval traceability system, reducing the process interference caused by cross-system operations and repetitive data entry. In the risk and emotion monitoring stage, an early warning mechanism is formed through processing data and self-assessment scales to promptly adjust resource allocation and execution pace. Under the premise of data compliance, permission stratification, and privacy protection, such tools significantly reduce information asymmetry and process obstacles, effectively curb the pressure gradient rise in the direct path, and enhance the positive effect level of the buffer path.

4. Policy responsive resource allocation and operation framework

4.1. Hierarchical and clustered resource allocation logic

In a high-frequency policy environment, the homogenized resource allocation model is not efficient enough and is prone to misallocation among different groups. Taking “policy release frequency - public awareness” as the coordinate axis, the audience is divided into four quadrants for precise targeting. For high-frequency and high-perception groups, priority should be given to concentrating the strength of MSL (Medical Science Liaison Officers), key evidence databases, and front-line capability improvement courses to ensure that they can quickly master and implement the new norms. The high-frequency but low-perception group, by means of process assistance tools, automatic alarm systems, and visual operation manuals, strives to make up for the perception differences and reduce the information lag effect. For groups with low frequency but high perception, emphasis should be placed on strengthening situational exercises, mentorship guidance, and case reviews to enhance their response capabilities. The low-frequency and low-perception group adheres to the stability of the basic business territory and focuses on maintaining relationship capital and consolidating the trust chain.

4.2. Rhythmic deployment and “threshold plan”

In the policy change monitoring system, a peak of the annual number of changes needs to be set. When the number of changes approaches the set threshold, it immediately switches to the “wartime” operation mode. Within the established model, non-core business activities should be moderately reduced, and limited resources

should be concentrated in the areas and departments most affected. MSL and compliance advisors should enhance collaboration to form an immediate Q&A and risk early warning mechanism. Implement the “minimum viable version” strategy, promptly launch the evidence package, carry out short-term rolling iterations, and continuously optimize and upgrade to ensure the timeliness and availability of core materials. In the maintenance of relationship capital, precise communication at key nodes should be emphasized. For instance, during critical moments such as the procurement cycle, price negotiations, and adjustments to the medical insurance directory, core contacts should be relied upon to maintain process consistency and the sustainability of cooperation. Such orderly deployment and contingency plans, in the face of concentrated shocks, can significantly reduce the risk of pressure concentration and maintain operational stability.

4.3. Organizational governance and indicator closed loop

The effectiveness of policy response is not only achieved independently through resource input, but also requires the construction of a governance closed-loop structure with the aid of an indicator system. It is proposed to build a three-level evaluation indicator matrix. The process layer elements, such as the quality of learning completion, the comprehensiveness of the evidence package coverage, and the time-consuming nature of the approval process, directly present the results of execution efficiency. The score of the Emotional Exhaustion Scale, the self-assessment of role stress, and the usability score of digital tools jointly constitute the perception layer, extracting the relevant data of the psychology of front-line workers and the adaptability of tools. The performance evaluation hierarchy involves the ratio of compliance incidents, the success rate of communication, and the effectiveness of task execution, outlining the final business performance profile. Conduct quarterly reviews, match data with human resources, capital flow, and time consumption, dynamically adjust the allocation ratio based on the performance of different links, and use a data visualization platform to transparently present hierarchical indicators. The team visually presents its implementation trajectory on the direct and buffer paths, enhancing the team’s self-regulation and goal-oriented levels, and thereby achieving a positive feedback mechanism for policy response.

4.4. Structuring and localization of academic resources

Enhance the alignment of academic resources with policy adjustments. For key specialties, a four-element database framework of “evidence—script—material—activity” is constructed and precisely mapped according to disease pathways and in-hospital processes, which can be directly integrated with clinical communication and supported by the most cutting-edge evidence-based guidelines and key research results. The script library has been reshaped into a clinically applicable communication vocabulary. This library brings together standardized slides, summary cards, and chart collections. Academic salons, case discussions, and teaching activities have been fully incorporated, alleviating the heavy burden of secondary processing on front-line representatives due to frequent changes. Therefore, regional annotations should be implemented for the detailed policies of local medical insurance, procurement, and pricing to ensure that the data can be directly applied in practice.

5. Summary

This study introduces policy perception and relationship capital elements into the JDR model and designs an “organization-individual” dual-pathway pressure transmission model to cope with policy shock periods. Empirical

logic indicates that the frequency of policies, due to the cascading effect of organizational requirements, directly exacerbates the phenomenon of emotional exhaustion. Academic resources and relationship capital effectively resisted this shock. Once the number of policy adjustments exceeded the critical value of four times, the marginal effect of resources significantly declined. Based on this dynamic rule, a resource allocation and operation framework should be established, with policy monitoring as the starting point, hierarchical classification as the key, and digital tools as the auxiliary, to pursue team resilience and customer communication stability on the basis of compliance. In the future, benchmarking analysis should be carried out in multiple regions, across multiple products, and at different levels of organizational development. The external implementation validity of thresholds, buffer ratios, and the intensity of intervention tools should be analyzed to optimize the dynamic coupling relationship of “policy—demand—resources—effectiveness.”

Disclosure statement

The author declares no conflict of interest.

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Enhancing Submersible Safety: Predictive Modeling and Search Model for Lost Submersibles

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Abstract: The Titan submersible accident has raised global concerns regarding submersible safety. To mitigate such risks and enhance survival probabilities, this study develops a safety support system aimed at predicting submersible trajectories and optimizing search operations. A Submersible Position Prediction Model is established, incorporating seawater salinity, temperature, current, and seabed elevation data from the Ionian Sea. Force analysis based on computer simulations is used to generate minute-by-minute positional data, resulting in a probability distribution of its location. Model validation is conducted using Caribbean Sea data. Furthermore, a Two-Dimensional Kernel Density Estimation Search Model is proposed to minimize search time for a lost submersible. The method partitions the probability distribution into four regions, each searched by a robot moving outward from the center, significantly improving search efficiency. A function relating search success probability to time is derived based on robot speed and detection range. The results show that the lost submarine can be found within 1.3 hours. Finally, a multi-submersible position prediction model is introduced, which updates the dive path of one submersible based on real-time positions of others, enhancing coordination and emergency response capabilities.

Keywords: Computer simulation; 2D KDE; Submersible position prediction; Search model; Force analysis

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1. Background

On June 18, 2023, a U.S. tourist submarine lost contact while exploring the wreck of the Titanic, which shocked the world. After the loss of contact, no one knew the location of the submersible. The search lasted for a long 4 days, and ultimately, only the wreckage of the submersible was found. This tragedy was caused by inadequate safety measures of the submersible. Concerns have been raised about the safety of the submersible.

In order to sustain the development of the industry, more stringent safety measures are necessary. The authors build a predictive model for the position of submersibles to prevent loss of contact and to speed up the search. After careful analysis of this issue, the authors have identified six main sub problems that need to be addressed in

this article: (1) Establish a model to predict the change of submersible position over time. (2) Establish a model to search the submersible and determine the probability of finding a submersible as a function of time. (3) Establish the mutual warning model of multiple submersibles.

2. Methodology and core concepts

According to existing research, there are two main methods for predicting the trajectory of a submersible: dynamic simulation and neural network prediction ^[1]. This article adopts a method similar to dynamic simulation. During the simulation of the submersible dive process, data on salinity, temperature, ocean currents, and seabed elevation were first collected. Based on these data, the density and resistance of seawater were calculated, enabling the determination of the submersible's state at any given moment. Through multiple simulation runs, the distribution of potential diving paths was derived. This model also explains the types of data required for predicting the submersible's position accurately.

For the design of search methods for a lost submersible, a two-dimensional kernel density estimation (2D KDE) was used to obtain the probability density distribution of its location. After simplifying the probability density distribution, a search model for searching elliptical regions was established. The elliptical area was divided into four sectors, and each was assigned a robot to conduct an inward-to-outward search. Based on the robot's speed and detection radius, a function relating search success probability to time was established.

There is existing work on submersible search models, but there is a lack of safety measures for coordinating multiple submersibles ^[2]. Regarding the influence of multiple submersibles on the diving process, a mutual positioning method among submersibles was proposed. Using the coordinates determined through inter-submersible communication, Model I was updated to reduce errors in trajectory prediction.

3. Model I: Submersible position prediction model

3.1. Force analysis of submersible

The state of the seawater is reflected in its density. According to the equation of state of seawater summarized, the density of seawater ρ can be derived ^[3]. The parameters of the function are seawater salinity $S(g/kg)$, temperature $T(^{\circ}C)$ and pressure $P(Pa)$. Density will increase with increasing salinity, decreasing temperature, and increasing pressure; otherwise, it will decrease, i.e. $\rho \propto S T^{-1}, P$.

Obtain the density of seawater $\rho_{STP}(kg/m^3)$ at pressure P :

$$\rho_{STP} = \rho(S, T, P) = \frac{\rho(S, T, 0)}{1 - \frac{P}{K(S, T, P)}} (kg/m^3) \quad (3.1)$$

For a given seawater depth, the pressure is approximated as that induced by surface seawater density at an equivalent depth. After obtaining the density of seawater, the thrust ocean currents and the resistance of seawater on the submersible can be solved.

The formula of seawater resistance is:

$$f = \frac{1}{2} C \rho_{STP} S_s v^2 (N) \quad (3.2)$$

Where C is the resistance coefficient, ρ_{STP} is seawater conditions, it can be monitored on-site; $v(m/s)$ is the area of the submersible; $S_s(m^2)$ is the fluid velocity ^[4].

When submersibles dive without power, they are pushed by ocean currents. The impact force F_c exerted by water on an object is related to the water velocity $v_c(m/s)$ and cross-sectional area S_s . The formula is:

$$F_c = \frac{1}{2} \rho_{STP} S_s v_c^2 (N) \quad (3.3)$$

Next, conduct a force analysis on the submersible. In the horizontal direction, the submersible is affected by its own thrust F_s , ocean current thrust F_c , and seawater resistance $f(N)$. The magnitude of the submarine thrust plus seawater resistance is equal to the ocean current thrust, and the forward direction of the submarine affected by the ocean current is equal to the direction of the ocean current. The formula is:

$$F_c = F_s + f(N) \quad (3.4)$$

In the vertical direction, the submersible's own gravity G is equal to the buoyancy F_b plus the water resistance f :

$$G = F_b + f(N) \quad (3.5)$$

Where the buoyancy of the submersible is proportional to its own volume $V(m^3)$ and seawater density ρ_{STP} . Its formula is as follows:

$$F_b = \rho_{STP} g V(N) \quad (3.6)$$

Where g is the gravitational acceleration of the region, which is .

3.2. Submersible diving simulation

In order to get the submersible position prediction model, a computer simulation method is used to calculate the speed and direction of the submersible's movement at each minute of diving, based on the surrounding conditions and its own situation.

Divide the diving process of the submersible into several discrete motion processes based on time, with an interval of one minute between each motion process. From the beginning of diving, the time t for the submersible to detach from the host ship is 0, the submersible position is $p(0,0,0)$.

According to formulas A and B, the magnitude and direction of the horizontal and vertical motion velocities of the submersible at t minute can be calculated and synthesized into a motion vector $v(x,y,z)$, where x,y,z are coordinates of the submersible at time t , i.e. $x(t),y(t),z(t)$.

The displacement of the submersible within t minute is $D(x,y,z)$, where $D(x,y,z)=v(x,y,z) \times 60$. Take the partial derivative of and obtain the velocity in the x axis direction:

$$\begin{aligned} v_x(t) &= \frac{\partial D(x,y,z,t)}{\partial x} \\ v_y(t) &= \frac{\partial D(x,y,z,t)}{\partial y} \\ v_z(t) &= \frac{\partial D(x,y,z,t)}{\partial z} \end{aligned} \quad (3.7)$$

Force analysis is performed on the submersible using its current position, denoted as $p(x,y,z,t)$, enabling estimation of its coordinates at the next one minute $p(x,y,z,t+1)$. The formula is:

$$\begin{aligned}
x(t+1) &= x(t) + v_x(t) \times 60 \\
y(t+1) &= y(t) + v_y(t) \times 60 \\
z(t+1) &= z(t) + v_z(t) \times 60
\end{aligned}
\tag{3.8}$$

According to the publicly available online seabed elevation map, the depth $d(x,y)$ of the diving area at coordinates (x,y) can be obtained. At a certain time t , if $z(t=1) < d(x,y)$, then the submersible has already made contact with the seabed, and the simulation stops.

It is worth noting that due to the operation of the submersible's own engine and the small changes in ocean currents, random position offsets are also needed. The effect of the offset at time t will be reflected in $p(x,y,z,t+1)$. The algorithm is shown in **Table 1**.

Table 1. Algorithm: The process of submersible diving

Input: $S, T, P, d(x,y), vc, S_v, V$
Output: submarine position
Set the starting point to $p(0,0,0)$.
for $t=1$ to ∞ do
Calculate the seawater density ρ_{STP} at position (x,y,z) based on (3.1).
Calculate the diving speed and direction based on the situation of the submersible, based on (3.4), (3.4).
Add random variations to the obtained speed $v(x,y,z)$ to simulate ocean current fluctuations and engine operation.
Calculate the position in based on (3.8).
If the $t+1$, end loop.
$z(t+1)$ end $d(x,y)$

3.3. Result of Model I

The diving process is simulated in Python. The dive initiation point is set at longitude 16°30'0"E and latitude 37°30'0"N. The direction of ocean current is northwest to southeast, and the size of ocean current decreases with increasing depth, and the seabed topography is relatively gentle on a small scale ^[5-8].

Through repeated simulations, the following results (**Figure 1** and **Figure 2**) are obtained:

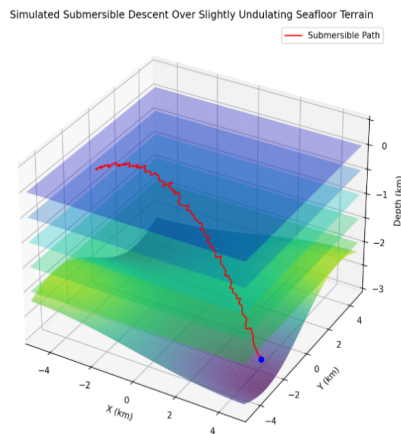


Figure 1. Submersible diving paths

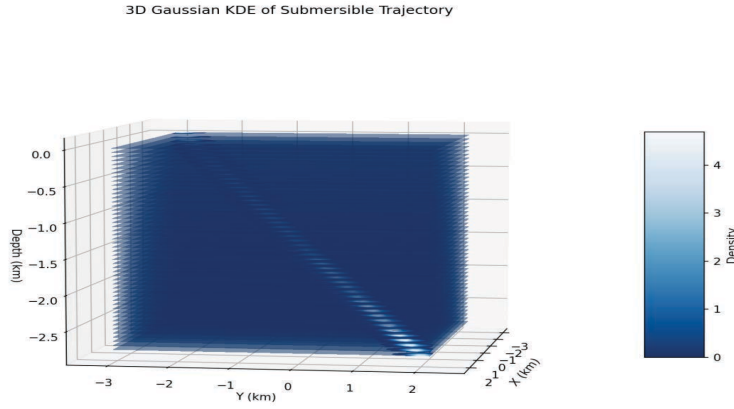


Figure 2. Probability density of submersible position

Based on these results, the final approximate position of the submersible can be estimated. As illustrated, the trajectory is significantly influenced by ocean currents. The predicted final location is confined to a small, roughly elliptical area with a high probability density.

Positional uncertainty arises from environmental variability and the submersible's own propulsion. Deviations in salinity, temperature, and current velocity from dataset averages contribute to this uncertainty. Consequently, the submersible requires a sensor suite including salinity, temperature, pressure, and flow sensors for real-time environmental monitoring. To account for propulsion-induced uncertainty, real-time monitoring of engine status and thrust direction is essential.

4. Model II: Two-dimensional kernel density estimation search model

4.1. Two-dimensional kernel density estimation of submersible

The process of searching for a submersible is related to the location of the submersible. With the distribution of the final position of the submersible obtained from Model I, two-dimensional kernel density estimation (2D KDE) is used, and the scatter plot of the point is converted into a usable probability density^[9–10].

Given a set of samples $X = \{x_1, x_2, \dots, x_n\}$ that are all two-dimensional vectors and taken from the same continuous distribution $f(x)$, the kernel density estimated at any point x is:

$$\widehat{f_h(x)} = \frac{1}{n} \sum_{i=1}^n \frac{1}{h^2} K\left(\frac{x - X_i}{h}\right) \quad (4.1)$$

Where h is bandwidth, which uses Scott's Rule. K is a kernel function defined in two-dimensional space. $K: \mathbb{R}^2 \rightarrow \mathbb{R}_+$, satisfying:

$$K(x) \geq 0, \int K(x) du = 1 \quad (4.2)$$

In this question, the coordinates of the submersible are represented by $p_r(x, y)$ i.e. p , so the formula is:

$$\widehat{f_h(p)} = \frac{1}{n} \sum_{i=1}^n \frac{1}{h^2} K\left(\frac{x - P_i}{h}\right) \quad (4.3)$$

The resulting probability boundary is observed to approximate an elliptical shape. After normalization and simplification, the final search area is reduced to an ellipse. It is worth noting that the probability of submarines appearing is higher as they approach the center of the ellipse.

4.2. Submersible search model

According to the above results, the probability of finding the submersible decreases as the distance from the center of the ellipse increases. This elliptical region is partitioned into four sectors along its axes, with each sector assigned to an autonomous search robot initiating exploration from the center outward. This search method can search the most likely location of the submersible in the shortest time. This method ensures the separation of coverage areas between robots while covering the entire elliptical area as much as possible. The searching process is shown in the following **Figure 3**.

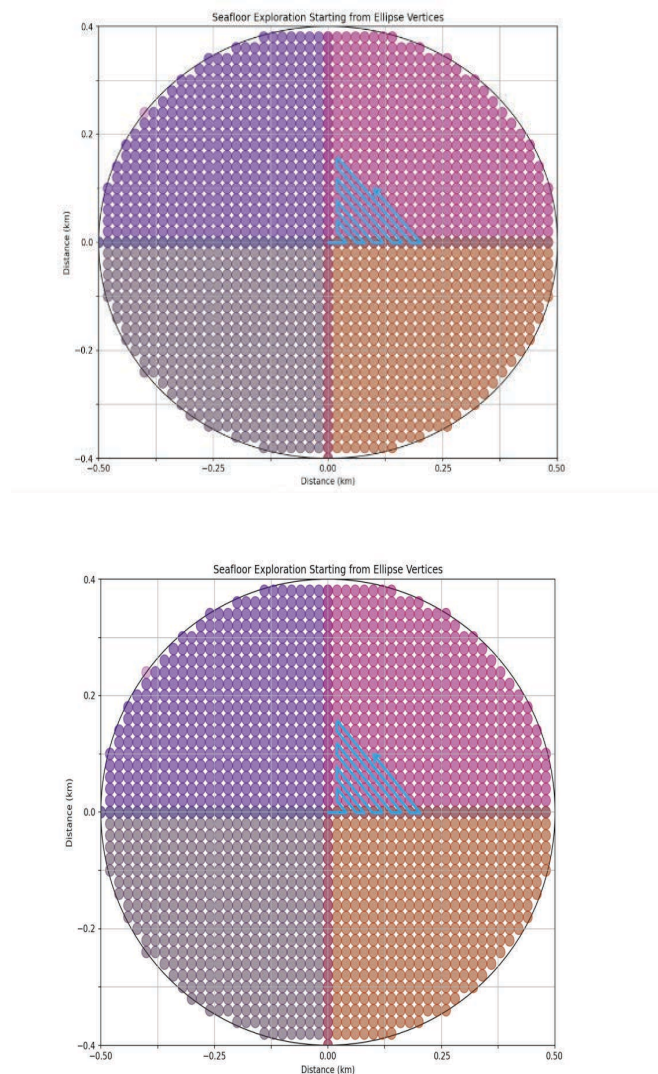


Figure 3. Searching process

Assuming a robot has a moving speed of $v_r(m/s)$ and a detectable radius of $r(m)$. The time t_i of the movement to the next location is

$$t_i = \frac{\sqrt{(x_{i+1} - x_i)^2 + (y_{i+1} - y_i)^2}}{v_r} \quad (4.4)$$

Where x_i and y_i is the location of a circle P_{ci} . Total searching time T_s is

$$T_s = \sum_{i=1}^{n-1} t_i \quad (4.5)$$

Where n is the circle number in a quarter of the elliptical.

The probability of finding the submersible p_s is the ratio of the product of the area of the search area at T_s and the probability density of the probability of the entire ellipse 1.

$$p_s = \frac{4 \sum_{i=1}^k \pi r^2 \times p_i}{1} \quad (4.6)$$

Where k is the number of points detected within a quarter ellipse at time T_s . p_i is the probability at the i -th detection point.

4.3. Result of Model II

In order to accelerate the search speed for the crashed submersible and obtain an estimate of the probability of successful search, the Two-dimensional kernel density estimation model is combined with the search model.

After the calculation, when the robot speed and the search radius, the time to complete the search is 1.28 hours. The Curve of the probability of search success over time (**Figure 4**) is shown below. It can be found that when the time is 1.3 hours, the probability of success of the search is close to 100%.

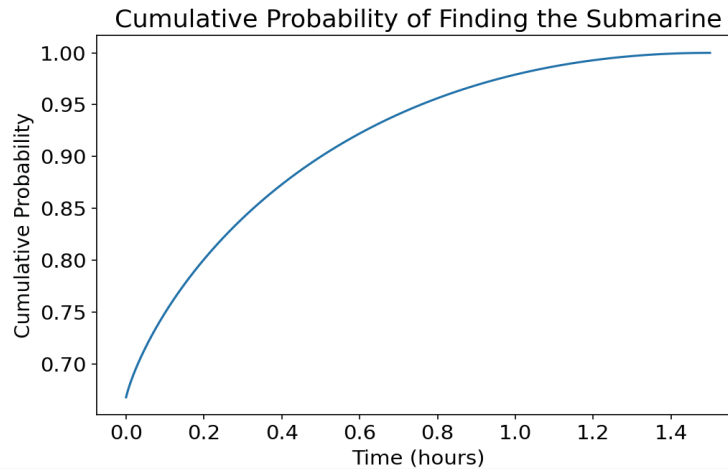


Figure 4. Curve of the probability of search success over time

5. Model III: Submersible position prediction model with multiple submersibles

5.1. Establish the model

Usually, in order to maximize profits, there is more than one submersible located in the same area. Studying the relationship between multiple submersibles is important for improving safety and rescue success rates. Due to

the inconvenience of communication between the submersible and the host ship in the deep sea, higher power signal receiving and transmitting equipment is required to ensure communication quality. In order to save costs, submersible located in multiple submersible centers was chosen as the communication hub. communicates with - simultaneously, measures precise positions with each other, summarizes them, and reports them to the host ship. At the same time, the submersible -also try to synchronize its own data to the host ship. Therefore, the submersible network is established, and host ship only needs to use sonar to determine the position of rather than all of the submersibles, which makes it more accurate.

When one of the submersibles loses contact, its location can be accurately measured. Assuming a submersible (denoted as S_n) loses communication and requires rescue operations, modifications are implemented to Model I based on its last known precise position .

5.2. Result of Model III

It is assumed that the submersible lost contact at a depth of 1500 meters in the same sea region in Model I, and used the precise position before losing contact as a starting point to obtain multiple simulation results. The result is shown in **Figure 5** below.

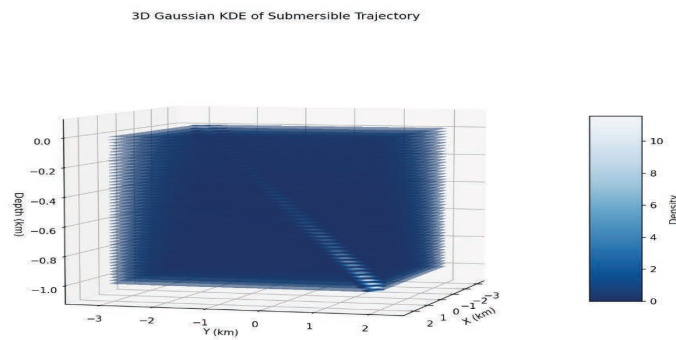


Figure 5. Result of Model III

As can be seen from the figure, the predicted area of the final possible location of the submersible is significantly smaller than that of **Figure 2**, which proves the accuracy of the model.

6. Conclusion

The model uses the latest, accurate Marine data to ensure the reliability of the results. After using the most important parameters, it can predict the position of the submersible more accurately and has a higher use value. In order to minimize search time, the optimal search path is selected according to the probability density of the submersible distribution, so the most likely location of the submersible can be searched in the shortest time. With the assistance of other submersibles, the position of the lost submersibles can be more precise. However, the uncertainty associated with the positions of other submersibles was not considered in this analysis. The results of the model are the most optimistic scenario, and there will be deviations from the facts.

Disclosure statement

The authors declare no conflict of interest.

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Can Market Integration Reduce Corporate Misconduct? Evidence from the Pilot Implementation of the Fair Competition Review System

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Abstract: Maintaining fair competition is the core of guaranteeing the effective operation of the market economy. Using the Fair Competition Review System introduced in 2016 as a quasi-natural experiment, this study explores the impact of the system on corporate misconduct. The study finds that the Fair Competition Review System is negatively associated with corporate misconduct. This effect operates by increasing firms' internal controls and mitigating the short-sightedness of the firms' management. It is more pronounced at firms located in regions with poorer business environments and among firms with lower information transparency. Finally, the Fair Competition Review System effectively reduces business and bankruptcy risks. Overall, the study provides micro-level empirical evidence for the governance effects of the Fair Competition Review System and valuable references for corporate governance practices.

Keywords: Market integration; Administrative monopoly regulation; Corporate misconduct; Internal controls

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1. Introduction

The prevalence of local protectionism has undermined the sustainability of economic development. For example, local protectionism restricts the free flow of production resources, leading to market segmentation and a series of negative impacts, such as increased enterprise marginal costs^[1]. Moreover, it contributes to higher regional carbon emission intensity and severe regional haze pollution^[2-3]. In China, local protectionism has become a significant constraint on economic development. Fiscal decentralization, a key feature of China's development model, can incentivize local governments to rapidly develop the economy, but it also encourages protectionism. This results in market fragmentation, hindering further high-quality development. Under fiscal decentralization, local governments have strong incentives to use administrative measures to protect local businesses, offering them favorable conditions while restricting fair market access for non-local enterprises.

In response, the Chinese government has initiated market integration to foster high-quality economic

development. For instance, Shanghai, Jiangsu, Zhejiang, and Anhui have signed a cooperation agreement under the central government's guidance. The agreement aims to dismantle administrative barriers caused by local protectionism, promote the free flow of resources, and enable the integrated development of regional markets. Research has shown that market integration benefits urban air quality, enhances economic resilience, and reduces corporate tax evasion^[4-6]. However, little is known about its relationship with corporate misconduct. To address this gap, this article investigates how the process of market integration influences corporate misconduct. A key milestone in China's market integration is the implementation of the fair competition review system. This system shifts regulatory focus from enterprises to the government, explicitly prohibiting local governments from setting unequal market access and exit conditions, as well as banning unfair preferential policies. By curbing local protectionism, it has significantly promoted market integration in China. Extensive research on the fair competition review system has demonstrated its positive impact on corporate green innovation, innovation in state-owned enterprises, and the ESG performance of firms^[7-9]. However, the relationship between the fair competition review system and corporate misconduct remains unclear. This study, therefore, investigates the role of market integration, focusing specifically on the implementation of the fair competition review system.

Corporate misconduct refers to unethical or illegal behaviors, such as fraud or improper disclosure, aimed at advancing a company's interests. These actions can damage a company's reputation and, in severe cases, lead to a loss of legitimacy, thereby increasing various costs. As a result, scholars have examined various ways to prevent corporate misconduct. From a supervisory perspective, mechanisms like director and officer liability insurance, non-controlling shareholder governance, and judicial digitalization have been found to reduce misconduct^[10-12]. Additionally, informal institutional factors such as Confucian culture and increased local happiness can suppress corporate misconduct^[13-14]. Executive characteristics, including higher female representation on boards and founder CEOs, have also been linked to a reduction in misconduct^[15-16]. Moreover, market factors such as reducing government subsidies and increasing competition in the banking sector can lower the likelihood of corporate misconduct^[17-18]. However, little attention has been paid to the influence of market integration on corporate misconduct. This article aims to explore whether market integration can act as a governance mechanism for corporate misconduct and to uncover the underlying mechanisms.

This article contributes to enriching research on the economic consequences of the fair competition review system. While existing studies have largely focused on how the system enhances positive outcomes like innovation, green initiatives, and ESG performance, less attention has been paid to its role in reducing negative factors, such as corporate misconduct. By exploring this issue, the article provides valuable insights into how the fair competition review system can address corporate misconduct, deepening understanding of the system's role and offering guidance for policymakers.

2. Theoretical analysis and research hypothesis

The fair competition review system implemented by the Chinese government has rigorously cracked down on market segmentation behaviors that undermine market competition, effectively promoting market integration development and ensuring market competition's adequacy and fairness. This legislation prohibits local governments from implementing policies restricting competition, such as setting unequal market access and exit conditions, and providing unequal preferential policies to local businesses. Between 2016 and 2021, under the influence of this system, 1.89 million market-distorting policies were abolished nationwide, effectively preventing

administrative monopolistic behaviors from harming the Chinese market. This crackdown on market segmentation behaviors has promoted market integration and ensured the adequacy and effectiveness of market competition.

When market competition is sufficient and effective, companies are not incentivized to engage in misconduct, as the costs of violating regulations or industry rules may outweigh the benefits gained from such misconduct. Specifically, when market competition reaches a certain level, if a company loses public trust due to misconduct, it may lose a significant number of customers, weaken its market position, and even pose a serious threat to the enterprise's survival. In conclusion, market competition, as a stringent punishment mechanism, can reduce the monitoring costs of stakeholders for listed companies, amplify the costs of corporate misconduct, create a strong deterrent effect on companies, and make them dare not engage in illegal or irregular operations ^[19].

On the contrary, a competitive environment brings external pressure to companies, motivating management to consciously comply with various regulations and actively fulfill their managerial responsibilities. Due to the enhanced "elimination effect" of market competition, any company deviating from cost minimization and profit maximization will ultimately be driven out by the market. In order to reduce the risk of bankruptcy faced by companies in market competition and the threats to job security and income levels faced by executives, the company's management will take proactive measures to increase competitiveness, such as improving corporate governance and reducing misstatements of financial information. In general, market competition will incentivize enterprises to operate in compliance, encourage them to comply with regulations, and actively reduce violations. This study thus proposes the following hypothesis:

H₁: The fair competition review system is conducive to reducing corporate misconduct.

3. Research design

3.1. Data and sample selection

The present study uses data from listed companies on the Shanghai and Shenzhen stock exchanges between 2012 and 2022 as the initial sample. Financial and insurance firms, ST, *ST, PT companies, and those with missing data were excluded, resulting in 24,168 annual observations. To mitigate the impact of outliers, Winsorization was applied, trimming the upper and lower 1% of the continuous variables. The financial data of the listed companies were sourced from the CSMAR and Wind databases.

3.2. Models and variables

To assess the relationship between the fair competition review system and corporate misconduct, the study constructs the following regression model:

$$VioNum = \alpha_0 + \alpha_1 Treat_i \times Post_i + \alpha_2 Controls_{i,t} + \sum Year + \sum Firm + \varepsilon_{i,t} \quad (1)$$

In the model, *VioNum* represents corporate misconduct frequency, which is defined as the number of corporate misconducts committed by a firm during a calendar year. The study followed Luo et al., corporate misconduct includes information disclosure misconduct, business misconduct, leaders' illegal transactions, and so on ^[20].

No natural experimental and control groups existed because the fair competition review system was not piloted. To ensure that the control group of companies was as unaffected as possible by the fair competition review system, this study categorized companies in industries with low levels of administrative monopoly as the

control group ($Treat=0$) and those in sectors with high levels of administrative monopoly as the experimental group ($Treat=1$). The Chinese government's implementation of the fair competition review system in June 2016 was defined as an exogenous event. The period from 2012 to 2015 was considered the pre-policy impact period ($Post=0$), and the period from 2016 to 2022 was considered the post-policy impact period ($Post=1$). $Treat*Post$ represented the net impact effect of the policy implementation on corporate misconduct in industries with high administrative monopolies. If α_1 is significantly negative, then Hypothesis H_1 is supported, suggesting that the fair competition review policy can reduce corporate misconduct. Controls refer to a set of variables related to corporate misconduct, including "Size", "LEV", and "Board", among others, whose definitions are provided in **Table 1**. $\sum Firm$ and $\sum Year$ correspond to individual and time-fixed effects, respectively. The error term is denoted by ε .

Table 1. Variable measurement

Variable	Definition
Dependent variable	
<i>VioNum</i>	The number of violations that occurred in the enterprise that year
Independent variable	
<i>Treat</i>	Firms in administrative monopolistic industries take the value of 1, otherwise 0
Post	The value of 1 in the year 2016 and after that, and 0 otherwise
Control variable	
Size	Ln (total assets)
Lev	Total debt / Total assets
Board	Ln (the number of board directors)
Indep	The number of independent directors / the number of all board directors
Dual	The value of 1 if the CEO is also the chairman of the board of directors, and 0 otherwise
SOE	The value is 1 for state-owned enterprises and 0 otherwise
Big4	Whether audited by a Big Four accounting firm
Growth	Increase in operating income for the year/opening operating income
cash	(Monetary funds + trading financial assets)/ Total assets

4. Empirical analysis

4.1. Descriptive statistical analysis

Table 2 shows that the mean value of Misconduct frequency is 0.283, with a standard deviation of 0.7513; this measure ranges from 0 to 9. These statistics suggest that the frequency of corporate misconduct varies considerably across firms. The mean value of the dummy variable ($Treat$) in the experimental group is 0.1345, indicating that the sample of enterprises in the administrative monopoly area is about 13.45%. The descriptive statistical results of other variables are similar to existing studies (e.g., Li et al.), within reasonable ranges, and will not be elaborated here ^[12].

Table 2. Descriptive statistics of the variables

Variable	N	Mean	SD	Min	Max
Treat	24182	0.1345	0.3412	0	1
post	24182	0.7236	0.4472	0	1
Treat* post	24182	0.0895	0.2855	0	1
VioNum	24182	0.2830	0.7513	0	9
Size	24182	22.418	1.2616	19.585	26.452
Lev	24182	0.4371	0.1977	0.03490	0.9079
Board	24182	2.1221	0.1970	1.6094	2.7081
Indep	24182	37.644	5.3923	28.570	60
Dual	24182	0.2702	0.4441	0	1
SOE	24182	0.3596	0.4799	0	1
Big4	24182	0.06140	0.2401	0	1
Growth	24182	0.9818	60.258	-11.925	9290.9
cash	24182	0.1870	0.1277	0.0008	0.9359

4.2. Results of the main regression test

The results of the baseline model are displayed in **Table 3**. In column (1), only individual and year fixed effects are controlled, and the results show that the regression coefficient of Treat×Post is -0.119, significant at the 1 % level. Column (2) presents the regression results after controlling for a series of control variables, indicating that the estimated coefficient of Treat×Post remains significant at the 1 % level. This shows that compared with the control group, the violation behavior of the experimental group after the implementation of market integration reform is significantly reduced. This confirms our hypothesis.

Table 3. Baseline regression results.

Variable	(1) VioNum	(2) VioNum
Treat* post	-0.119*** (-4.46)	-0.106*** (-3.95)
Size		0.076*** (5.88)
Lev		0.381*** (7.48)
Board		-0.077 (-1.45)
Indep		-0.002 (-1.43)
Dual		-0.032* (-2.08)
SOE		0.005 (0.16)

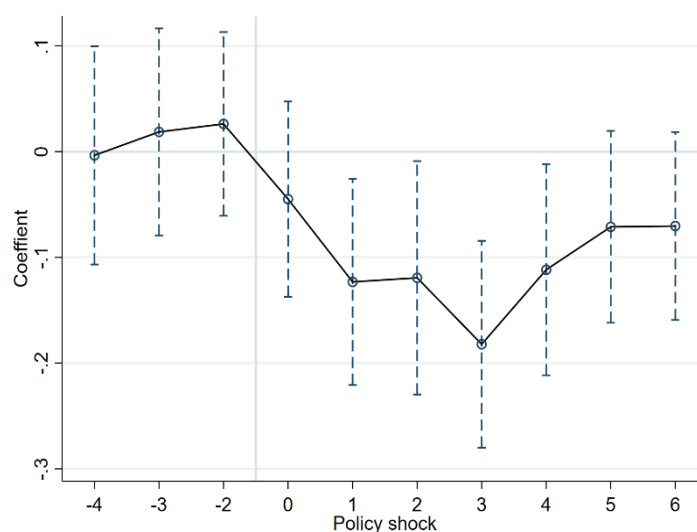
Table 1 (Continued)

Variable	(1) VioNum	(2) VioNum
Big4		-0.039 (-0.90)
Growth		-0.000 (-0.085)
cash		-0.199*** (-3.53)
Firm FE	YES	YES
Year FE	YES	YES
Observations	24168	24168
R-squared	0.0217	0.0293

Note: Standard errors in parentheses are clustered by firm: *** $P < 0.001$, ** $P < 0.01$, * $P < 0.05$, + $P < 0.10$.

4.3. Robustness tests

Parallel trend testing is essential before implementing DID. The study examined trend similarity between treatment and control groups. The research results are shown in **Figure 1**. Before the implementation of FCRS, there was no significant difference in the enterprises' violations. In 2016, when FCRS was introduced, treatment group violations decreased significantly compared to controls, with this trend persisting in subsequent years, satisfying parallel trend requirements.

**Figure 1.** Parallel trend test

Second, Placebo testing addresses potential interference from unobservable factors. We randomly assigned policy shock variables to samples and performed re-regression, repeating this process 500 times. **Figure 2** shows that estimated coefficients follow a normal distribution with a mean of zero, indicating a minimal possibility of results being affected by other macro policies or random factors.

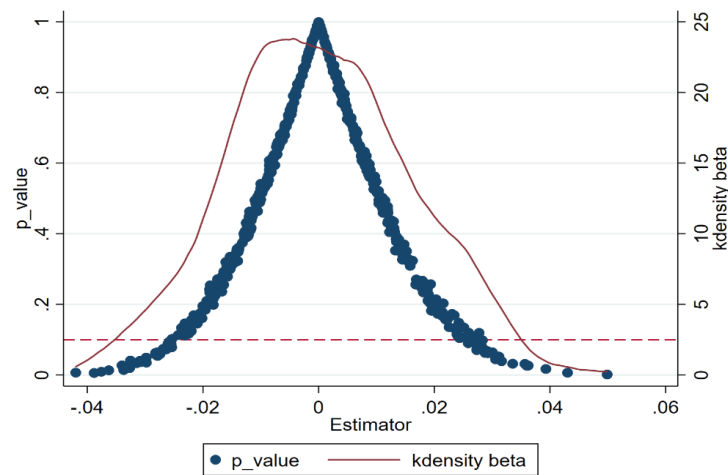


Figure 2. Placebo test

Third, Propensity score matching (PSM) addresses sample selection bias. Using all control variables as covariates, the study conducted 1:1 nearest-neighbor matching to control for sample heterogeneity between treatment and control groups. Results using matched samples (**Table 4**, column 1) remain consistent with baseline regression, confirming robustness.

Finally, alternative measurements and samples test robustness. First, following Chen et al., the study measured misconduct using a dummy variable (VioDum), with consistent results (**Table 4**, column 2)^[15]. Second, the study reselected the experimental group by calculating each region's average marketization index (2012–2015), excluding companies from the top one-third high-marketization regions, and selecting administrative monopoly industry companies as the treatment group. Results are shown in **Table 4** (column 3).

Table 4. Robustness tests

Variable	(1) VioNum	(2) VioDum	(3) VioNum
Treat* post	-0.106*** (-2.98)	-0.040*** (-2.97)	-0.027*** (-2.82)
Year FE	YES	YES	YES
Firm FE	YES	YES	YES
N	3259	24168	24023
Adj-R ²	0.0091	0.0195	0.0177

4.4. Mechanism test

In the mechanism test, the study examined the impact of the fair competition review system on internal control quality and short-sightedness in management. The regression analysis results are shown in **Table 5**. It can be observed that internal control quality is positively correlated with the fair competition review system, and it is significant at the 1% confidence interval level. The second column of **Table 5** shows that management short-sightedness is significantly negatively correlated with the fair competition review system. Thus, the proposed mechanism is validated.

Table 5. Mechanisms test

Variable	(1) ICQ	(2) Myopia
Treat* post	14.99*** (4.78)	-0.0034*** (-5.59)
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	24168	24168
Adj-R ²	0.0449	0.0366

4.5. Cross-sectional analysis

4.5.1. Business environment

A favorable business environment reduces enterprise misconduct incentives through fair competition and free resource flow, while a poor environments obstruct factor mobility and encourages short-term behavior to meet financial goals. As a fundamental reform for unified market construction, FCRS reduces administrative barriers, improves market conditions, and strengthens external governance. Therefore, the study expects FCRS to have stronger effects on non-compliance in regions with poor business environments.

Following Li et al., the study constructs a provincial business environment evaluation system using the entropy method and divides samples into high and low groups based on the mean value (high = 1, low = 0) ^[9]. Regression analysis using Model (1) shows that the interaction term Treat × Post is significantly negative only in the poor business environment sample (Table 6, columns 1–2), confirming that FCRS more effectively inhibits enterprise violations in regions with poor business environments.

4.5.2. Information transparency

Information transparency reflects external parties' access to the company's internal information. Higher transparency increases the marginal cost of management misconduct, while lower transparency creates information asymmetry that may exacerbate violations ^[21].

FCRS strengthens external supervision and reduces opportunities for opportunistic behavior, particularly benefiting companies with poor information transparency. The study expects FCRS to have stronger inhibitory effects on misconduct in less transparent companies. Following Lang et al., the study uses analyst forecast accuracy (Trans) as a proxy for corporate information transparency ^[22]. Group regression results in **Table 6** (columns 3–4) show that FCRS significantly reduces enterprise violations at the 1% level in the poor information transparency group.

Table 6. Mechanisms test

Variable	(1) High-BE	(2) Low-BE	(3) High-Trans	(4) Low-Trans
Treat* post	-0.065 (-1.44)	-0.160*** (-4.30)	-0.105 (-1.21)	-0.110*** (-3.81)
Controls	Yes	Yes	Yes	Yes
Year FE	Yes	Yes	Yes	Yes
Firm FE	Yes	Yes	Yes	Yes
Observations	12917	11110	4661	15528
Adj-R ²	0.0283	0.0317	0.0284	0.0274

4.6. Further research based on enterprise risk

Compliance laws are essential for businesses, as violations can seriously impact the company. Enterprise violations will not only damage the enterprise's reputation but also exacerbate the risks faced by the enterprise. This manifests as increased business operation risk and a higher probability of financial distress. Therefore, the impact of FCRS on business risk and bankruptcy risk needs to be further explored.

First, referring to Ohlson's (1980) measurement of corporate financial distress, the study uses O_Adj calculated by the O-Score model to measure bankruptcy risk ^[23]. Secondly, referring to the studies of John et al., the volatility of corporate earnings (O_Risk) is used to measure operational risk ^[24]. The correlation regression results are shown in **Table 7**. The estimated coefficients of Treat*Post are all significantly negative, which indicates that implementing FCRS significantly reduces enterprises' financial and operational risks and further supports the positive governance role of implementing FCRS.

Table 7. Additional analysis

Variable	(1) Bankruptcy risk	(2) Operational risk
Treat* post	-0.184*** (-3.43)	-0.006** (-2.49)
Controls	Yes	Yes
Year FE	Yes	Yes
Firm FE	Yes	Yes
Observations	24168	19972
Adj-R ²	0.0283	0.011

5. Conclusion

Using Chinese A-share listed companies, this study investigates FCRS effects on corporate misconduct and analyzes underlying mechanisms and heterogeneous influences. Results show that FCRS, as a key market integration mechanism, effectively curbs corporate misconduct through robustness tests. Mechanism analysis reveals FCRS operates as external governance, reducing misconduct by strengthening internal controls and decreasing managerial short-termism. Heterogeneity analysis indicates stronger effects in regions with poor business environments and companies with low information transparency.

Based on these findings, the study proposes three policy implications: First, strengthen FCRS implementation. The government should refine institutional design, ensure consistent nationwide implementation, and establish supervision mechanisms for regular effectiveness assessment and timely optimization. Second, prioritize business environment improvement. Given stronger FCRS effects in poor business environments, the government should streamline procedures, enhance service efficiency, eliminate local protectionism, and remove market barriers to create transparent, predictable conditions that fundamentally reduce misconduct incentives. Third, promote corporate governance and transparency standards. Since FCRS works through internal controls with stronger effects in low-transparency companies, the government should enforce stricter disclosure requirements, enhance governance frameworks, and implement stronger managerial oversight to foster long-term thinking and discourage opportunistic behaviors.

Disclosure statement

The author declares no conflict of interest.

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Cost Awareness of Medical Expenses of OPD Patients in a Selected Level I Hospital in San Juan, Batangas: Input for Policy Recommendation

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Abstract: The rising cost of healthcare, particularly in outpatient departments (OPDs), poses significant challenges for patients who often shoulder expenses out of pocket. This study explored the cost-consciousness of OPD patients in a Level I hospital in San Juan, Batangas, and examined their awareness of medical bills. Utilizing a mixed-methods approach, the quantitative phase employed a descriptive cross-sectional design with 150 OPD patients, while the qualitative phase applied a phenomenological design through in-depth interviews with 22 participants. Findings revealed that most patients were unaware of the actual costs of their medical care, with awareness highest for medications but lowest for procedures and medical supplies. Lack of cost awareness was linked to delayed treatments, poor adherence, emotional distress, and financial strain. The study concludes that cost unawareness significantly affects patient outcomes and decision-making. It underscores the urgent need for clear price disclosure, improved billing communication, and patient education. Policy recommendations include institutionalizing transparent pricing, streamlining financial aid processes, integrating financial counseling in OPD services, and leveraging telemedicine to reduce indirect costs. A research simulacrum was also proposed to guide policy modeling and implementation. Ultimately, this study highlights the vital role of financial transparency in advancing healthcare equity and improving access to essential services.

Keywords: Cost-consciousness; Outpatient department; Financial transparency; Coping mechanisms; Healthcare equity

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1. Introduction

The rising costs of healthcare have become a pressing concern globally, with outpatient departments (OPDs) emerging as a significant point of discussion in health economics and policy. Unlike inpatient care, which has been widely studied, outpatient services often receive less attention despite their critical role in providing accessible healthcare to communities, particularly in developing countries^[1]. In the Philippines, Level I hospitals serve as the

frontline facilities offering essential outpatient services to individuals from diverse socio-economic backgrounds, many of whom struggle with limited financial resources ^[2].

Outpatient medical expenses vary considerably, encompassing diagnostic tests, prescribed medicines, medical supplies, and procedures, all of which contribute to patients' financial burden ^[3]. Studies suggest that patients' lack of cost awareness often leads to financial distress, delayed treatments, and poor adherence to prescribed regimens ^[4]. This is particularly evident in the Philippine healthcare system, where out-of-pocket payments remain high and continue to be a barrier to timely care, especially in rural and semi-urban areas ^[5]. When patients are unaware of the costs they may incur, unexpected financial shocks can lead to emotional stress, postponement of care, or reliance on alternative remedies ^[6].

San Juan, Batangas, as the research locale, provides a vital context for examining these challenges in a Level I hospital setting. Understanding patients' awareness of medical expenses and their coping mechanisms is essential in identifying gaps in transparency, communication, and financial accessibility in OPD care. By focusing on the awareness of costs associated with diagnostics, medications, supplies, and procedures, this study aims to provide insights into how financial barriers shape patients' healthcare decisions and outcomes.

Ultimately, the findings will contribute to policy recommendations that promote cost transparency, strengthen patient education, and improve financial support systems. These efforts align with the broader goal of ensuring equitable and sustainable healthcare delivery in the Philippines ^[7].

2. Research questions

This study aimed to examine the extent of cost awareness among participants regarding their medical expenses in the OPD, focusing on the following areas:

1. What is the extent of cost awareness of the medical expenses incurred by the participants in the OPD along:
 - 1.1. Diagnostic
 - 1.2. Medicine
 - 1.3. Supplies
 - 1.4. Procedure
2. What policy recommendations and research simulacrum can be proposed based on the findings of the study?

3. Scope and limitation of the study

This study seeks to examine the cost awareness of medical expenses incurred by patients in the Outpatient Department (OPD) of a selected Level I hospital in San Juan, Batangas. It focuses on understanding the extent of patients' awareness of various components of medical expenses, including diagnostic tests, medicines, supplies, and procedures. Additionally, the study aims to identify potential policy recommendations to address challenges faced by OPD patients in managing healthcare costs.

The study included OPD patients from the selected Level I hospital who had sought treatment at least once within the past three years and were willing to participate. Data were collected through a structured questionnaire and interviews, focusing on patients' self-reported awareness of medical costs.

The investigation specifically examined awareness of costs related to diagnostic tests, medicines, supplies, and procedures, and how this awareness influences healthcare decisions. While some information regarding coping

mechanisms for managing financial impact was collected, the study did not explore these strategies in depth.

Several limitations are acknowledged. Data were collected from a limited number of Level I hospitals in San Juan, Batangas, and may not fully represent OPD patients' experiences in other regions. Self-reported data are subject to recall bias or personal perceptions of costs, and participants may not have a complete understanding of the breakdown of their medical bills. The cross-sectional design captures only a snapshot of experiences at the time of data collection, limiting insights into long-term trends or changes in cost awareness.

The study did not include the perspectives of healthcare providers or hospital administrators regarding medical service costs or existing policies that influence cost transparency. Additionally, broader socioeconomic factors such as income levels or insurance coverage, which may affect patients' ability to afford care, were not examined.

Finally, while the findings inform policy recommendations aimed at improving cost transparency and financial assistance for OPD patients, the implementation of these recommendations falls outside the scope of this study. Nonetheless, the study provides valuable input to guide potential policy changes to enhance patient access to healthcare services, improving cost transparency and financial assistance for OPD patients.

4. Literature review

This literature review presents key related literature and studies relevant to the study that provide the researcher with sufficient ideas and insights that served as a frame of reference and the insights that led to the conceptualization and formulation of the research.

4.1. Cost awareness of medical expenses

Awareness of healthcare costs plays a vital role in shaping patient decision-making, particularly in outpatient settings where most expenses are paid out-of-pocket. In the Philippine context, many OPD patients lack clear knowledge of the costs associated with diagnostics, medications, procedures, and supplies. This lack of transparency often leads to financial strain, delayed treatment, or even avoidance of essential care. A baseline survey conducted across primary care sites in the country highlighted that out-of-pocket costs remain a major concern, especially for low-income patients, and these costs directly influence health-seeking behavior^[8].

Among the four major categories of medical costs, medications were found to have the highest awareness, while procedures and supplies had the lowest. This may be attributed to the fact that patients frequently purchase medicines directly from pharmacies, making prices more visible, whereas hospital-billed procedures and supplies are often bundled, making them harder to understand^[9]. Without clear cost breakdowns, patients are left uncertain about their financial obligations, contributing to confusion and mistrust in the healthcare system. This underscores the importance of transparent billing systems to ensure patients can make informed healthcare decisions.

4.2. Policy recommendations

The findings strongly suggest the need for policies promoting financial transparency and patient education. Hospitals should implement clear, itemized billing systems that break down costs for diagnostics, procedures, medications, and supplies. Equally important is the integration of financial counseling into OPD services, enabling patients to better understand their options and prepare for potential expenses. Previous research emphasizes that patient empowerment through financial literacy contributes to more informed healthcare choices and greater

satisfaction with medical services ^[9].

Telemedicine also presents an innovative solution to reducing indirect costs such as transportation and lost wages. In the Philippines, teleconsultation fees range widely, but studies show that many patients perceive online consultations as more convenient and less expensive compared to in-person visits ^[10]. Streamlining government financial assistance, expanding PhilHealth coverage for outpatient services, and embedding mental health support to address financial stress are also crucial recommendations. Collectively, these strategies can reduce financial barriers, improve healthcare access, and foster greater trust in the health system.

4.3. Research simulacrum

This study also proposed the use of a research simulacrum as a tool for modeling the potential effects of policy changes. A research simulacrum is essentially a mock-up or simulation of real-world research processes, allowing policymakers and researchers to test the feasibility and projected impact of interventions before implementation. For example, simulacrum models have been used in education and clinical training to help stakeholders understand the outcomes of certain practices in a controlled environment ^[11]. Applying this concept in healthcare cost awareness can demonstrate how pricing transparency or financial counseling might influence patient decision-making and outcomes.

The use of research simulacrum also offers advantages in training future healthcare researchers, enhancing their ethical decision-making, and supporting skill development. Emerging technologies such as virtual reality can make these simulations more immersive and realistic, providing deeper insights into patient behavior ^[12–13]. However, challenges remain, such as the resource requirements for developing high-fidelity simulacra and the limited evidence on their long-term effectiveness ^[14–15]. Despite these challenges, simulacrum-based approaches can serve as valuable tools for both research and policy design, offering a proactive way to anticipate the effects of proposed interventions on real-world healthcare delivery.

5. Research design

5.1. Study design

This study employed a mixed-methods approach to examine the medical expenses incurred by Outpatient Department (OPD) patients in a selected Level I hospital located in San Juan, Batangas. The research incorporated a descriptive cross-sectional research design for the quantitative component, which focused on determining the extent of cost awareness among OPD patients regarding diagnostic tests, medicines, supplies, and procedures.

The quantitative component of the study adopted a descriptive cross-sectional research design, which is particularly well-suited to assess the awareness levels of patients concerning their medical expenditures at a specific point in time. Cross-sectional research was defined as a study that collects data at a single point in time, providing a snapshot of the participants' conditions, attitudes, or behaviors ^[16]. This method allowed for the measurement of various variables, such as the extent of cost awareness in areas like diagnostic tests, medicines, supplies, and procedures, and is commonly used when researchers aim to describe and quantify the characteristics of a population.

Cross-sectional research designs were considered efficient as they allowed the researcher to collect data from a large number of participants within a relatively short time frame ^[17]. This was especially important for understanding current conditions regarding healthcare expenses. In this study, retrospective data from the years

2022, 2023, and 2024 were gathered to explore how OPD patients in San Juan, Batangas, are aware of the costs of various medical services. By gathering data from a wide range of patients, the study provided critical insights into how factors like socio-economic status, insurance coverage, and frequency of healthcare use may affect cost awareness and financial decision-making. The descriptive nature of the study helps present a clear picture of cost awareness among OPD patients, providing information that can be used by healthcare providers and policymakers to improve cost transparency and healthcare affordability.

In essence, the use of a descriptive cross-sectional method ensures a comprehensive examination of the medical expenses of OPD patients. This approach allowed for the quantification of cost awareness across key areas of healthcare services. By focusing on measurable variables, this study provides a solid foundation for informing policies and strategies aimed at enhancing transparency and improving healthcare affordability and accessibility.

5.2. Data collection

The data collection for this study followed a structured process that combined both quantitative and qualitative methods to ensure reliability and validity. For the quantitative component, survey questionnaires were distributed to 150 OPD patients who had visited within the past three years. The survey measured awareness of costs related to diagnostic tests, medicines, supplies, and procedures, with participants completing the forms in approximately 10 to 15 minutes. Prior to answering, the patients were informed about the study, and their consent was obtained. Assistance was provided to clarify questions, and all responses were reviewed and securely stored. To maintain clarity and appropriateness, the survey tool was pretested and refined before full implementation.

For the qualitative component, in-depth semi-structured interviews were conducted with 20 participants selected from the survey pool who volunteered to share their personal experiences. The interviews explored the emotional and financial burdens of medical expenses, lasted 30 to 45 minutes each, and were conducted in private to ensure confidentiality. All sessions were audio-recorded with consent and transcribed for analysis. Ethical considerations were prioritized throughout the process, including informed consent, confidentiality, and the option to withdraw at any time.

5.3. Instrument

This study utilized two primary instruments for data collection: a survey questionnaire for the quantitative component and an interview guide for the qualitative component. The survey questionnaire was structured to assess OPD patients' awareness of medical expenses, with sections covering diagnostic tests, medicines, supplies, and procedures, and employed Likert scales to measure the extent of their knowledge and perceptions. These instruments enabled the collection of both measurable data and rich personal narratives, ensuring a comprehensive understanding of OPD patients' cost awareness and financial experiences.

5.4. Discussion

This study presents the discussion and interpretation of data gathered from the respondents through structured interview questions.

6. Extent of cost awareness of the medical expenses incurred in the OPD

6.1. Diagnostic

Understanding the cost awareness of medical expenses among outpatient department (OPD) patients is crucial

for assessing financial accessibility and healthcare affordability. Rising medical costs have increasingly burdened patients, particularly those undergoing diagnostic services. Patients generally demonstrate a moderate level of awareness regarding diagnostic costs, with the highest-rated items reflecting weighted means between 3.20 and 3.23, interpreted as “Aware.” This indicates that while patients have a functional understanding of diagnostic-related expenses, gaps remain that could compromise timely and informed decision-making.

The top-rated item, “I can identify the differences in costs between various diagnostic tests” (WM = 3.23, SD = 0.74), illustrates that patients recognize cost variations among X-rays, CT scans, and laboratory tests. This awareness reflects a positive trend, likely driven by digital healthcare records and public campaigns promoting transparency. Yet, the variability in responses suggests uneven comprehension. Diagnostic procedures often represent a significant cost component in outpatient services, and unawareness can lead to financial strain and avoidance of necessary tests ^[20].

The second-highest-rated item, “I have been informed if there are additional charges for diagnostic tests” (WM = 3.22, SD = 0.79), highlights moderate but inconsistent communication between healthcare providers and patients. While some patients receive adequate information about extra charges, others remain unaware. Fragmented communication contributes to patient dissatisfaction and diminished trust in medical institutions ^[21]. Implementing financial counseling and including cost discussions in routine consultations can improve understanding and patient confidence ^[22].

The third item, “I understand if there are discounts or subsidies available for diagnostic test costs” (WM = 3.20, SD = 0.74), demonstrates awareness of financial assistance, though suboptimal. Programs like PhilHealth or local government subsidies are available, yet patients often remain unaware, leading to delayed or foregone care ^[23]. Cost awareness in diagnostics not only informs patients but also influences healthcare-seeking behavior and treatment adherence ^[24].

However, lower scores on items such as “I know whether the diagnostic tests are covered by my insurance or not” (WM = 2.76, SD = 0.95) indicate gaps in understanding insurance coverage, a critical factor in out-of-pocket expenses. Many patients either underutilize or postpone necessary diagnostics due to uncertainty about reimbursement ^[25]. Similarly, comprehension of cost calculation methods (WM = 2.79, SD = 0.92) and awareness of expedited service fees (WM = 2.97, SD = 0.89) remain limited, reflecting systemic issues in cost transparency and patient financial literacy ^[26]. The composite mean of 3.06 (SD = 0.64) suggests a general, moderate level of awareness, emphasizing the need for institutionalized cost discussions, patient education, and standardized pricing mechanisms ^[27].

6.2. Medicine

Medication expenses form a significant part of out-of-pocket costs for OPD patients, particularly those with chronic or multiple conditions. Awareness of drug costs, including brand versus generic options, insurance coverage, and discounts, is essential for informed decision-making. This shows that patients have relatively high awareness of price differences between branded and generic medications (WM = 3.28, SD = 0.72). This suggests that national campaigns promoting generics have begun to influence patient decisions, enabling more cost-effective choices and improved adherence ^[28].

The second-highest awareness relates to the duration of medication use and total cost (WM = 3.11, SD = 0.84), showing that patients consider not only immediate prices but also long-term financial implications. Knowledge of medication costs over time supports better planning and adherence ^[29]. Awareness of available discounts or

government programs (WM = 3.04, SD = 0.85) remains moderate and uneven, reflecting gaps in communication and accessibility of assistance programs ^[30].

The lowest-rated items, including insurance coverage (WM = 2.69, SD = 1.03), availability at pharmacies (WM = 2.69, SD = 0.98), and awareness of alternatives (WM = 2.72, SD = 0.95), indicate insufficient comprehension of critical aspects of medication affordability. Over-the-counter medication costs (WM = 2.85, SD = 0.92) also highlight a limited understanding ^[31]. The composite mean of 2.93 (SD = 0.70) reflects moderate awareness but reveals that many patients possess only partial understanding, which can lead to poor financial planning, nonadherence, and unnecessary financial strain ^[32]. Enhancing patient education, clear communication, and structured cost discussions are therefore essential to improve medication-related decision-making ^[33].

6.3. Supplies

Medical supplies, though often considered minor, contribute significantly to overall OPD expenses. Patients demonstrate moderate awareness, with the highest-rated item being “I understand the overall impact of supply costs on my total medical expenses” (WM = 3.20, SD = 0.81). This suggests recognition that even small items like syringes, cotton, or diagnostic kits can accumulate and impact overall billing ^[34].

However, lower-rated items reveal gaps in awareness. “I know whether I will pay for the medical supplies or if it is covered by my insurance” (WM = 2.71, SD = 0.99) and “I am knowledgeable about the medical supplies used for procedures and their costs” (WM = 2.83, SD = 0.93) indicate limited transparency and communication ^[35]. This lack of clarity can increase patient anxiety and reduce trust in healthcare institutions ^[36]. Standardized billing, real-time disclosure, and patient education are critical strategies to improve supply cost awareness ^[37]. The composite mean of 2.96 (SD = 0.70) highlights a moderate but incomplete understanding among patients.

6.4. Procedure

Procedural costs in outpatient settings involve multiple components such as anesthesia, additional tests, and professional fees. Patients have moderate awareness of procedural costs, with the highest-rated item being “I have been informed if there are additional charges related to a procedure” (WM = 3.22, SD = 0.78). Awareness of layered costs reduces “bill shock” and improves adherence to medical advice ^[38].

Awareness of government programs or discounts (WM = 3.21, SD = 0.79) and potential fees for complications (WM = 3.15, SD = 0.78) further suggests a developing literacy about financial support and risk-related costs ^[39]. Yet, lower-rated items like insurance coverage (WM = 2.83, SD = 0.99) and breakdown of specific procedure costs (WM = 2.86, SD = 0.89) indicate insufficient transparency and communication, which may lead to delayed procedures or financial distress ^[40]. The composite mean of 3.00 (SD = 0.67) confirms a moderate awareness level, highlighting the need for institutionalized patient counseling, standardized pricing lists, and digital tools for cost transparency ^[41].

7. Proposed policy recommendations and research simulacrum

7.1. Policy recommendations: Transparent cost disclosure in outpatient departments (OPD)

The dissemination of transparent costs in outpatient departments (OPD) has gained increased attention as stakeholders recognize its crucial role in patient participation, informed decision-making, and health outcomes. A lack of clarity regarding medical expenses often leaves vulnerable patients unprepared and deprived of their rights to make informed healthcare decisions ^[42]. Promoting transparency in healthcare pricing facilitates equitable access

and affordability, serving as a catalyst for the realization of sustainable development goals (SDGs) ^[43]. With rising medical costs and increasingly complex insurance structures, providing direct and comprehensive cost information enables patients to actively participate in their care ^[44].

The revised policy recommendation seeks to establish a **robust and standardized framework** for the transparent disclosure of outpatient service costs. The objective is to ensure that all OPDs provide comprehensive, easily accessible, and understandable price information. This includes not only the absolute cost of services but also the potential out-of-pocket expenses depending on different insurance coverage scenarios ^[45]. Ensuring clarity and usability is critical to enhancing patient understanding, engagement, and compliance.

The standardized framework should align with effective budgeting practices ^[46]. A calibrated approach ensures OPDs have the necessary technological infrastructure, trained personnel, and resources to implement cost disclosure efficiently. Additionally, the framework must account for variations in services and pricing across OPDs, promoting a level playing field while maintaining accuracy and integrity in cost reporting ^[47].

The projected budget for policy implementation covers several components, including: Investment in IT systems to consolidate and communicate service costs across facilities. Development of a digital platform that provides comprehensive price information. Training programs for OPD staff to ensure adherence to disclosure standards. Public information campaigns to educate patients on effectively using cost information ^[48].

A **gradual implementation timeline** is recommended. Pilot programs in selected OPDs will allow testing of the framework and technology, followed by evaluation before wider rollout. This iterative approach facilitates refinement based on real-world feedback, ensuring effective, sustainable adoption ^[49].

The success of the policy will rely on clearly defined **Key Result Areas (KRAs)**, including: Patient satisfaction, assessed through structured questionnaires evaluating clarity of cost information and overall experience. Compliance rates of OPDs in providing timely and accurate cost disclosures ^[50].

A comprehensive **assessment framework** will integrate both qualitative and quantitative methods, including pre- and post-implementation surveys, focus group discussions, and analysis of administrative data to determine changes in patient behavior and satisfaction ^[51]. Regular evaluation ensures alignment with public health objectives, while feedback mechanisms allow continuous improvement, reinforcing the culture of transparency in OPD cost disclosure ^[52].

7.2. Proposed research simulacrum

The proposed research simulacrum illustrates the integration of patient cost awareness with policy evaluation, structured as shown in **Figure 1**.

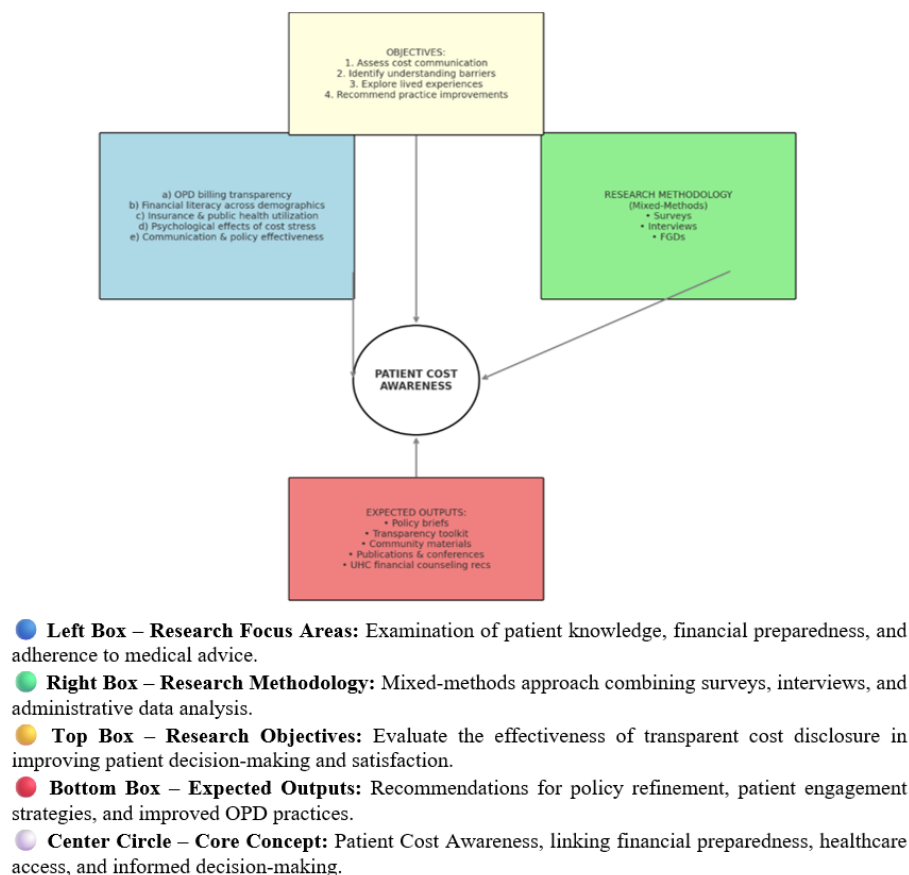


Figure 1. Proposed research simulacrum

This framework provides a **comprehensive roadmap** for both the implementation and evaluation of transparent cost disclosure policies, ensuring that patients are empowered, healthcare access is equitable, and resource allocation is optimized ^[53].

8. Conclusion

The following conclusions were drawn based on the highlights of the findings.

Patients in the outpatient department demonstrated a general awareness of medical expenses, but this awareness was often limited to surface-level knowledge. Many remained unsure about cost breakdowns, insurance coverage, and billing computations, indicating a need for deeper cost comprehension.

The findings supported the need for concrete policy interventions and further research on patient cost awareness and financial empowerment. The proposed recommendations and research simulacrum offered practical and sustainable solutions to promote transparent, inclusive, and financially informed outpatient care.

9. Implications of the results/findings to profession and self-actualization

The results of this study carry significant implications for healthcare professionals, particularly those working in outpatient settings. The findings emphasize the vital role of health professionals—not only as providers of clinical care but also as facilitators of financial transparency and patient education. Nurses, physicians, and administrative

staff may need to integrate cost-related communication into their routine interactions with patients, ensuring that individuals are fully informed of the expenses tied to diagnostics, medications, procedures, and supplies. This shift calls for a more holistic approach to patient care, one that acknowledges the financial realities that influence treatment decisions and adherence.

Professionally, the study highlights the importance of developing competencies in health financial literacy, empathetic communication, and system navigation. Healthcare workers who possess these skills are better positioned to support their patients' needs, improve health outcomes, and contribute to more ethical, patient-centered service delivery. For administrators and policymakers, the findings reinforce the need to establish institutional policies and programs that advocate for cost transparency and equitable access to care.

On a personal level, the research journey has fostered a deeper understanding of the socio-economic challenges that patients face in accessing basic medical services. It has reinforced the value of compassion, accountability, and responsiveness in healthcare practice. This awareness supports self-actualization by aligning professional responsibilities with a meaningful purpose—to empower patients not only through clinical treatment but also through informed decision-making. The experience serves as a reminder that health equity is not just about providing services but also about equipping people with the knowledge and support to access them responsibly and confidently.

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On Self-deceit

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Abstract: There lies a paradox in self-deceit, where one acts as the deceiver, knowing the facts, but at the same time, as the deceived, not knowing it. Psychoanalysis avoids the paradox through the unconscious mechanisms; Existentialists, however, by declining the unconscious, avoid the paradox because, in order to cover the truth, one surely knows it. The article, by testifying that the deceiver's self and the deceived's self are one and the same, uncovers self-deceit in Rous-seau's sincere confession because he separates the agent-self and the confessor-self, while both are the same self. The article further explores self-deceit as a pretense based on Austin's philosophy. The pretense cannot be seen, but can be detected through understanding its context. The article concludes that psychology should understand the paradox of self-deceiver as a way of self-integrity within a hermeneutic insight.

Keywords: Self-deceit; Deceiver's paradox; Bad faith; Sincerity; Pretense; The self

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1. Introduction

Is self-deceit possible? Speaking of self-deceit, people all remember Aesop's Fox who desired grapes. The grapes are too high for the fox to reach. Then the fox reinterprets its failure by claiming—these grapes are too sour, and it does not want to eat them^[1]. Here comes a question: when the fox denies its desire for grapes, that is, how can the reader tell whether the fox is deceiving itself or simply pretending.

Self-deceit implies a paradox. How can we simultaneously act as both the deceiver, aware of the truth, and the deceived, unaware of it? It means that there exist dual selves—an active self that deceives and a passive self that is deceived^[2]. Psychologists assume that self-deceit works on Freudian mechanisms of the unconscious, where the self that deceives, along with the concealed truth, remains in the unconscious, and the deceived self stays unaware in the conscious.

Assuming a person is a visitor in psychoanalysis. The analyst declares that the person has not accepted his interpretation. The person told him frankly, "I have really accepted your analysis." He scrutinizes the person, just like he has penetrated their defenses, "No, you are deceiving yourself. You haven't accepted my analysis. That's clear. It's just that you are not aware of it." What he says makes the person feel uncertain. So the person reflects

on himself cautiously and really believes that the person does accept his damn analysis. But this only further confirms his assertion, “There! Precisely! It proves that you are totally immersed in self-deceit. That is why you are completely unaware of the truth that you have rejected my analysis!”

Explaining self-deceit based on the hypothesis of the unconscious, according to the fictional dialogue above, will lead to a paradox, as demonstrated by Liu Chang, where claiming the absence of self-deceit turns into evidence of its presence, and admitting self-deceit may contradictorily show its absence^[3]. It brings people to the core nature of self-deceit, which, as Sartre describes it, is a perpetual threat against sincerity, yet one that self-deceit mimics sincerity to itself^[4].

2. Self-deceit as bad faith

Sartre explains self-deceit as bad faith—the inauthentic modality of being-in-the-world. He rejects Freud’s unconscious, arguing that bad faith (self-deceit) operates in a state of fully transparent awareness^[5]. Since the deceiver and the deceived are one and the same person, it means that the self, as the deceiver, should know the truth concealed from itself when being deceived. More precisely, one must know the truth clearly in order to conceal it more carefully. However, Sartre has not proved the premise—the deceiver and the deceived are one and the same person. They need to prove how the deceiver and the deceived can know that they are the same “I” in self-deceit.

Suppose a driver accidentally kills a child. He feels very sad every time he reflects on the incident^[6]. It requires, in his self-reflection, dual selves—one that reflects and the other being reflected, and which one is feeling sad? It is the reflector, not the reflectee, feeling sad, which proves Sartre’s premise. More clearly, I can know the reflector and the reflectee are the same “I”, because I, as the reflector, can feel sad when reflecting on some sad things.

The driver is buried by grief and is deeply depressed. Friends take turns to console him, “It wasn’t fully your fault. It rained heavily that day. The kid came out of nowhere. It might be fate, and think about your children and parents, they need you...” If the driver was easily persuaded by such comforting words, attributing the accident to external conditions or something like fate, and abandoning his own grief, he would fall into bad faith in Sartre’s sense. “Hell is other people” means that through kind persuasion, others take away one’s own pain beyond words^[7]. The more one cures, the more bad faith there is.

Byung-Chul Han argues that Sartre’s bad faith implies heroism, maybe leading to an oppression of positive psychotherapy. Under the guise of “be yourself”, it creates deeper anxiety or guiltiness^[8]. It forces people to deeply delve into the dark side of the mind, attempting to eliminate the darkness—secrets, negative thoughts, crazy feelings, and so on. As Hannah Arendt observes, the darkness is the very nature of the mind, a needed part to shape human experience^[9].

3. Sincerity as the opposite of self-deceit

The investigation of the self originates in the thoughts of Augustine and Rousseau. The self, for ancient Greeks, referred to agents who act in the world. Understanding “know thyself” is to know the world; the Greeks desire for the knowledge of their place in the world. The topics in the Platonic dialogues go around the soul, the universe,

humanity, and the polis, not around themselves like private lives. In contrast, Augustine's *Confessions* is about himself, where he introspects about all his wrong thoughts and the way he corrects them. In this way, the self becomes an inner realm separate from the external world. Through introspection, the self, purified by Augustine, would not fall into the dilemma of truth and falsehood, for it has been reconciled with God's order/love.

Rousseau also shows numerous faults he commits in his *Confessions*. He writes in the preface—"Let the trumpet of the Day of Judgment sound when it will, I will present myself before the Sovereign Judge with this book in my hand. ... I have told the good and the bad with equal frankness. I have neither omitted anything bad, nor interpolated anything good. ... I have unveiled my inmost self even as Thou hast seen it, O Eternal Being. Gather round me the countless host of my fellow-men; let them hear my confessions, lament for my unworthiness, and blush for my imperfections." Then let each of them in turn reveal, with the same frankness, the secrets of his heart at the foot of the Throne, and say, if he dare, "I was better than that man?"^[10].

Through admitting mistakes before God, Rousseau shows inner sincerity. In this way, he proves that he is the best person in the world. In contrast, Augustine never thinks he is better than anyone else, and he does not, like Rousseau, try to persuade God to look and see if he is the best. If God says—"Stop rambling! Just tell me what you did", I guess Rousseau's response would be—"I admit all my sins, so I am the best one. I never concealed the truth from my inner self, so you can see my sincerity." Here comes an interpretative gap between God's self and Rousseau's self—one as an agent and the other as a feeler. Rousseau, as an agent, is so dishonest, yet as a feeler, is so sincere.

The sincerity of the inner self by Rousseau complicates the understanding of self-deceit. Based on the established language usage, words like lying, theft, and robbery are referred to as untruthful behaviors in a negative way, and accordingly, those who carry out such actions mentioned above are not considered honest persons. Although the word—sincere—is usually referred to a positive relationship between people, Rousseau enlarges its connotations by referring to the inner feelings during self-introspection. From Rousseau's perspective, self-introspection can automatically encounter the true self, which is not true because we possess a mind. The more complex the mind, the harder it is to determine between what is deception, what is pretense, and what is the true self^[11]. There is no such thing as pure feelings, isolated from behaviors and relations, and it is impossible to possess a purely sincere inner self, which is bad faith in the terms of existentialists.

4. Self-deceit as pretense

It is difficult to tell the boundary between self-deceit and pretense. Austin, an amazing Philosopher, comes to help us out of the situation with his essay on pretense. Sometimes, self-deceivers do not need to conceal the truth; instead, they may disguise it through pretense—by acting as if it were something else^[12].

Consider a thief goes to a jewelry store, and here comes a policeman. The thief pretends to clean the glass rather than running or hiding. People can see a man who is cleaning, but cannot see his pretense, for understanding pretense demands a hermeneutic insight. Sherlock Holmes, for instance, can identify pretense since he is able to detect most of the contextual connections in the act of pretending. He always sees things from their most meaningful standpoints.

Then, how can people identify their own pretense? Here comes a Japanese novel named *Snowy Night*^[13]. An old couple has lost their son, and put themselves in self-deceit for a long time to alleviate the pain of grief. They, in

the way of self-deceit, struggle to accept their son's death, keeping weave elaborate lies for each other, and pretending that their son is still alive. In this way, they can piece their fragmented lives together. This story urges people to reinterpret "what is self-deceit" from the perspective of self-deceivers, and people recognize that self-deceit can serve as an approach to self-construction in exceptional situations ^[14].

People are all self-deceivers when seeking self-realization—When Aesop's fox declaims, "the grapes are sour", it has not ignored the fact, but preserved self-integrity against the existential lack; When kids pretend the chairs are horses to each other during playing together, they are not self-deceivers, but self-constructors; When actors/actresses are immersed in the roles they are playing, forgetting who they really are, they do not deceive themselves, but achieving the true self; When a girl who has had plastic surgery watches herself in the mirror, imagining her beauty is natural, she is constructing a strong self to settle existential anxiety. In fact, people do not need to remember all life stories, like the embarrassing moments, to build their self-identity.

5. Conclusion for future investigation

When people use the sentence structure of "I know it is true, but I still act as if it is not true", people are not concealing facts from themselves. People are trying to lead a meaningful life, although people live in a world shaped by facts. How can people still find implications in lives when the truth is brutal? This is the paradox belonging to the self-deceivers themselves, and psychology should understand it ^[15]. To what extent people understand this paradox is to that extent people understand self-deceit, and people also need to tell what truly concerns them when investigating self-deceit.

It is never a simple task, but a lifelong creative effort for people to maintain a balance between truth and implications ^[16]. To fully understand self-deceit, people may not require psychology to offer a final definition or a ready-made psychometric scale. People need to know more about "who I am" and "what should I do" ^[17]. It is not hard to know that the world is nothingness. The hard part lies in clarifying what people truly love—Is there anyone or anything in the world that people cannot let go of? If not, then it does not matter; but if so, then promise to do something for what people love. In this way, maybe there is no such thing as self-deceit.

Disclosure statement

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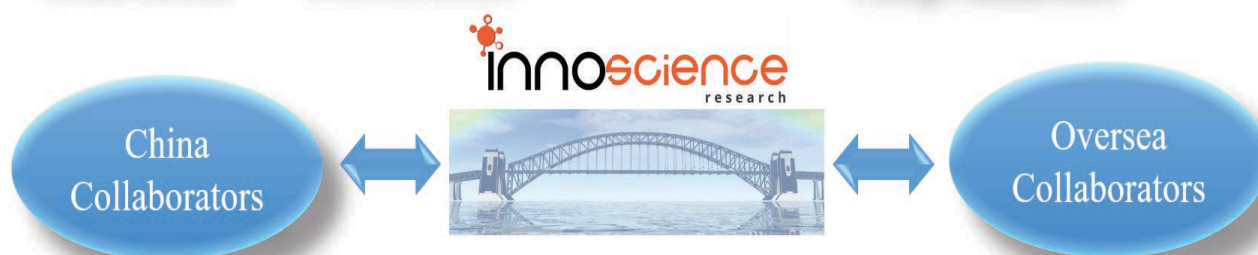
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