

$$\text{Standard time} = \text{Normal time} + \text{Relaxation time} = \text{Normal time} \times (1 + \text{Relaxation rate}) \quad (2-2)$$

The standard working time before optimization is calculated based on formulas (2-1) and (2-2), as shown in **Table 1**.

Table 1. Standard time for the production process before optimization

Process content	Average observation time (s)	Expansion rate	Standard time (s)
Sew shoulders	61.03	10%	67.13
Make the placket	47.88	10%	52.67
Make pockets	63.75	10%	70.12
Make sleeves	85.76	10%	94.34
Sew sleeves	23.54	10%	25.89
Make the collar	49.70	10%	54.67
Make the under-collar	17.17	10%	18.89
Join the collar	48.88	10%	53.77
Sew the collar	73.84	10%	81.22
Make cuffs	93.07	10%	102.38
Sew cuffs	41.34	10%	45.47
Make collar buttons	35.08	10%	38.59

2.2. Production line balance analysis

The capacity of the production line is affected by the balance rate of the production line. If the balance rate of the production line is low, the capacity will also be relatively low. Therefore, optimizing the balance rate of the production line is very important for its capacity. By comparing the actual production capacity of the production line with the planned production capacity, one can identify the processes that affect production efficiency and optimize them. This involves reasonably allocating resources and optimizing the production process flow to ensure an average workload across all workstations on the production line. First, it is necessary to clarify the processing time for each workstation. Based on this, the reasons for the different times used by different workstations can be identified, and different optimization methods can be applied based on these reasons, ultimately aiming to improve the balance rate of the production line^[7]. When analyzing the balance rate of the production line, it is necessary to use a lot of indicator data, such as the production line balance loss rate and smoothness index.

$$\text{Production line balance rate } P = \frac{\sum_{i=1}^n T_i}{T_{\max} \times S} \quad (1)$$

$$\text{Balance loss rate } IR = 1 - \quad (2)$$

$$\text{Smoothness index } SI = \sqrt{\frac{\sum_{i=1}^n (T_{\max} - T_i)^2}{S}} \quad (3)$$

According to formulas (2-3), (2-4), and (3-5), the production line balance rate (P) is calculated to be 61.52%, the balance loss rate (IR) is 38.48%, and the smoothness index (SI) is 54.60. It can be seen that the production line balance rate of ZY company's garment sewing workshop is poor, the efficiency of shirt production is low, and

there is a significant potential for optimization and improvement of the production line.

2.3. Problems existing in the clothing production workshop

The production processes are unbalanced. In order to analyze the operation of

these 12 processes more intuitively, the standard times of each process of the A-type shirt sewing production line are depicted in a bar graph, as shown in **Figure 1**.

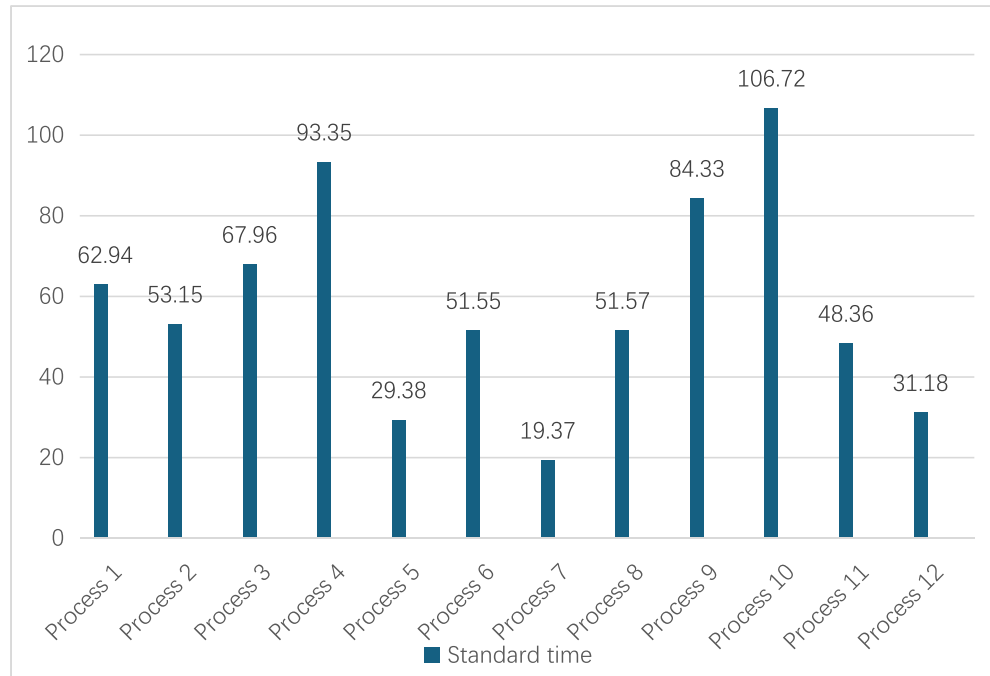


Figure 1. Standard time of each station

As shown in **Figure 1**, there is a significant difference in time consumption between workstations on the production line of this model shirt sewing workshop, with a clear bottleneck process, leading to idle production equipment and resources during the production process.

Insufficient production efficiency. ZY Company has an average daily market demand of 500 pieces of Type A shirts, and the workshop operates based on the legal working time of 8 hours per day. Therefore, the ideal production rhythm is: $8 \times 60 \times 60 \div 500 = 57.6s$. As shown in **Figure 1**, the time for the 5 processes exceeds the ideal production rhythm, and nearly half of the processes have severely low production efficiency.

Production management issues. The management of workshop production equipment is chaotic, and the sanitation conditions need improvement. The production site of ZY company is disorganized, and the layout of the production workshop is very unreasonable. Many old and damaged production equipment are placed haphazardly on the production site. As the core of enterprise production efficiency, the management and maintenance level of production equipment directly affects the production line's capacity. Due to the arbitrary placement of production equipment, the hygiene conditions of the workshop are poor, with a lot of dust, which greatly affects the working environment and the mental and physical health of the production staff. The placement of production materials is chaotic and unordered. In the process of garment production and processing, many production materials and tools are required, so toolboxes and material racks are often carelessly arranged by the staff. After using materials and tools, staff sometimes cannot return them to their places in time, resulting in increased time costs when looking for

them for the next use. Some reworked products that do not pass quality inspection are piled together with ordinary work-in-progress items, and during the production process, they may need to be re-inspected because they cannot be distinguished, leading to unnecessary waste of production resources and costs.

3. Improvement of production line balancing based on the IE method

3.1. Bottleneck process improvement

The operational processes of Procedure 4 and Procedure 9 exhibit significant

complexity, as both procedures involve 5 operational steps, which is relatively more than other procedures, and require a high level of coordination between workers' hands. Long-term engagement in such high-difficulty coordinated operations can lead to muscle fatigue issues for workers. Therefore, by adding one more worker for each of Procedure 4 and Procedure 9, not only has the operational time and efficiency significantly improved, but it also ensures a smooth production process, reducing idle time for subsequent workers and equipment.

The standard operating procedures for the current two processes only outline the key steps and do not provide specific, detailed guidance on "motion optimization" and fatigue relief." In this case, non-standard operations largely do not adhere to the principles of motion economy, ultimately leading to an increase in workload for both processes and a decrease in overall efficiency of the production line; at the same time, the defect rate caused by operational deviations is also significantly higher than in other processes. To address this issue, a set of motion standards has been developed, which employees can refer to, and they can also choose their positions based on their own habits, thereby enhancing their collaboration under standard conditions.

3.2. Implement 6S management

6S management focuses on sorting, setting in order, cleaning, standardizing, and safety, centering on elements such as people, places, materials, and methods in the production site. It aims to create a clear and concise working environment through standardized management, achieving rational and efficient control of various production factors ^[8].

The specific implementation can be advanced step by step: the first step is "Sorting", which requires accurately distinguishing the actual use of items on the production site, keeping necessary items while clearing out surplus raw materials, tools, and other items from the site, thus reducing the space occupied by ineffective items from the source; the second step is "Arranging", where all items in the workplace are classified, organized, and fixed to specific locations, ensuring that each item has a designated storage area. This meticulous management not only significantly enhances the cleanliness of the work environment but also allows employees to easily know the storage locations of the required materials, and this visualization management is a key link in building an efficient and orderly work environment.

After completing the organization and arrangement, the next step is "cleaning", which means a thorough cleaning of the production site to continually maintain a tidy environment. Finally, through "literacy improvement", the authors enhance employees' professional quality, cultivate a good work attitude, and encourage employees to consciously adhere to company rules and regulations; at the same time, with "safety" as a premise, the authors guide employees to maintain a proactive working state, create a harmonious and relaxed work atmosphere, and thereby strengthen employees' sense of collective honor and promote the effective implementation of 6S management.

4. Analysis of the optimization effects of improved production line balancing

Table 2 below shows the standard working times for each procedure on the production line after improvement.

Table 2. Standard time for the production process after optimization

Process content	Average observation time (s)	Expansion rate	Standard time (s)
Sew shoulders	48.59	10%	53.45
Make the placket	47.88	10%	52.67
Make pockets	42.84	10%	47.12
Make sleeves	50.84	10%	55.92
Sew sleeves	44.87	10%	49.36
Make the collar	49.70	10%	54.67
Make the under-collar	40.33	10%	44.36
Join the collar	48.88	10%	53.77
Sew the collar	52.83	10%	57.11
Make cuffs	51.62	10%	56.78
Sew cuffs	41.34	10%	45.47
Make collar buttons	35.08	10%	38.59

From **Table 2** and **Figure 2**, it can be seen that the standard operation time for each process has been reduced to below the ideal cycle time, which means that the production line can complete the production of products within the stipulated time. The optimized production line's production capacity can meet market demand, which also aligns with our optimization principles. Using formulas (2-3) and (2-4), the study finds that the balance rate and balance loss rate of the improved production line are 86.56% and 13.52% respectively, with the balance rate of the production line increasing by 25.04%. This indicates that the improved production line has achieved a more ideal balance state.

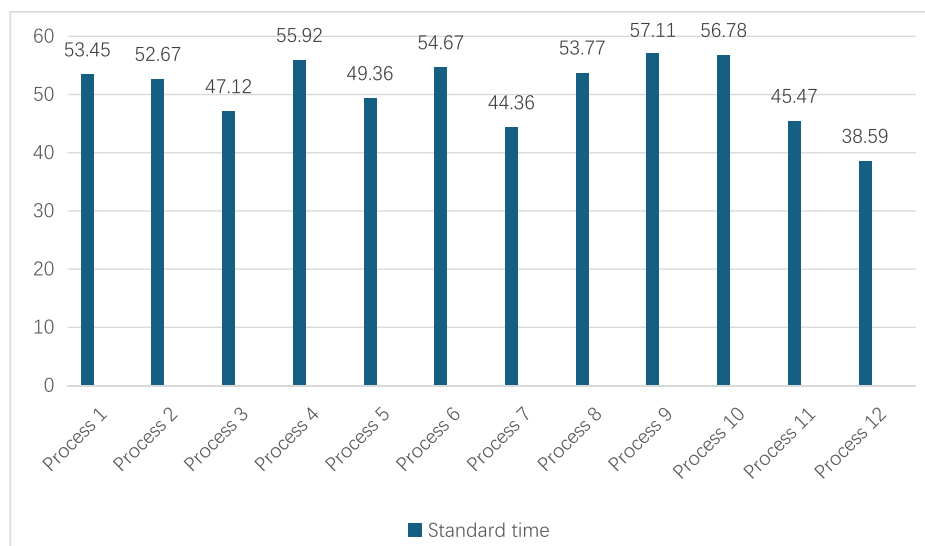


Figure 2. Standard time of each station

5. Conclusion

This article selects the clothing sewing production line of ZY Company as the research object, with the core goal of improving the line balance rate, and systematically optimizes the production line by introducing Industrial Engineering (IE) theories and methods. During the research process, targeted optimization improvement plans were formulated and implemented in response to key pain points such as the existing bottleneck processes in the production line (e.g., the complex operations of processes 4 and 9 mentioned earlier) and irregular on-site management. Ultimately, this not only significantly improved the balance rate and overall production capacity of the production line, laying a solid foundation for ZY Company's future development, but also provided a referable case for production line optimization practices in the entire manufacturing industry.

Disclosure statement

The author declares no conflict of interest.

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Play-Based Intervention Plan for ADHD Children's Behavioural Problems: Creative Social Task System

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Abstract: Attention Deficit Hyperactivity Disorder (ADHD) is one of the most common neurodevelopmental disorders in children, often disrupting learning and social adaptation. In recent years, play-based interventions have attracted growing attention for their naturalness and high acceptance. This paper reviews their application value and proposes innovative strategies, focusing on the potential of play-based methods to address behavioural problems in children with ADHD.

Keywords: Attention deficit hyperactivity disorder; Play-based intervention; Behavioural issues; Social skills

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1. Introduction

With the growing emphasis on non-pharmacological therapies for ADHD, play-based approaches have become an increasingly important way to address behavioural problems. Their appeal lies in being natural, engaging, and well accepted by children ^[1-2].

Recent developments have expanded beyond traditional cooperative games and contextual role-play to include digital games and virtual reality technology ^[3-4]. These innovative strategies not only help children with ADHD improve their attention and behavioural control, but also enhance long-term outcomes through peer interaction and family involvement.

This study builds on Cordier et al.'s "Play-based Intervention Model", integrating modern digital tools and family collaboration to design a comprehensive intervention plan for children with ADHD aged 6–10 ^[1]. The goal is to reduce their behavioural problems, enhance their social skills, and support adaptability in both home and classroom environments.

2. Literature review

Play-based interventions aim to enhance children's social, emotional, and behavioural skills through natural play

scenarios. They are increasingly recognised as an effective supplementary method and have been given a stronger theoretical foundation in recent decades.

Piaget's theory of cognitive development underscored the central role of play in helping children make sense of the world. Through play, children can practice and consolidate their acquired skills while exploring new ones. As they mature, their play shifts from self-centred to more social forms that consider the perspective of others ^[5-6].

Building on Rogers' humanistic psychology, Axline introduced child-centred play therapy, guided by eight basic principles ^[7]. She emphasised that therapists need to follow the child's lead rather than attempting to control or guide the direction of play. This method enables children to explore their emotions and experiences in a safe environment, thereby fostering problem-solving skills.

In recent years, researchers have increasingly focused on ADHD-specific challenges in games and their potential theoretical value. Studies show that children with ADHD struggle with empathy, cooperation, impulsivity, rules-breaking, and sustaining attention ^[8-9]. These behaviours contribute to peer rejection, further aggravating social difficulties ^[10]. Such findings provide a theoretical rationale for play-based interventions, which aim to improve social skills and behavioural regulation through structured play.

In 2009, Cordier et al. proposed a play-based intervention theory model based on the integration of ADHD and play-related research ^[1]. This model suggested that the lack of intrinsic motivation and behavioural control ability in children with ADHD significantly affects their behaviours during play. It outlined four intervention principles — intrinsic motivation, internal control, reality suspension, and situational shaping — aimed at structuring the play environment to counteract the negative impact of ADHD traits.

Wikes and Barnes et al. validated the model through a pilot study, showing that children with ADHD have significantly improved social gaming abilities, and this improvement also has a positive impact on gaming partners ^[11]. Importantly, these studies also found that peers and parents can enhance intervention effectiveness and improve skill transferability.

In 2017, Wilkes et al. conducted a 12-month follow-up trial confirming that children with ADHD can maintain their social skills for a long time after interventions. Their companions also showed sustained improvement in both home and clinic environments. This highlighted the importance of parental and peer involvement in intervention design ^[12].

More recently, with advances in the understanding of the mechanism of ADHD symptoms and digital technologies, play-based interventions have expanded in scope. For example, between 2019 and 2020, several studies proposed an augmented reality (AR) gaming environment called the "AR therapist" as a cognitive-behavioural therapy for ADHD patients ^[4]. In 2024, Wilkes-Gillan et al. developed a peer-mediated play-based intervention model to address the challenge of social participation in children with ADHD. Through peer interaction in the game, the model improves ADHD children's social game skills, cooperation abilities, and social-emotional expression. Moreover, this study highlighted the key role of parents in the intervention process and emphasised the cooperative relationship between parents, therapists, and children, which is considered a core element for successful intervention ^[2].

In summary, play-based interventions represent a child-centred developmental adaptation approach, particularly suitable for improving social and behavioural abilities in children with ADHD. From Cordier et al.'s theoretical framework to the empirical verification of subsequent research, play-based intervention has shown promising application prospects in the treatment of children with ADHD. Research has shown that by stimulating children's intrinsic motivation, cultivating empathy, introducing peers, and involving parents, social skills in

children with ADHD can be effectively improved with long-term benefits ^[1, 13].

3. Intervention design

3.1. Target population and intervention domain

This intervention plan is aimed at students aged 6–10 diagnosed with ADHD, mainly with behavioural problems. The main concerns of these students include: lack of concentration (difficulty in maintaining classroom attention for more than 10 minutes, difficulty completing tasks, and being easily distracted); impulsive behaviours (difficulty waiting for turns, frequent interruptions, and rule-breaking); and social behaviour problems (lack of empathy, frequent conflicts with peers in group activities) ^[14]. This plan applies to the following situations:

Group intervention: Pair ADHD students with typically developing peers for cooperative gaming activities ^[15].

Family intervention: Include parents in intervention activities, engage in cooperative game activities, and continue the intervention effect.

Classroom integration: Children with ADHD participate in natural situational games in regular classes.

3.2. Intervention design

3.2.1. Core idea

This intervention plan extends Cordier et al.'s “Play-Based Intervention Model”, incorporating new elements such as digital games and situational role-playing ^[1]. It uses game interaction as a carrier to help students with ADHD improve their behavioural control and social skills.

3.2.2. Specific solution framework

The entire intervention phase is divided into four stages, lasting for 12 weeks, as shown in **Table 1**.

Table 1. Four stages of the intervention phase

Stage	Target	Main activities and methods
Phase 1 Preparation Period (2 weeks)	ADHD Children: Basic Social Rules, Emotion Recognition Pairing partners: Understanding ADHD traits and auxiliary strategies Teachers and Parents: Observation and Recording Methods, Supporting Techniques	(1) Situational tasks: Individualised task settings, such as simple collaborative puzzles and building blocks. (2) Rule learning: Through the “Task Map”, guide children to understand the alternating waiting and task objectives.
Phase 2 Pair Work Period (3-6 weeks)	Developing attention and collaboration skills Enhance the ability of emotional recognition	(1) Task-oriented games: Introduce “Construction Tasks” or “Treasure Hunt Adventures”, requiring children with ADHD to cooperate with peers to solve the tasks. (2) Feedback mechanism: Teachers provide immediate feedback upon completion of the tasks.
Phase 3 Group Task Period: (7-10 weeks)	Enhance team collaboration and social interaction Enhance attention and creativity	(1) Multi-character collaborative tasks: Such as “Pirate Treasure Hunt” or “Space Exploration”, where each member assumes different roles, working together to complete the task. (2) Situational role-playing: Guiding the development of empathy and social skills through gameplay.
Phase 4 Integration of Family and Classroom (11-12 weeks)	Promote skill transfer and family participation Promote social skill and problem-solving skills	(1) Family bonding tasks: Design a family game day, using “family mission cards” to help parents participate in the intervention process. (2) Classroom nature games: Children with ADHD engage in “free play” activities with their peers in the classroom, observed by the teacher who provides positive feedback.

3.2.3. Innovative features and detailed activity design

Contextual role-playing: Story-based games such as “Jungle Adventure” or “Pirate Treasure Quest” encourage cooperation, role-taking, and problem-solving ^[16]. Students alternate roles, supporting the development of emotional recognition, turn-taking, and problem-solving skills for students with ADHD. After each round, the teacher offers immediate feedback and encourages students to review their own performance.

Introduction of a digital tool app: A digital tablet-based game is used to train students with ADHD to develop endurance in completing specific tasks. The game is designed with a reward system, where completing tasks earns virtual medals or unlocks achievements.

Involvement of families and parents: Parents are invited to participate in “parent-child cooperative games”, such as “rule-based card games” or “family role-playing days”, to help children maintain behavioural adjustments in the home environment. Additionally, parents can use feedback cards to record their child’s performance in family activities and provide this feedback to the teacher on a weekly basis for continuous adjustments, thereby establishing a two-way feedback system between school and home.

Integration of Classroom Situations

Integrate children with ADHD into natural classroom settings to carry out group activities, such as collaborative “story chain” games where students with ADHD take turns with their peers to create stories. Meanwhile, the teacher monitors remotely, provides immediate behavioural cues, and records performances for weekly summaries.

3.2.3. Assessment and feedback system

This programme innovatively combines collaborative gaming, situational role-playing, and digital apps to provide an intervention approach that is applicable across multiple settings for children with ADHD ^[3]. To better understand the effectiveness of the intervention, a combination of quantitative and qualitative methods will be used. For instance, behaviour scales such as the Conners’ Parent Rating Scale will be applied to assess improvements in core ADHD behaviours ^[17]. Periodic assessments will be conducted using standardised tools such as the Test of Playfulness (TOP), the Social Skills Improvement System (SSIS), and the Parent-Child Relationship Questionnaire ^[18–20]. Lastly, weekly parent guidance classes will be scheduled to share progress, enable parents to learn strategies for cooperation, and discuss challenges in implementation.

4. Conclusion

This study proposes an innovative play-based intervention plan for children with ADHD aged 6 to 10, aiming to improve their behavioural problems and social adaptation abilities through cooperative games, contextual role-playing, and digital tools. Family participation and peer interaction also play an important role in promoting effective cooperation between families and schools through a two-way feedback system. In addition, the programme innovatively introduces digital app tools to improve children’s task execution and self-management abilities through instant feedback and reward mechanisms.

With the continuous development of technological means, future research can apply more virtual reality and artificial intelligence technologies into the intervention process to achieve more efficient intervention effects.

Disclosure statement

The author declares no conflict of interest.

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An Analysis of Visual Cognitive Differences in the Audi Logo's Century-long Evolution: A Quantitative Study Based on Generational Groups

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Abstract: The Audi logo has evolved over a century. This study investigates consumers' visual perceptions and purchase intentions regarding the 2016 and 2024 logos. Based on a survey of 123 respondents across generations, results reveal cognitive differences in "memorability", "technological sense", "heritage", and "indifference." Younger groups (1990s and 2000s) show more indifference toward the new logo, which emphasizes technology but weakens emotional connection and heritage. Findings suggest that balancing tradition with innovation is key to cross-generational recognition.

Keywords: Audi brand logo; Generational cognitive differences; Visual cognition; Brand impression; Emotional connection; Brand heritage; Cognitive transfer

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1. Introduction

Throughout its century-long development, Audi has consistently been driven by technological innovation, continuously pushing the boundaries of the automotive industry. The logo, as the brand's core visual element, serves as its "face", playing a crucial role in brand communication and image building. A simple, unique, and meaningful logo can leave a deep impression on consumers, evoke emotional resonance, and thus enhance brand recognition and reputation. Audi's four-ring logo, with its simple yet powerful design, has become one of the most recognizable symbols among global automotive brands ^[1-3].

With the passage of time and evolving consumer demands, the Audi logo has undergone numerous evolutions, each reflecting the brand's strategic adjustments and market positioning over different historical periods (**Figure 1**). From its initial complex design to its subsequent simplification and modernization, the evolution of the Audi logo is not only a visual innovation but also a symbol of the brand's pursuit of breakthroughs in products and strategy. In the digital age, Audi has refreshed the four-ring logo, adopting a pure black, flat design to give it a more technological feel, appealing to younger audiences.

In today's diverse society, consumers of different generations differ significantly in their values, lifestyles, and consumer attitudes ^[4]. These differences inevitably influence their visual perception and emotional response to brand logos. Whether the Audi logo's design is sufficiently novel and unique, and whether it satisfies consumers' pursuit of technology and innovation, will directly influence their perception and attitude toward the Audi brand ^[5-6]. This study aims to answer the following questions: How do different age groups perceive the different versions of the Audi logo (2016 and 2024)? Does the new (2024) logo effectively convey brand values such as technology and innovation? What is the relationship between brand experience and logo perception? Through in-depth research on these questions, this study will provide valuable insights for Audi's sustainable development in its electrification transformation and market competition.

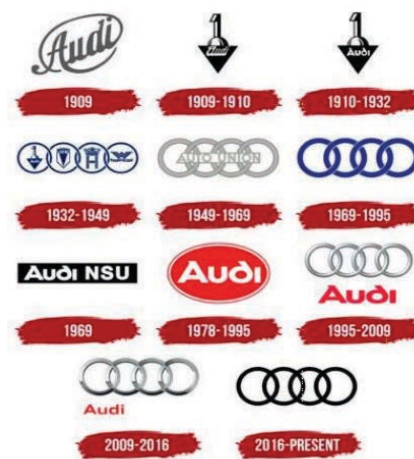


Figure 1. Changes in Audi's logo over the past century

2. Literature review

Brand logos—the brand's “first visual language”—combine identification, symbolism, and emotional projection. In semiotic terms (Barthes, 1967), they operate as sociocultural codes, while Gestalt principles show that recognition privileges wholeness, simplicity, and symmetry ^[1, 7].

Visual memory research identifies salience and uniqueness as the main routes to retention (Nelson, 1979), implying that effective marks are memorable, distinctive, symbolic, and culturally congruent. Yet the contemporary push toward simplification, though beneficial for digital media, can thin cultural depth ^[8]. In automotive branding, visual evolution reflects technology, market demand, and strategy: Tesla's shift from an ornate shield-and-wordmark to a pared-back metallic “T” (**Figure 2**) exemplifies minimalism aligned with a high-tech, future-mobility positioning ^[9].



Figure 2. Tesla logo changes

3. Research methods

This study adopted a quantitative approach, using a questionnaire survey of 123 respondents grouped by birth decade (1960s–2000s). The survey examined perceptions of the Audi logo (e.g., memorability, uniqueness, technological appeal, legacy, monotony, indifference), Audi ownership, purchase intentions, and general evaluations (aesthetics, preference). Data analysis involved cross-tabulations, correlation tests, and symmetry tests. Cross-tabulations compared frequency distributions across generations, correlation tests explored associations between age and logo preference, and symmetry tests assessed links between perceptual dimensions and other variables.

4. Data analysis and results

4.1. Consistency of logo internal dimensions

Attractiveness, beauty, memorability, and liking were highly correlated within logos from the same year ($r > 0.8$), confirming the internal consistency and scale reliability of logo evaluation (Cronbach's $\alpha > 0.94$), as shown in **Table 1**.

Table 1. Reliability statistics for the logo evaluation scale

Reliability statistics		
Cronbach's Alpha	Cronbach's Alpha based on standardized items	N of items
.948	.948	4

4.1.1. Logo perception difference analysis (2016 vs. 2024)

Memorability. For the 2016 logo, younger cohorts reported higher memorability (2000s: 64.7%; 1990s: 63.3%) than the 1980s cohort (52.4%); the 1960s cohort selected none ($n = 2$). This pattern suggests stronger recall among younger respondents, with the 1960s estimate unstable due to the very small sample (**Figure 3**). **Uniqueness.** Perceived uniqueness was highest in the 2000s cohort (49.0%), and lower in the 1990s (26.5%) and 1980s (23.8%), indicating greater sensitivity to the design among younger respondents. **Established brand.** Associations with “established/legacy” were strongest in the 1980s (47.6%) and 1990s (38.8%) cohorts, and weaker in the 2000s (15.7%), suggesting mid-age cohorts weigh heritage more heavily. **High-tech/monotonous/indifferent.** Each of these responses was low overall (~10%), implying limited high-tech associations and few extreme reactions to the 2016 mark. Proportions for the 1960s cohort fluctuate because $n = 2$.

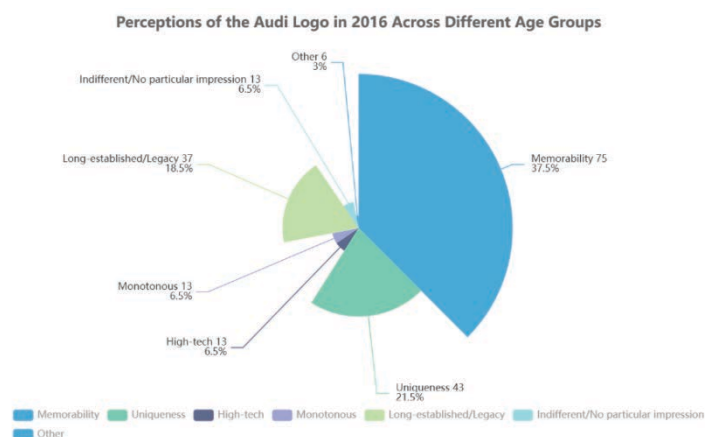


Figure 3. Perceptions of the Audi logo in 2016 across different age groups

4.1.2. Perception of the 2024 logo

Indifference: For the 2024 logo, indifference rose sharply: 49% of the 2000s and 49% of the 1990s cohorts reported being indifferent, versus 14% in the 1980s group (overall 43%). This suggests weaker salience and identity cues in the new mark; estimates for the 1960s cohort are volatile, given the very small *n* (**Figure 4**). Memorability among younger cohorts fell to 8%–14% (2000s: 7.8%; 1990s: 14.3%), whereas the 1980s cohort remained higher (47.6%). The pattern indicates that the 2024 logo has yet to establish lasting recall with its core younger audience. Perceptions of “high-tech” and “monotonous” were broadly similar across cohorts (~17%–23%), implying that while the mark signals technology, its minimalism is read by some as overly plain. “Long-established/legacy” associations declined markedly (~8% overall), indicating a reduced sense of heritage in the 2024 treatment.

In summary, relative to 2016, memorability dropped from ~61% to ~17%, while indifference increased from ~11% to 43%. Younger cohorts (1990s–2000s) are the most indifferent; the 1980s cohort is comparatively more tolerant. Although the 2024 design cues technology (18% agreement), heritage, and emotionality have weakened, creating a brand-equity gap. Implications: Strengthen identity elements and depth cues (e.g., motion/lighting, subtle gradients, restrained 3D) to boost memorability. Use a clean, high-tech system in digital touchpoints (website/app), while retaining tactile four-ring textures in physical media (showrooms/OOH) to balance tech and tradition. For younger cohorts, pair the logo with interactive activations (co-branded drops, AR/social filters). In brand storytelling, foreground the dual narrative of “100 years of Audi” and “future technology” to rebuild emotional linkage.

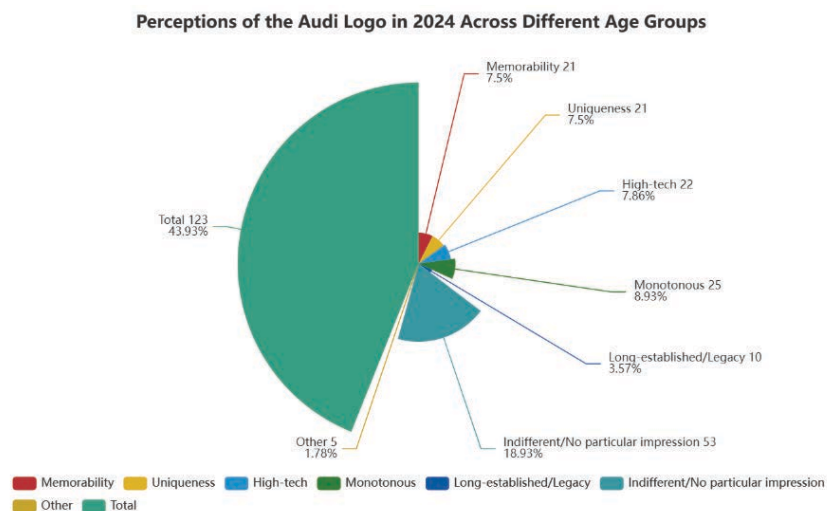


Figure 4. Perceptions of the Audi logo in 2024 across different age groups

4.2. The impact of brand ownership on purchase intention

Ownership experience strongly predicts future purchase. Among Audi owners (current or former), 86.7% reported that they would or would consider buying again, versus 65.2% among those who have never owned an Audi (**Table 4**). Non-owners constitute the majority of the sample (72.4%; ≈89/123). Within this group, 47.2% indicated they would consider a future purchase (≈42/89), and an additional ~18% indicated they would buy, together matching the 65.2% future-intention rate. For previous owners (15.4%; ≈19/123), 57.9% (11/19) expressed repurchase consideration. For current owners (12.2%; ≈15/123), 40% (6/15) stated they would buy, and 46.7% (7/15) would

consider buying again, totaling 86.7% positive intent.

These patterns underscore the reinforcing effect of brand experience on loyalty and highlight a sizable opportunity among non-owners. The results offer a quantitative basis for segmentation (owner vs. non-owner), CRM nurturing (leveraging positive prior experience), and targeted trade-in/upgrade incentives.

Table 4. Ownership and purchase intent of Audi brand vehicles by age group

Age cohort	Previously owned, not current	Currently own	Never owned	Row total
2000s	0 (0.0%)	0 (0.0%)	8 (15.7%)	8 (15.7%)
1990s	1 (2.0%)	1 (2.0%)	6 (12.2%)	8 (16.3%)
1980s	2 (9.5%)	0 (0.0%)	6 (28.6%)	8 (38.1%)
1960s	0 (0.0%)	1 (50.0%)	0 (0.0%)	1 (50.0%)
Overall	3 (2.4%)	2 (1.6%)	20 (16.3%)	25 (20.3%)

5. Discussion of results

The findings reveal a clear tension between classicism and innovation in Audi’s visual identity. The 2016 four rings outperform the 2024 treatment on memorability and uniqueness, especially among younger cohorts (1990s–2000s). By contrast, the 2024 minimalist, tech-forward design elicits higher indifference ($\approx 43\%$ overall; 49% in the 1990s–2000s) and more “monotonous” attributions, indicating that salience and identity cues have weakened. This imbalance between technology and heritage aligns with Gestalt principles: effective marks must sustain holistic, culturally anchored associations rather than rely on reduction alone.

Framed within a three-tier brand-cognition model—recognition \rightarrow memory \rightarrow identification—the 2024 logo largely achieves only recognition. Memorability drops from $\sim 61\%$ (2016) to $\sim 17\%$ (2024), and emotional identification lags, particularly among younger audiences. These outcomes suggest that design minimalism needs complementary meaning-making devices (narrative, motion, depth cues) to carry heritage across generations.

Context matters: Although the 2024 system targets China, young consumers prioritize technological expressiveness and interaction over flat minimalism alone. Beyond the static mark, brand communication should therefore integrate interactive activations (e.g., AR filters, launch animations) and a dual narrative of “100 Years of Audi” \times “Future Technology” to rebuild emotional linkage and cultural depth in local markets.

The results also underscore the behavioral role of experience: owners (current/former) show 86.7% positive repurchase intent versus 65.2% for non-owners, confirming that experience amplifies loyalty and should be leveraged in CRM and upgrade/trade-in programs. At the construct level, attractiveness, aesthetics, memorability, and liking move together ($r > 0.8$; $\alpha = 0.948$), indicating a coherent evaluative mechanism: when the logo succeeds on one of these dimensions, others tend to rise in tandem.

Implications: To close the gap, strengthen identity and depth cues (subtle motion/lighting, restrained gradients, tactile or 3D accents) to boost memorability, while keeping a clean digital system for UI contexts. In physical media, retain the textural heritage of the four rings to balance tech and tradition. For younger cohorts, pair the logo with interactive, participatory touchpoints and co-branded cultural moments. Strategically, treat the logo as part of an experience ecosystem where storytelling, channels, and owned experiences collectively deliver heritage and innovation.

Disclosure statement

The author declares no conflict of interest.

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Exploring Pathways to Enhance Public Management Efficiency in the Context of Digital Government Development

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Abstract: Against the backdrop of digital government development, public administration emphasizes the use of technological tools, functional optimization, data-driven decision-making, and management model innovation. Traditional public management models can no longer meet the demands of digital government development, necessitating the exploration of effective strategies and pathways to enhance public management efficiency. Based on this, this article analyzes and elaborates on existing issues in public management within the context of digital government development. It then specifically explores methods and pathways for improving public management efficiency, aiming to provide references for enhancing the efficiency of public management in public institutions under the backdrop of digital government development.

Keywords: Digital government development; Public administration; Philosophy; Innovation; Efficiency

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1. Introduction

With the continuous innovation and application of digital technologies, the state has intensified efforts in digital government development through policy guidance. By fully leveraging modern information technology, digital technology, and media technology, it has optimized and innovated government public administration and social governance, effectively enhancing management standards and providing a driving force for social construction and development. Against this backdrop, public institutions must also undergo corresponding transformation and innovation in public management. They should align with the requirements of digital government development by introducing advanced technologies, renewing management philosophies, and innovating management models. This will facilitate the digital, informatized, and intelligent transformation of public management, comprehensively enhancing its efficiency and quality. However, current public management practices in public institutions still exhibit issues such as outdated management philosophies, imbalanced “human-technology” relationships, a lack

of innovation in management models, and shortages of specialized talent. To further enhance public management efficiency, public institutions should intensify research on public management innovation within the digital government development framework.

2. Challenges in public management under digital government development

2.1. Outdated public management concepts

In the digital government context, lagging public management concepts are a key factor hindering efficiency. Many administrators lack a big data mindset, failing to accurately comprehend and effectively apply information processing methods suited for the big data era. They persist in traditional management thinking within public administration, unable to fully integrate information resources and achieve digital transformation. Concurrently, traditional public management concepts lack awareness of data sharing, particularly between public institutions and citizens. This results in inadequate information communication mechanisms and low data sharing levels, ultimately leading to inefficient information processing, cumbersome approval procedures, increased management costs, and diminished public management efficiency ^[1].

2.2. Imbalance in the “human-technology” relationship

Amid the advancement of digital government construction, the digital transformation of public administration continues to progress. However, digital public management is not merely a technical issue but a complex challenge of balancing the “human-technology” relationship. Overemphasizing technology while neglecting the genuine needs of the public not only fails to enhance good governance but also undermines the efficiency and quality of public administration. Current public management practices reveal critical imbalances requiring urgent resolution. On one hand, some units excessively rely on technology, diminishing the core value of human agency. On the other hand, accelerated digital government development demands increasingly sophisticated digital competencies from managers. Yet, a mismatch persists between personnel capabilities and technological advancement, resulting in a management predicament where “high-skill tasks remain unmanaged while low-skill tasks lack proper handling” ^[2].

2.3. Public management models require innovation

Under the digital government framework, public management must innovate its models by fully leveraging technologies like big data, cloud computing, and blockchain to enhance traditional approaches, thereby improving efficiency and service quality ^[3]. However, current public management practices in public institutions reveal significant room for innovation. On one hand, existing models persistently suffer from “data silos” and “data smoke stacks”, characterized by high barriers to data sharing and low communication efficiency across departments, levels, and between administrative bodies and service recipients, resulting in a limited data sharing scope. Simultaneously, internal management systems remain fragmented, with persistent issues like “one app per task” and “one portal per department.” This not only hampers public management efficiency but also increases management costs through redundant system development. On the other hand, traditional public management models primarily rely on offline services, with insufficiently developed online functionalities. Consequently, certain public management tasks still require manual offline coordination and multiple visits, failing to effectively enhance management efficiency.

2.4. Shortage of professional digital governance talent

In the context of digital government development, enhancing public management efficiency requires support from specialized digital governance professionals. Current public institutions face a relative shortage of such talent, with existing managers' capabilities and comprehensive competencies failing to meet the demands of innovative public management under new circumstances, resulting in low efficiency. On one hand, institutions neglect recruiting specialized digital governance talent and fail to offer competitive compensation packages, leading to high turnover. On the other hand, public institutions underinvest in cultivating digital governance talent, failing to develop targeted, scientific training programs. They lack effective incentive mechanisms and neglect talent management, thereby failing to effectively enhance the technical proficiency, professional capabilities, and overall competence of public management personnel.

3. Pathways to enhancing public management efficiency in the context of digital government development

3.1. Innovating public management concepts

Under the digital government framework, public management must promptly innovate its management concepts to achieve “digital transformation” at the conceptual level. This involves embedding digital technologies into public management workflows to comprehensively advance the digital and informational transformation of public administration. Simultaneously, it requires fully recognizing the value of data, treating digital elements as a vital “productivity factor” in public management, and leveraging the value and advantages of information and data resources to provide decision support across all stages of public administration^[4]. Specifically, public management must adopt a data-driven decision-making philosophy. Leveraging big data and artificial intelligence technologies, it should transition from traditional experience-based decision-making to data-driven approaches. By intelligently integrating and analyzing massive datasets through these technologies, public management can achieve a deep, precise understanding of public needs. This enables continuous optimization and improvement of management processes and methodologies, effectively enhancing the scientific rigor and effectiveness of public management decisions. Simultaneously, public administration must embrace collaborative governance and open sharing principles. Public institutions should dismantle traditional information silos between departments, deepen cross-departmental collaboration, establish unified data management platforms, and strengthen data sharing. Through collaborative governance and data sharing, effective coordination across policy implementation and public service delivery in public institutions can be achieved, thereby enhancing public management efficiency^[5].

3.2. Balancing the “human-technology” relationship

In the context of digital government development, enhancing public management efficiency requires a balanced approach to the “human-technology” relationship. This entails steadfastly upholding the value stance of “people-centered, technology-assisted”, fully implementing the “people-centered” public management philosophy, prioritizing public needs, and focusing on enhancing public recognition, satisfaction, and support. On one hand, it involves scientifically managing the relationship between human-centered management and technological support. Human-centered management emphasizes placing people at the core, respecting and valuing human contributions, rights, and participation in public administration. Technological support, conversely, emphasizes the need to reasonably and fully integrate emerging technologies—such as big data, blockchain, and artificial intelligence—into public management within the digital government framework, thereby providing technical backing for

enhanced administrative efficiency. In balancing human-centered management and technological support, people must also foster deep integration between people and technology. While introducing and applying advanced technologies, public institutions should prioritize skill development for public administrators, unlocking their inherent potential to ensure they can efficiently utilize digital technologies and tools to deliver high-quality, high-efficiency public services ^[6]. On the other hand, public institutions must establish robust oversight and feedback mechanisms. This involves systematically evaluating the effectiveness of technology for official purposes, regularly collecting and organizing feedback on technology usage from public administrators, and adjusting and optimizing technology strategies based on the actual circumstances and needs of public administration within the institution. Concurrently, by scientifically conducting performance evaluations and refining accountability mechanisms, the sense of responsibility among public administrators regarding technology usage should be strengthened. This helps prevent the misuse of technology and effectively balances the “human-technology” relationship.

3.3. Innovating public management models

Under the framework of digital government development, public management must prioritize innovative management models. This involves strengthening the application of advanced technologies to build a modern public service system and elevate service standards. Public institutions should focus on the digital and intelligent transformation of service models, breaking free from the limitations of traditional, single-mode management approaches. New management models should be adopted to drive steady improvements in management efficiency. First, public institutions should rationally utilize online service tools like “two microblogs and one mobile app” to broaden public service coverage and bridge the gap between institutions and citizens. These platforms enable direct communication and information exchange with the public, streamlining service processes, enhancing information transmission efficiency, and reducing information loss during dissemination to ensure smooth workflow progression ^[7]. Simultaneously, these online tools should be leveraged to develop new public service functions—such as online applications, online reviews, online supervision, and online evaluations—to elevate the efficiency and quality of public administration. Second, public institutions must continuously deepen reforms in streamlining administration, delegating power, and improving services. While optimizing traditional offline management models, they should intensify the development of online management platforms. This dual approach ensures face-to-face communication and services offline to enhance public satisfaction, while providing diverse, convenient online services to meet varied public needs. In summary, under the framework of digital government development, public management must innovate and implement bidirectional, coordinated online-offline management and service models to elevate public management efficiency.

3.4. Recruiting and cultivating digital governance talent

Talent development is a critical safeguard for enhancing public management efficiency in the digital government context. Therefore, public institutions should intensify efforts to recruit and cultivate digital governance talent in alignment with the demands of public management innovation and development, building a high-quality talent pool to provide human resource support for improving public management efficiency ^[8]. On the one hand, public institutions should refine talent recruitment and incentive mechanisms for digital governance professionals. By offering competitive compensation packages and tailoring career development paths to individual needs, they can attract top-tier digital talent to join the public management workforce. Concurrently, institutions must establish

robust, scientifically grounded incentive systems for digital projects to encourage and motivate digital talent to actively participate in public governance innovation. On the other hand, public institutions should intensify cross-disciplinary talent development by formulating scientifically sound interdisciplinary training programs. These programs should integrate content from information technology, public administration, law, and other fields to cultivate versatile digital talent, with particular emphasis on developing digital thinking, digital skills, and public governance capabilities. Training approaches should integrate theory with practice. Beyond systematic instruction in disciplinary knowledge and skills, practical methods such as cross-departmental collaboration should be employed to comprehensively enhance digital talent's integrated practical capabilities. Furthermore, public institutions must strengthen talent management by establishing scientific and reasonable personnel evaluation mechanisms. Regular assessments and analyses of professionals' expertise, operational competencies, and overall qualifications should be conducted. Based on evaluation outcomes, talent development plans should be adjusted to continuously improve the quality of digital workforce development.

4. Conclusion

In summary, enhancing public management efficiency under the backdrop of digital government construction is the fundamental guarantee for ensuring public service quality. Public institutions should actively innovate management concepts, balance the "human-technology" relationship, pioneer management models, and introduce and cultivate high-quality digital governance talent to effectively elevate public management efficiency. Moving forward, driven by digital government development, public management should deepen the integration and application of digital technologies. This includes embedding cutting-edge technologies such as cloud computing, the Internet of Things, and blockchain into management practices while developing personalized public service models. Such efforts will fully leverage the public management functions of public institutions, driving their sustained and stable development.

Disclosure statement

The author declares no conflict of interest.

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Spatial Investigation and Analysis of Bridge Heritage in Jining Based on ArcGIS Pro

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Abstract: This paper investigates the bridge heritage of Jining through literature review, field surveys, and spatial analysis using ArcGIS Pro. The study examines their chronological distribution, spatial patterns, hydrological settings, and protection levels. Findings show that the bridges, dating from the Tang dynasty to the modern era and concentrated in the Ming and Qing periods, are mainly clustered along the Grand Canal and the Si River, reflecting Jining's role as a transportation hub and center of Confucian culture. Most bridges are classified as provincial cultural relics and are located in rural areas, where limited resources and awareness constrain preservation. Current utilization remains largely confined to static display, with insufficient integration into tourism, cultural innovation, and rural revitalization. To address these issues, this study proposes strengthening the "Four Essentials" (scope, signage, archives, management), enhancing digital documentation, and promoting cultural-tourism integration to advance both heritage protection and regional development.

Keywords: Bridge heritage; ArcGIS Pro; Spatial analysis; Preservation and utilization

Online publication: September 9, 2025

1. Introduction

Jining, located in southwestern Shandong Province, is renowned as the "City of Canals" due to the Grand Canal running through it, along with the Yellow, Dawen, and Si Rivers ^[1]. Influenced by this geographic setting, numerous bridges were historically constructed, many of which are still preserved today. These ancient bridges possess significant historical, scientific, and artistic value, and their further exploration and digital utilization could greatly promote cultural tourism and enhance regional identity. This study focuses on the existing bridge heritage in Jining, compiling data on their names, locations, construction periods, and structural features, and analyzing their historical evolution, spatial distribution, and protection levels. The aim is to provide a foundation for the revitalization and sustainable development of Jining's bridge heritage.

2. Research objects and scope

Bridge heritage refers to the remains of human bridge-building activities, reflecting construction capabilities at different historical stages. Such heritage embodies historical, technological, social, cultural, and artistic values. According to their significance, bridge heritage can be classified into world, national, and local levels, thereby forming a systematic and complete heritage framework [2].

The focus of this study is the existing bridge heritage in Jining. According to the literature review and field surveys, 18 historic bridges at the municipal level or above have been preserved, characterized by diverse types, wide distribution, and a long chronological span. Influenced by Confucian and canal cultures, these bridges possess rich historical and cultural connotations, offering great potential for revitalization and functional transformation. Therefore, this paper investigates and analyzes these 18 bridges through fieldwork and data analysis, aiming to explore new approaches for their protection and utilization.

3. Research methods

3.1. Literature collection

Through the collection and analysis of local gazetteers, government documents, and other relevant literature, the basic information and visual records of Jining's extant ancient bridges were compiled. This provides foundational data for assessing the current condition of the bridges and for conducting subsequent field investigations.

3.2. On-site field survey

Building on the review of relevant literature, conducting on-site surveys constitutes a crucial component of research on Jining's bridge heritage. Field investigations enable a comprehensive understanding of the spatial and temporal distribution, structural forms, and decorative features of extant bridges, as well as an assessment of their preservation status and the environmental factors influencing them. Moreover, such surveys provide firsthand data that inform strategies for the adaptive reuse of bridge heritage, laying a solid foundation for subsequent in-depth research.

3.3. Spatial data analysis using ArcGIS Pro

In this study, the extant bridge heritage in Jining was abstracted as spatial nodes, which were precisely geolocated and vectorized using software such as ArcGIS Pro. Mathematical analyses, including standard deviational ellipse, nearest neighbor index, and kernel density estimation, were then applied to summarize and characterize the temporal patterns and spatial distribution of Jining's existing bridge heritage.

The Standard Deviational Ellipse (SDE) refers to the calculation of distribution centroids for different historical time slices, which provides an intuitive representation of the spatial distribution changes and directional trends of Jining's extant bridge heritage over time, thereby enabling the analysis of its spatiotemporal evolution [3]. The calculation formula is as follows:

$$M(X, Y) = \left[\sum_{i=1}^n x_i/n, \sum_{i=1}^n y_i/n \right] \quad (1)$$

$$\tan \theta = \left[\left(\sum_{i=1}^n x_i^2 - \sum_{i=1}^n y_i^2 \right) + \sqrt{\left(\sum_{i=1}^n x_i^2 - \sum_{i=1}^n y_i^2 \right)^2 + 4 \left(\sum_{i=1}^n x_i y_i \right)^2} \right] / 2 \sum_{i=1}^n x_i y_i \quad (2)$$

In the formulas, $M(X, Y)$ represents the coordinates of the mean center, θ , denotes the orientation angle of the ellipse, and x_i, y_i are the spatial coordinates of each point feature.

The Nearest Neighbor Index (NNI) is a method used to measure the spatial distribution patterns of point features^[4]. The spatial arrangement of points can be categorized as clustered, random, or uniform. The NNI is determined using the nearest neighbor ratio R , calculated as follows^[5]:

$$r_E = 1/2\sqrt{n/A} \quad (3)$$

$$R = r_I/r_E \quad (4)$$

In the formula, r_I represents the observed mean nearest neighbor distance, r_E is the expected mean nearest neighbor distance, n is the number of ancient stone bridges, and A denotes the study area. The spatial pattern is interpreted as follows: when $R < 1$ ($r_I < r_E$), the distribution is clustered; when $R > 1$ ($r_I > r_E$), the distribution is uniform; and when $R = 1$ ($r_I = r_E$), the distribution is random.

Kernel Density Estimation (KDE) is used to analyze the spatial differentiation of Jining's extant bridge heritage^[6]. KDE is defined as follows: given a set of points x_i, x_n sampled from a population with an underlying density function f the value of $f(x)$ at a location x can be estimated using the formula:

$$f(x) = (1/nh) \sum_{i=1}^n k[(x - x_i)/h] \quad (5)$$

In the formula, $K[(x - x_i)/h]$ is the kernel function, h is the bandwidth ($h > 0$), is the number of sample points, and $(x - x_i)$ represents the distance between the estimation point and the sample point x_i .

4. Results and analysis

4.1. Historical distribution changes

Survey results indicate that the 18 extant bridge heritage sites in Jining can be categorized into five construction periods: Tang, Yuan, Ming, Qing, and modern times. The Ming dynasty accounts for the largest share, with nine bridges (50% of the total), followed by the Qing dynasty with four bridges (23%) and the modern period with three bridges (17%). The earliest and most historically significant examples are Bian Bridge and Huitong Bridge, constructed in the late Tang and Yuan dynasties, respectively, each representing 5% of the total.

Analysis using the Standard Deviational Ellipse (SDE) function in ArcGIS Pro reveals shifts in the spatial centers of bridges across these periods (**Figure 1**). Bridges built during the Ming dynasty were concentrated primarily around Rencheng and Yanzhou districts, displaying a compact distribution pattern. By the Qing dynasty, the center shifted northeastward, encompassing Qufu, Zoucheng, and Sishui, with the distribution becoming more dispersed than in the Ming period. For other periods, the limited number of surviving bridges results in scattered distributions that preclude robust spatial assessment.

This transition from centralized clusters in the Ming dynasty to more dispersed patterns in the Qing period reflects broader regional dynamics, suggesting that the evolution of bridge construction was closely linked to shifting political, economic, and cultural centers within Jining.

Bridges constructed during the Ming dynasty number nine in total, primarily distributed across Rencheng District, Yanzhou District, and Zoucheng City. Among them, Rencheng contains the largest share with four

bridges (44%), followed by Yanzhou with three bridges (33%), and Zoucheng with two bridges (22%). The four bridges built during the Qing dynasty are evenly distributed between Qufu and Sishui, with two in each city (50% respectively). For the modern period, three bridges remain, of which two are located in Rencheng (67%) and one in Qufu (33%). In contrast, the earliest bridges—Bian Bridge from the late Tang dynasty and Huitong Bridge from the Yuan dynasty—are singular survivals, located in Sishui and Rencheng respectively (**Figure 2**).

In summary, across different historical periods, the number of bridge heritage sites in Jining and its subordinate districts has exhibited varying trends. Although the spatial distribution differs by era, the bridges are predominantly concentrated in five areas: Rencheng, Qufu, Sishui, Yanzhou, and Zoucheng. This distribution pattern aligns with the historical status of Rencheng as the “Canal Capital” and the administrative center of Jining during the Ming and Qing dynasties, as well as Yanzhou’s role as a transfer hub along the Sishui section of the Grand Canal. Analyzing these historical shifts further corroborates that these regions were densely populated and economically active in ancient times, conditions that necessitated the construction of numerous bridges. The survival of these structures thus serves not only as tangible cultural heritage but also as material evidence of historical development.



Figure 1. Standard deviation ellipse measurement and calculation diagram

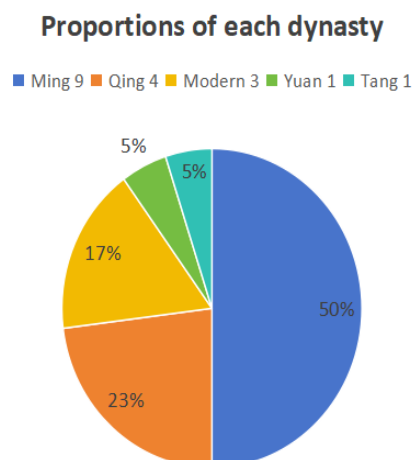


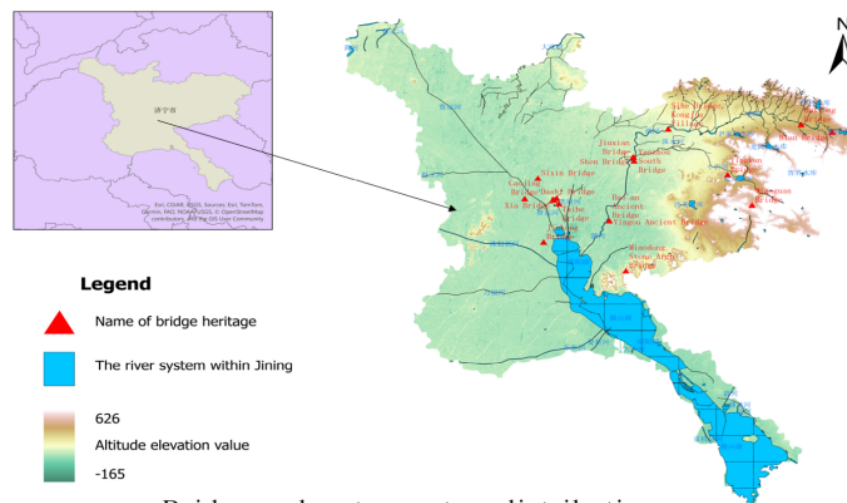
Figure 2. Proportions of each dynasty

4.2. Spatial distribution

4.2.1. Distribution of bridge heritage along river systems

By importing the geographic coordinates of Jining's extant bridge heritage together with the city's major river systems into ArcGIS Pro, a river-bridge distribution map was generated. The results show that among the 18 existing bridges, eight are located within the Si River Basin, accounting for 44% of the total. Representative examples include the nationally protected Bian Bridge in Sishui, as well as provincial-level protected bridges such as Nandai Bridge and Jiuxian Bridge in Yanzhou, underscoring the high cultural value of bridge heritage in the Si River Basin. Within the Grand Canal Basin, six bridges (33% of the total) remain, including provincial-level protected sites such as Xia Bridge and Taihe Bridge in Rencheng. The remaining four bridges (22%) are distributed across other minor river systems within Jining (Figures 3 and 4).

Statistical analysis shows that the majority of Jining's extant bridge heritage is concentrated along the Si River and the Grand Canal basins, which together account for 77% of the total. This predominance indicates the relative density of ancient bridge construction in these two areas. It further suggests that, compared with other river basins, the Si River and the Grand Canal supported denser populations and more frequent travel demands in historical periods, thereby necessitating the construction of a greater number of bridges. This distribution pattern underscores the intrinsic coupling between water systems and human settlement, transportation, and socio-economic development in the region.



Bridge and water system distribution map

Figure 3. Bridge and water system distribution map

Proportion of each basin

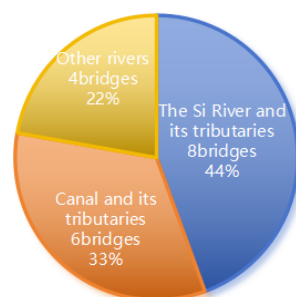


Figure 4. Proportion of each basin

The existing bridge heritage in Jining is primarily concentrated in five administrative regions: Rencheng District, Qufu City, Yanzhou City, Sishui City, and Zoucheng City. Among them, Rencheng District preserves the largest number, with seven bridges, accounting for 39% of the total. Qufu, Yanzhou, and Sishui each retain three bridges, representing 16% respectively, while Zoucheng has the fewest, with only two bridges (13%) (Figures 5 and 6).

Legend

- Name of bridge heritage
- Liangshan City
- Jinzhang City
- Yutai City
- Jiaoxi City
- Wenshang City
- Weishan City
- Rendheng City
- Sishui City
- Yanzhou City
- Zoucheng City
- Qufu City

Spatial distribution map of bridge heritage

176

The proportion of bridge heritage in various regions

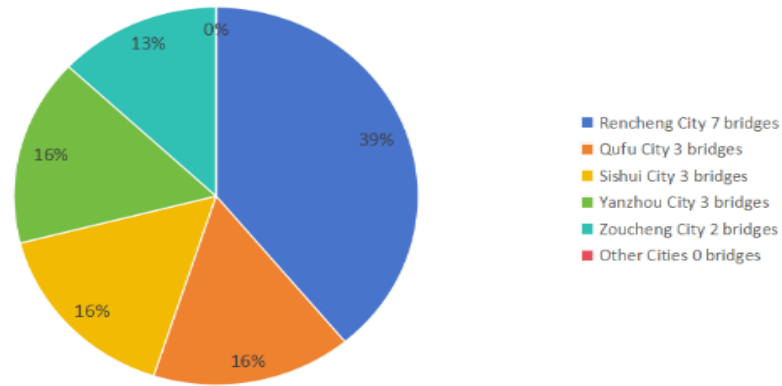


Figure 6. The proportion of bridges in various regions

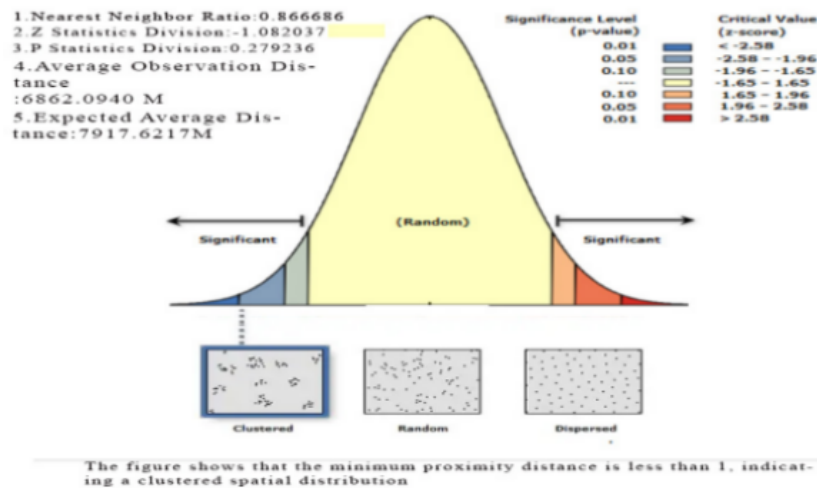


Figure 7. Nearest neighbor exponential distribution plot

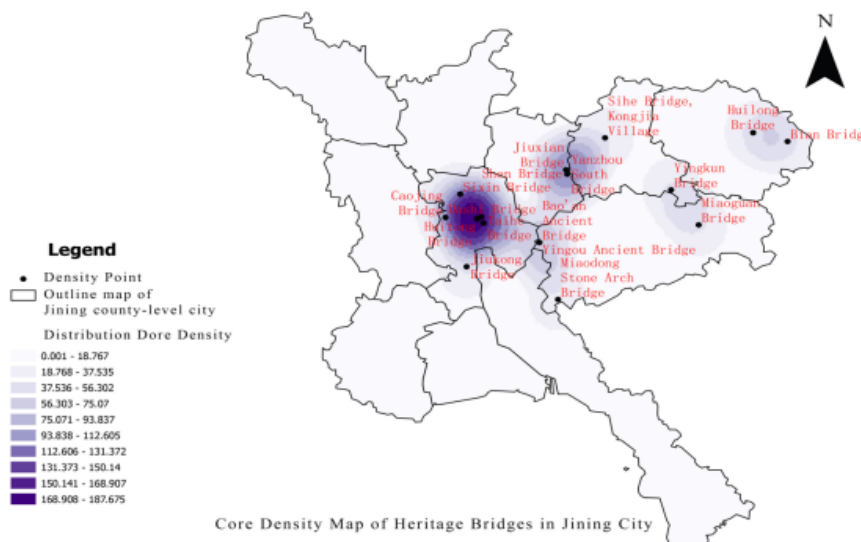


Figure 8. Core density map of heritage bridges in Jining City

4.3. Protection levels and spatial distribution of bridge heritage

Among the 18 extant bridge heritage sites in Jining, the protection levels can be categorized into three tiers: nationally protected key cultural relics, provincial-level protected cultural relics, and municipal-level protected relics. Specifically, there is one nationally protected bridge—the Bian Bridge in Sishui—accounting for 6% of the total. Provincial-level protected bridges number 13, representing 72%, while four bridges are under municipal protection, accounting for 22% (**Figure 9**). These statistics indicate that Jining’s bridge heritage is predominantly composed of high-value sites at the national and provincial levels, together accounting for 78% of the total. This underscores the significant cultural and historical value of these structures and highlights the need for focused preservation and further research.

The only nationally protected bridge in Jining—the Bian Bridge in Sishui—is located in a rural area. Among the provincial-level protected bridges, seven are situated in rural areas, five in urban districts, and two in townships. Of the municipal-level protected bridges, two are located in rural areas and one is in a township. In summary, 10 bridges (56% of the total) are located in rural areas, six (33%) in urban districts, and two (11%) in townships. This distribution indicates a predominance of rural-located bridge heritage, which also exhibits a relatively broad spatial coverage. These rural bridges not only represent key components of the historical transportation network but also function as vital links supporting the daily lives and economic activities of local residents (**Figure 10**).

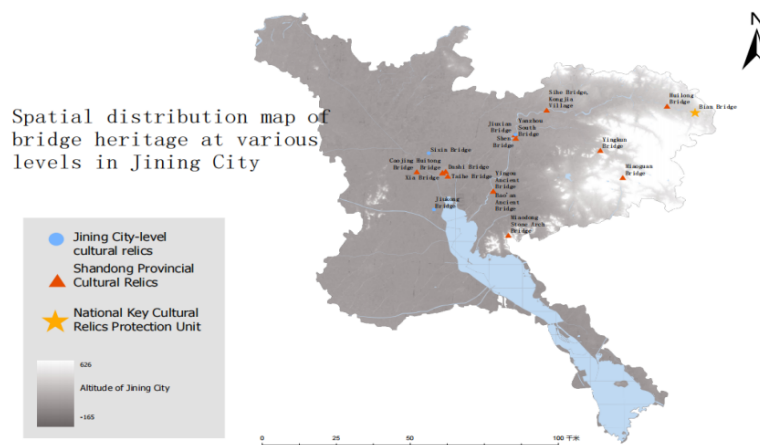


Figure 8. Spatial distribution map of bridge heritage at various levels in Jining City

Distribution of bridge heritage grades Number of Levels

■ National Key Cultural Relics Protection Unit
 ■ Shandong Provincial Cultural Relics Protection Unit
 ■ Jining City-level cultural relics protection unit

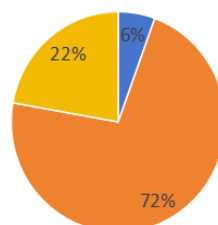


Figure 9. Distribution of bridge heritage grade number of levels

Distribution map of bridge heritage towns

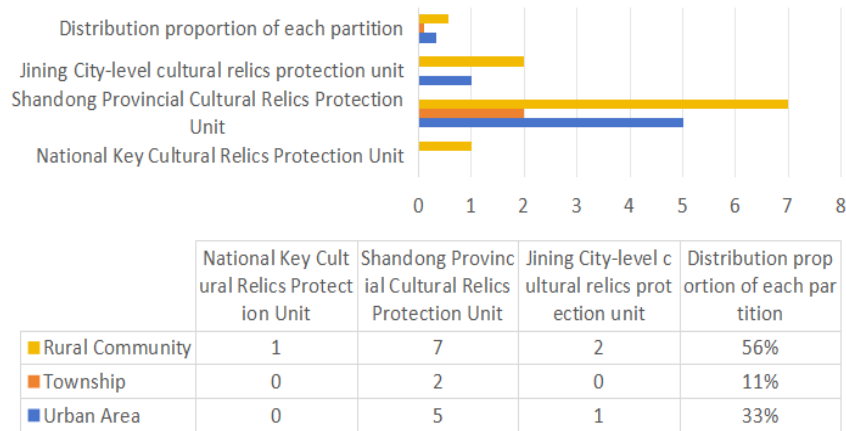


Figure 10. Distribution map of bridge heritage towns

5. Findings

This study systematically analyzed the extant bridge heritage in Jining in terms of historical temporal distribution, geographic spatial distribution, riverine system distribution, protection levels, and administrative region distribution, yielding the following conclusions.

5.1. Temporal distribution of bridge heritage

The construction of Jining's extant bridge heritage is primarily concentrated in five historical periods: late Tang, Yuan, Ming, Qing, and the modern era. Bridges built during the Ming and Qing dynasties account for the majority, representing 73% of the total. Analysis using the Standard Deviation Ellipse (SDE) function in ArcGIS Pro shows that, from the Ming dynasty onward, the spatial layout of extant bridges gradually shifted from a core centered in Rencheng District toward the northeast, forming a concentrated distribution zone centered around Qufu and Yanzhou. This shift indirectly reflects the historical transition and relocation of Jining's urban core during the Ming and Qing periods.

5.2. Spatial and riverine distribution of bridge heritage

The extant bridges are predominantly concentrated along the Si River and the Grand Canal, together accounting for 77% of the total. This pattern reflects historically dense populations and frequent waterborne transportation in these areas, which drove the construction of numerous bridges. In terms of administrative regions, bridges are mainly distributed in Rencheng, Qufu, Yanzhou, Sishui, and Zoucheng. Rencheng serves as the core cluster, while Qufu, Yanzhou, and Sishui form secondary clusters, and Zoucheng represents a peripheral area. These spatial patterns underscore the historical importance of these regions as transportation and population centers.

5.3. Protection levels and urban–rural distribution

Among the 18 extant bridges, protection levels are categorized into national, provincial, and municipal tiers. The sole nationally protected bridge—the Bian Bridge in Sishui—accounts for 6% of the total. Provincial-level protected bridges number 13 (72%), while municipal-level protected bridges number four (22%). These high-value

sites, accounting for 78% of the total, highlight the significant cultural and historical value of Jining's bridges and the need for focused preservation and research.

Regarding the urban–rural distribution, 10 bridges (56%) are located in rural areas, six (33%) in urban districts, and two (11%) in townships. The predominance of rural-located bridges, combined with their broad spatial coverage, indicates that bridge heritage not only formed an integral part of historical transportation networks but also served as vital links supporting local residents' daily life and economic activities.

6. Summary

Overall, the study demonstrates that Jining's bridge heritage exhibits clear temporal, spatial, and protection-level patterns. The majority of bridges were constructed during the Ming and Qing dynasties, with their spatial distribution gradually shifting from a core in Rencheng to the northeast. Bridges are mainly concentrated along major waterways and urban centers, and high-value protected sites dominate the heritage landscape. The findings provide a comprehensive understanding of the historical evolution, spatial characteristics, and preservation status of Jining's bridges, offering a solid foundation for future conservation, management, and research initiatives.

7. Current Status and improvement measures for the protection of bridge heritage in Jining

As a cradle of Qilu culture, Jining preserves a number of historic bridges that embody profound socio-cultural value and considerable potential for revitalized use. Yet, despite existing legal frameworks at both national and local levels, many of these sites face severe conservation challenges, highlighting the urgency of systematic scholarly attention.

7.1. Deficiencies in the “four haves” and improvement strategies

Implementation of the “Four Haves”—defined boundaries, explanatory signage, archival records, and dedicated management—remains uneven. Boundaries are often limited to physical delineation without considering the broader historical environment, resulting in conflicts with urban development, such as illegal construction near Qufu's Bao'an Bridge ^[7]. Explanatory signage is typically superficial, failing to convey historical, structural, or cultural depth; for instance, the Bian Bridge in Sishui provides only basic information despite its national heritage status. Archival documentation is fragmented, with inadequate surveying data and repair records, while unreliable online information further obscures value assessment. Finally, management suffers from blurred responsibilities and insufficient resources ^[8].

To address these gaps, protection boundaries should be scientifically defined, with intrusive structures removed. Comprehensive interpretive systems, including detailed signage, digital databases, and mobile applications, should be established to ensure authenticity and enhance public education. A specialized heritage task force, integrating professionals, local authorities, and community representatives, is essential for coordinated and responsive management ^[9–10].

7.2. Challenges in revitalized use and improvement strategies

Current utilization remains confined to static presentation, neglecting integration with waterways, routes, and settlements, thereby weakening cultural interpretation and restricting functions in education, tourism, and

community participation. Given the concentration of bridge heritage in Rencheng, Yanzhou, and Qufu—areas already rich in tourism resources—bridges could be developed as cultural focal points within integrated tourism zones, drawing on models such as Zhaozhou and Xiaoqikong^[11]. Cultural and creative industries linked to bridge heritage would further enhance visibility and diversify use. Such initiatives can transform conservation from static display toward dynamic, multifunctional cultural regeneration, simultaneously advancing local economies and resident livelihoods while safeguarding heritage values^[12–13].

8. Conclusion

Through ArcGIS Pro–based spatial analysis, this study identifies the temporal distribution, spatial clustering, hydrological context, and protection status of Jining’s bridge heritage. The findings reveal both their richness and their embodiment of regional culture, shaped by Confucian and canal traditions. However, deficiencies persist in boundary delineation, archival and signage systems, management mechanisms, and revitalization models. Targeted improvements are therefore proposed to establish a sustainable and systematic conservation framework that integrates preservation with innovative reuse, thereby achieving both cultural continuity and regional development.

Disclosure statement

The author declares no conflict of interest.

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The “Gatekeeper” in the Construction of a Law-based Government: Research on the Functional Positioning and Implementation Mechanism of the Government Legal Counsel System

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Abstract: The government legal counsel system is an important institutional arrangement for the construction of a law-based government. Its function has gradually evolved from “post-event relief” in the early stage to “pre-event prevention, in-event control, post-event remediation” throughout the entire process of risk management and control, playing the role of “gatekeeper” for maintaining the legitimacy of government actions. This paper takes the innovative practice of the government legal service advisor system in Wenzhou City as a sample and, in combination with the general situation across the country, deeply analyzes the practical difficulties existing in the system in terms of functional positioning, subject selection and employment, operation mechanism, guarantee system, etc. It is necessary to start by clarifying the core functional positioning of the “gatekeeper.” The implementation mechanism of the government legal counsel system is systematically optimized through the establishment of a scientific and standardized selection mechanism, the improvement of a coordinated and efficient operation mode, the strengthening of independent and professional performance guarantee, and the improvement of a digitally empowered smart platform, thereby effectively enhancing its effectiveness in serving the construction of a law-based government.

Keywords: Rule of law government; Government counsel; Functional positioning; Implementation mechanism

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1. Introduction

Building a law-based government is an essential requirement for modernizing national governance. The government legal counsel system, as an important institutional innovation, bears the key responsibility of guarding the “legal gate” for administrative decision-making and is an important line of defense against legal risks and ensuring law-based administration. With the development of practice, the theoretical and practical significance of the system has become increasingly prominent, but there is still a significant gap between the design of the

system and its actual operation. Despite continuous exploration and innovation in various regions, there are still widespread problems such as neglect, hiring but not using, functional deficiency, and insufficient effectiveness, which restrict the effectiveness of the system and also affect the quality and credibility of government decision-making ^[1]. In this context, it is of great practical significance to examine the functional positioning and actual operation of the system in depth. This paper aims to systematically clarify the core function of government counsel in the rule of law government, analyze the causes of the mismatch between institutional design and practice, combine the practices in Wenzhou and other places, analyze the main challenges faced by the current system, and then propose practical and feasible optimization paths to provide theoretical and practical references for promoting the system to truly move from “tangible coverage” to “effective coverage.”

2. The functional positioning and theoretical basis of the gatekeeper

2.1. Multi-dimensional functional positioning

The government legal counsel system is not a single-function mechanism but serves multiple complex roles as a “gatekeeper” in building a law-based government (**Table 1**). Its primary function is to conduct pre-legality reviews of major administrative decisions, normative documents, law enforcement actions, and contracts, ensuring the legality of administrative acts from the outset and preventing flawed policies from being introduced. Beyond legal review, high-quality legal advisors also offer professional insights and optimization suggestions based on legal principles, social impacts, potential risks, and enforcement costs. This multidimensional analysis enhances the scientific rigor and enforceability of administrative decisions by incorporating legal expertise and long-term strategic thinking ^[2].

By proactively engaging in key areas such as major project negotiations, petition handling, and emergency response, legal advisors provide solutions to prevent conflicts and offer professional support in administrative reconsideration and litigation. This reduces the risk of legal losses and economic damage, fulfilling a full-process risk control function—prevention before events, control during implementation, and remedies afterward. This comprehensive legal participation mechanism strengthens the government’s capacity to manage complex legal issues and contributes to a more stable, transparent, and predictable legal environment. Additionally, legal advisors play a vital role in promoting legal education. Through participation in legal training and provision of daily legal advice, they enhance the legal awareness and law-based decision-making capabilities of government officials, foster a culture of legality within administrative agencies, and help cultivate a positive atmosphere of respecting, learning, abiding by, and applying the law within the government.

Table 1. Core functions and manifestations of government counsel

Core functions	Main forms of expression	Stages of action
Guarantee of legality	Legality review of major decisions, filing review of normative documents, and legal risk review of contracts	Before and during the event
Decision-making consultation and argumentation	Provide legal feasibility studies, risk assessment reports, and alternative proposals	Beforehand
Risk prevention and mitigation	Participate in emergency response, major project negotiations, administrative reconsideration, and litigation representation	During and after the event
Enhanced rule of law capacity	Hold legal lectures, provide daily legal advice, and spread the idea of the rule of law	The whole process

2.2. Theoretical basis

One is the theory of management by objectives. The theory holds that the government legal counsel system is an important tool and key performance indicator for achieving the macro-strategic goal of “building a law-based government.” Specifically, the goal of building a law-based government is highly abstract and systematic, and must be implemented in specific administrative practices through operational decomposition mechanisms. The legal counsel system is an important vehicle for achieving this transformation. By breaking down the overall goals step by step into specific tasks of the legal counsel, not only can the system always operate around the core goals, but also the normativity and legality of administrative decision-making can be effectively enhanced.

The second is the theory of collaborative governance. This theory breaks through the traditional single-subject management model of government and emphasizes the collaborative participation of multiple social forces. In the context of increasingly complex modern public governance, it is difficult for governments to deal with increasingly diverse legal issues and governance challenges by relying solely on internal forces. Collaborative governance theory advocates building an open and interactive governance network through collaboration between the government and external professional forces. The legal counsel system is an important form of practice in which the government works in collaboration with lawyers, scholars, legal experts, and other professional forces to promote the rule of law in governance. This synergy is not only reflected in the legal oversight of administrative decisions by legal advisors, but also in their role as a “bridge” that organically combines legal practice experience, academic research results, and policy-making processes, thereby enhancing the professionalism and foresight of government governance ^[3].

The third is the theory of organizational boundaries. The theory points out that there are information barriers within government organizations, which can lead to “information silos” that affect decision-making efficiency and scientificity. Organizational boundaries are not only reflected in the division of functions among departments, but also in differences in knowledge structure, information access channels, and decision-making thinking patterns. Legal counsel, especially external legal counsel, as an external role that crosses organizational boundaries, can bring in external information resources and independent professional perspectives to make up for the limitations of internal decision-making. This external perspective helps to break the established administrative mindset and provide more innovative and compliant solutions. By introducing external professional forces, the government can not only enhance its own legal risk prevention and control capabilities but also achieve effective supervision and supplementation of administrative power at the institutional level, thereby comprehensively improving the scientific and legal nature of administrative decision-making.

3. Real-world dilemmas: An analysis based on the Wenzhou sample and national issues

The implementation of the government legal service advisor system in Wenzhou is a pioneering exploration, but the research data (see **Figure 1** for details) profoundly reveals the universal predicament faced by this system.

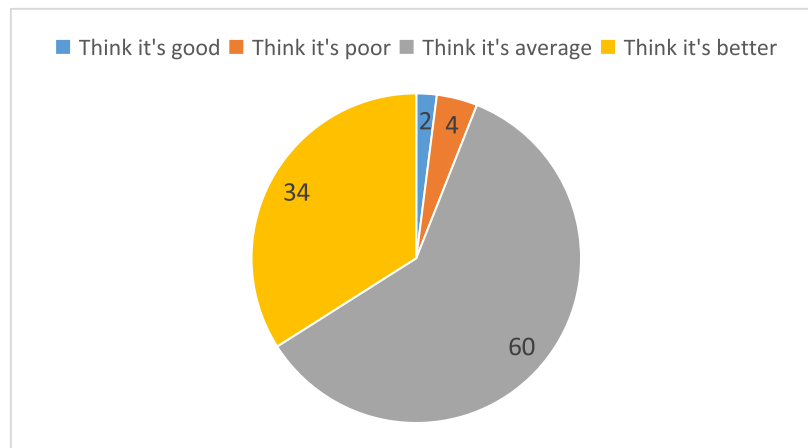


Figure 1. A survey on the satisfaction of the staff of the Wenzhou Municipal Bureau of Justice with the “Government Legal Service Advisor” system

3.1. Ambiguous subject positioning and unclear gatekeeping duties

First, the scope of subjects eligible to serve as government legal advisors, the boundaries of their responsibilities, and their participation mechanisms still lack unified national standards. Although cities like Wenzhou have experimented with involving scholars, experts, and lawyers in legal advisory roles, there remains a lack of clarity regarding their selection criteria, professional qualifications, service scope, and accountability mechanisms.

Second, functional roles are often overlapping, and responsibilities remain undefined. In practice, legal scholars, social experts, and full-time lawyers frequently lack effective coordination due to unclear role divisions and ambiguous primary or secondary responsibilities. For example, in the review of an administrative decision involving economic policy adjustments, a law professor may focus on legal compliance, an economics expert on economic impact, and a practicing lawyer on legal risk management—resulting in fragmented input rather than integrated legal advice^[4].

Third, legal opinions issued by legal counsel lack institutional authority and binding effect. Currently, such opinions are often treated merely as internal reference materials in the decision-making process, with no clear legal standing or enforceable effect. As Hou Mengjun noted, administrative authorities may choose whether or not to follow these opinions without facing legal consequences for non-adoption^[5]. This weakens the gatekeeping function of legal counsel and limits their ability to provide effective legal oversight and risk prevention, ultimately undermining the quality and legality of government decision-making.

3.2. The selection mechanism is flawed, and the “gatekeeper” team is not professional

First, the selection process is rather arbitrary and lacks standardized and institutionalized mechanisms. Song Zhimin pointed out long ago that in the early days, many places did not include legal advisors in the government procurement sequence when selecting them, nor did they establish an open and transparent selection process^[6]. They often relied on internal recommendations from judicial administrative departments or introductions through personal connections of leaders, and there were phenomena of “valuing reputation over expertise” and “valuing connections over ability.” This non-institutionalized selection process not only affects the professionalism and independence of the legal counsel team but may also lead to an imbalance in the allocation of legal service resources. Although some places, such as Wenzhou, have made improvements in institutional building in

recent years and established relatively standardized selection processes, there are still structural problems in the composition of their advisory teams. For example, in Wenzhou's current 22-person legal counsel team, nearly 60% of the members are over 46 years old (**Table 2**), showing a trend of an older age structure. Although there is a high proportion of highly educated talents in the team, some members lack practical experience in local rule of law practice, and the match between their professional background and local governance needs still needs to be improved.

The second is the lack of an effective competition mechanism and personnel mobility, which leads to a lack of institutional vitality. At present, most local governments have not established open and transparent competitive selection and dynamic elimination mechanisms in the process of hiring legal advisors. Once appointed, unless there is a major mistake, legal advisors tend to remain in office for a long time, creating what is known as the “iron hat advisor” phenomenon. This lack of an exit mechanism and performance evaluation system can easily lead to a lack of renewal motivation for the advisory team, making it difficult to introduce new forces and diverse perspectives, and thus affecting the continuous improvement of overall service quality and professional level.

Table 2. Age and educational background distribution of government legal service consultants in Wenzhou

Project	Classification	Number of people	Proportion
Age	Under 30	0	0%
	30–35 years old	2	9.09%
	36–45 years old	7	31.82%
	46–55 years old	11	50.00%
	Over 56 years old	2	9.09%
Educational background	Bachelor's degree	3	13.64%
	Master's	8	36.36%
	Doctor	10	45.45%
	Postdoctoral	1	4.55%

3.3. The operation mechanism is not smooth, and the “gatekeeping” effectiveness is not obvious

The traditional passive service model of “calling only when there is a problem” makes it difficult for government legal advisors to have an in-depth understanding of the decision-making background and the entire process. The opinions they provide often remain superficial and lack systematicness and foresight. Although Wenzhou attempts to implement the “resident representative office” mechanism to improve the participation of legal advisors, the actual effect of the mechanism remains highly uncertain if it is not truly integrated into the core process of administrative decision-making. One of the deep-seated obstacles is that some administrative officials still have a strong “official-centered” mindset, are reluctant to give up the space for decision-making autonomy, and are resistant to legal scrutiny, which directly limits the role of legal advisors. On the other hand, legal advisors generally face difficulties in obtaining information during the course of their duties. Due to the independent systems and strict data barriers of various government departments, there are serious “information silos”, and advisors often have to work in a “half-blind” state with incomplete information^[7]. According to a survey in Wenzhou, as many as 66% of legal advisors believe that poor access to information is the main problem in their work, which greatly affects

the professionalism and accuracy of legal advice. In addition, the current assessment mechanism for legal advisors focuses more on formal indicators such as the number of reviewed documents, and lacks in-depth assessment of key performance dimensions such as the quality of opinions, the adoption rate, and the ability to anticipate risks. At the same time, the remuneration mechanism is poorly designed. In many regions, “free service” or symbolic payment is still implemented, which fails to reflect the professional value of legal services and also makes it difficult to motivate consultants to devote themselves fully to their work.

3.4. The security system is weak, and the “gatekeeping” foundation is not solid

In many regions, the funds for government legal advisors have not been separately included in the fiscal budget, or the standards set are significantly too low to match the actual service demands. For instance, in Jilin Province, it was explicitly stipulated in the early years that no remuneration would be paid to external legal advisors. Such institutional arrangements led to a high turnover rate and uneven professional capabilities of the advisory team, which could not provide stable and high-quality support for government decision-making. In terms of the management mechanism, there are prominent problems of overlapping responsibilities and unclear ownership. The repetitive assignment of tasks and inconsistent standards by different departments have led to a lack of effective guidance and supervision in the daily performance of consultants. More importantly, there are obvious, ambiguous areas in the current mechanism for defining responsibilities. On the one hand, there is a lack of clear regulations on what legal or professional responsibilities legal counsel should bear if they provide wrong opinions due to professional negligence and cause administrative decision-making mistakes; On the other hand, there is also a lack of institutional basis on how to hold decision-makers accountable if the government fails to adopt the correct legal advice provided by advisors and thus causes disputes or losses. The absence of such a two-way accountability mechanism results in a serious mismatch of rights, responsibilities, and benefits, with both sides lacking adequate constraints and positive incentives, and to some extent weakens the original intention of the legal counsel system^[8].

4. Optimize the path: Build an effective gatekeeping mechanism

4.1. Define the functional positioning and refine the “gatekeeping” responsibilities

Firstly, a unified “List of Powers of Government Legal Advisors” should be formulated through local government regulations or administrative normative documents, etc., to clearly define the specific scope of matters that must involve legal advisors in consultation, argumentation, and legality review in a “list-based” manner. Such matters should at least include: decisions involving major public interests, policy adjustments that may affect social stability, major investment and construction projects, and the use of large amounts of fiscal funds. Positive list management can effectively reduce the discretionary space of administrative agencies in deciding whether to seek legal advice and prevent legal risks from the source.

Secondly, establish a “mandatory procedure” system and a “justification” mechanism for the legality review of major decisions. It is clearly stipulated that any decision-making matter included in the power list shall not be submitted to the meeting for discussion or signed and implemented without the written legality review and signature of the legal counsel. If the decision-making body decides not to adopt the opinions raised by the legal counsel, it must state the reasons in writing and file them together with the legal opinion for future reference. This, on the one hand, sets legality review as a prerequisite hard constraint for decision-making, and on the other hand, by “stating reasons”, it forces decision-making authorities to make careful considerations, thereby substantially

increasing the weight of legal opinions.

In addition, the organization and use of legal advisors should be actively optimized, and a specialized grouping mechanism for government legal service advisors should be implemented^[9]. Specialized groups such as the administrative decision-making group, civil and commercial contract group, the administrative litigation and reconsideration group, and foreign-related legal affairs group can be classified based on the professional background, practical experience, and areas of expertise of the advisors. Through this model of “categorized deployment and on-demand invocation”, it ensures that professionals handle professional matters, significantly enhancing the accuracy and quality of legal services.

4.2. Standardize the recruitment mechanism and build a strong “gatekeeper” team

First, a transparent and standardized selection process should be established. In principle, all consultants should be recruited through open recruitment, competitive review, etc. The recruitment announcements should be made public in a timely manner, and the standards and procedures should be clearly defined to ensure that the process is open and transparent, avoiding “internal designation” or “favoritism”, and guaranteeing the competitiveness and professionalism of the consultant team from the source.

Secondly, scientific and comprehensive access conditions should be set. The selection criteria should not simply focus on fame, title, or social title, but should take into account the candidate’s professional field fit, years of practice, typical achievements, industry reputation, as well as political quality and professional ethics. According to the actual needs of government legal services, the requirements for different positions can be refined to ensure that the candidates have the corresponding practical ability and compliance awareness. In terms of team structure, emphasis should be placed on the combination of senior, middle-aged, and young members, and the echelon structure should be consciously optimized. In particular, in regions like Wenzhou, where legal innovation is vigorous, the proportion of young legal advisors under the age of 35 can be appropriately increased to inject new ideas and methods into the team and enhance overall vitality and responsiveness. At the same time, people should also actively break down geographical restrictions and select outstanding lawyers and legal experts from a wider range to avoid the tendency of “localization” and “circleization.” In terms of management mechanisms, it is suggested that a fixed-term system be implemented, such as a three-year term, with an automatic dismissal upon the expiration of the term and re-recruitment to avoid “permanent appointment.” More importantly, establish a dynamic assessment and exit mechanism that is in line with the tenure, set key performance indicators including the quality of opinions, adoption, and the effectiveness of risk prediction, and resolutely dismiss or not renew consultants who fail the assessment, fail to perform their duties properly, and lack effectiveness, so as to achieve a healthy flow of personnel and always maintain the advanced nature and professional standards of the consultant team^[10].

4.3. Innovate the operation mode and enhance the “gatekeeping” efficiency

First, people should deepen the design of the mechanism for legal advisors’ participation in decision-making and promote their in-depth involvement throughout the entire chain, from decision motions, plan drafting, expert arguments, compliance reviews, to policy implementation and post-evaluation. Change the previous passive service model of “seeking only when there is a problem and asking only when there is a lawsuit” and achieve a fundamental shift from “putting out fires after the fact” to “providing protection throughout the process”, move the legal risk prevention line forward, and truly exert the early warning and planning functions of legal advisors.

Secondly, it is suggested that the government take the lead in establishing a unified “government legal counsel work platform” and implement digital task management. Gradually achieve data integration with urban government big data systems, administrative law enforcement platforms, etc., and, on the premise of ensuring information security, rely on the authority management mechanism to partially open key data query ports to legal advisors, fundamentally break down the “information silos” caused by departmental segmentation, and ensure that advisors can put forward accurate opinions with full knowledge.

Finally, it is necessary to establish a performance appraisal system with quality at its core. Change the previous evaluation tendency of emphasizing quantity over quality, and highlight result-oriented indicators such as the rate of legal opinion adoption, the accuracy of decision-making risk prediction, and the correlation between the rate of losing cases and legal opinion, to form a multi-dimensional performance evaluation model. In terms of the remuneration mechanism, the model of “basic salary + performance bonus” is implemented to make the remuneration level truly reflect the professional value and contribution of legal services, thereby establishing a sustainable incentive and guarantee mechanism.

4.4. Strengthen guarantee and supervision to build a solid foundation for “gatekeeping”

In terms of financial support, efforts should be made to promote the inclusion of legal counsel funds as a special expenditure in the local government’s fiscal budget, which should be separately listed and managed, fundamentally changing “free services” or temporary arrangements where the budget is attached to administrative funds (**Table 3**). Clarify management responsibilities to avoid the chaotic situation of “multiple management and unclear rights and responsibilities.” Clarify that the judicial administrative department is the unified leading unit for government legal counsel work, fully responsible for the selection and appointment, daily management, performance evaluation and supervision, and accountability of government legal counsel at the same level. Other types of employing units should put forward demands and cooperate in performing their duties under the overall coordination of the judicial administrative department, so as to eliminate problems such as multiple authorities, conflicting instructions, and management vacuum. To enhance management efficiency and work synergy.

The most crucial thing is to improve the two-way responsibility mechanism to ensure that rights and responsibilities are consistent. On the one hand, it is necessary to clarify the obligations and responsibilities of legal advisors through employment contracts, and hold them accountable for breach of contract in accordance with the law and regulations for providing wrong opinions due to major faults or violations of professional norms that cause significant losses, and strengthen the sense of responsibility and professional ethics of advisors. On the other hand, it is even more necessary to strictly enforce the responsibility of the decision-making body. For those who, despite receiving legal and reasonable opinions, refuse to adopt them, act arbitrarily, and thereby cause major decision-making mistakes or losses, the decision-making body and the relevant responsible persons shall be held legally accountable. Only in this way, with mutual restraint and equal rights and responsibilities, can people prevent advisors from being “indifferent and perfunctory”, and restrain decision-makers from being “arbitrary and disregarding the rule of law”, and truly form a good governance ecosystem where legal advisors dare to speak and tell the truth, and decision-makers respect the law and revere the rules.

Table 3. Key points for the implementation of the optimization path of the government legal counsel system

Optimize dimensions	Core measures	Expected results
Functional Positioning	List-based management, mandatory procedures, justification system, and classified performance of duties	Clear responsibilities, enhanced effectiveness, and substantive participation
Recruitment mechanism	Open competition, clear standards, optimized structure, tenure elimination	The team is professional, well-structured, and dynamic
Operating mode	Whole-process embedding, digital platform, quality-oriented assessment	Unobstructed information, efficient processes, and effective incentives
Safeguards supervision	Fiscal budget guarantee, judicial administration, two-way accountability	Solid foundation, orderly management, equal rights and responsibilities

5. Conclusions

The effectiveness of the government legal counsel system, as the “gatekeeper” of a law-based government, is directly related to the level of law-based administration and the realization of social fairness and justice. The current practice shows that the system is moving from “physical coverage” to “effective coverage” in the deep water zone, facing multiple challenges such as functional positioning, team quality, operation mechanism, and guarantee system. Wenzhou’s exploration of “government legal service advisor +” provides useful local experience, but also exposes common problems. In the future, people must adhere to systems thinking and carry out comprehensive reforms that combine top-level design with grassroots innovation. The first step is to get to the root of the matter and clarify the authoritative position of legal advisers as “gatekeepers” and the rigid binding force of their opinions through legislation or high-level policy documents. On this basis, a scientific, standardized, efficient, and well-guaranteed implementation mechanism will be established around the core goal of “selecting the best, managing well, using effectively, and ensuring security.” Only in this way can government legal advisors truly move from “advisory” to “guarding”, from “form” to “substance”, and truly build a solid legal defense line for the construction of a law-based government, ultimately achieving the core requirement of “putting power in the cage of institutions.”

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Improvement of Evidence Rules for PUA Psychological Control in Domestic Violence Cases

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Abstract: Domestic violence is a global social problem. This paper uses PUA emotional control as a starting point, focusing on the key factors in the identification of psychological violence evidence in current judicial practices in mainland China. By tracing the special behavioral patterns of PUA psychological control and drawing on advanced international experiences from the United States, the United Kingdom, and Taiwan region, it is suggested that Chinese Mainland build a localized evidence system at institutional, technical, and social levels to provide a systematic solution for improving evidence rules for psychological violence, thereby better protecting women's rights and promoting the effective implementation of related anti-domestic violence legal norms.

Keywords: Domestic violence; Psychological control; PUA; Evidence rules

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1. Introduction

PUA emotional control, as a new form of violence in the digital age, poses severe challenges to traditional judicial evidence rules due to its phased development characteristics, the covert dissemination methods enhanced by digital technology, and the blurred boundaries between psychological manipulation and legitimate emotional communication.

2. The applicability dilemma of evidence rules for mental control in domestic violence

2.1. The misalignment of evidence forms and forms of violence

The current judicial system's rigid reliance on physical evidence fundamentally contradicts the non-contact and fragmented characteristics of mental control cases. A large amount of evidence exists in the form of electronic data, while PUA manipulation behaviors typically exhibit a cyclical pattern of "intermittent belittling and periodic reassurance", leading to numerous cases being dismissed due to insufficient evidence. The reasons are: on one

hand, a single piece of evidence cannot effectively prove the abuser's "continuous control" behavior; as victims are often in a vulnerable position in domestic violence situations, they can typically only provide fragmented chat records, making it difficult to form a closed evidence chain to meet the same proof standards as other cases, resulting in courts frequently being unable to make effective determinations due to insufficient evidence. On the other hand, the existing types of evidence inadequately cover the emotional harm caused by manipulation; the long-term psychological damage from self-denial experienced by victims cannot be equivalently proven through injury reports, and other relevant evidence materials cannot be considered by judicial authorities, leading to insufficient relevance and adaptability of the existing related evidence.

2.2. The structural deficiency of the psychological assessment system

The harm caused by PUA mind control is psychological trauma, but the lack of unified psychological assessment standards and procedures in the country's anti-domestic violence judicial practice makes it impossible to effectively convert "psychological injury" into legal evidence. On the one hand, the degree of psychological trauma caused by mental control needs to be determined through professional psychological evaluation, but the country does not have a unified evaluation standard for "domestic violence mental control." Courts in various regions may draw different conclusions using empirical data from different psychological scales; some scholars have put forward the criterion of "degree and frequency." However, there are still disadvantages, such as strong subjectivity and difficulty in unifying standards, which affect the unity of judicial appraisal. On the other hand, psychological assessment needs to be initiated by a professional institution, but victims are often unable to independently apply for evaluation due to "learned helplessness", and courts or public welfare organizations do not have the authority to take the initiative to entrust assessment.

2.3. The imbalance in the victim's burden of proof

Due to the private nature of domestic violence, victims of psychological control often face difficulties in gathering and presenting evidence. Firstly, proving "psychological control" requires submission of sensitive evidence. For instance, to prove instances of emotional degradation, one needs to provide evidence of abusive messages from the perpetrator, which can easily be exaggerated by the abuser and may lead to both exposure of the victim's privacy and damage to their reputation. For example, victims in cohabiting relationships fear that by disclosing chat records, they might face social stigma due to their non-marital status. Secondly, the "shame" associated with traditional gender power structures plays a role. Traditional patriarchal views weaken a woman's voice within the family, coexisting with the current advocacy for women's economic and psychological independence. Therefore, women, who are the primary victims of domestic violence, are likely to be labeled as "weak" or "incompetent." This sense of shame reinforces concerns about privacy and dampens the victim's motivation to gather evidence. Thirdly, the vulnerable position of emotional control makes evidence gathering challenging. Being manipulated places one party in an extremely disadvantaged position, and with the reinforcement of learned helplessness, it becomes difficult to effectively obtain crucial evidence, thereby undermining the effectiveness of judicial intervention.

3. The special nature of evidence in domestic violence PUA psychological control

3.1. Behavioral phases leading to fragmentation of evidence forms

PUA psychological control presents a progressive feature of three stages: "Devaluation-Control-Destruction", with

each stage showing significant differences in the forms of evidence. In the devaluation phase, evidence primarily consists of frequent insulting language, such as extreme statements like “you might as well die.” At this point, it is necessary to verify its sustained characteristics through semantic density analysis. In the control phase, the evidence is concentrated in digital monitoring traces, such as abnormal frequency location-sharing records and forced itinerary reporting data. This requires judicial authorities to analyze the perpetrator’s intent and intensity using spatiotemporal trajectory analysis. In the destruction phase, evidence focuses on the victim’s self-destructive tendencies in chat records and judicial opinions on psychological harm, allowing for a reasonable application of PTSD diagnostic criteria to establish a causal relationship with prior behaviors.

It is important to note that the evidence chain in such cases has nonlinear characteristics. The causal relationship between harm and violent behavior generally exhibits indirectness and latency, and a victim providing evidence from only one stage does not effectively prove the perpetrator’s “sustained emotional control” over them ^[1]. Comprehensive determination must rely on additional evidence, including testimony from third-party witnesses, psychological assessments from authoritative institutions, among others. For example, in the Peking University Bagou case, the psychological harm consequences lagged behind the specific acts of violence by for a long time, while testimony from the victim’s roommate and device chat records ultimately corroborated each other ^[2].

3.2. The difficulty of applying evidence in behavioral techniques

PUA spiritual control is a tactical form of emotional manipulation. On one hand, such behaviors often accompany specialized strategies like the “gaslighting effect”, “emotional kidnapping”, and “economic restraints.” A particular behavior may seem like a daily interaction, but it actually conceals a manipulative intention, which can only be identified by considering the power structure between both parties and the long-term context; traditional evidence rules, with their emphasis on objectivity and directness, are not applicable. For instance, a typical expression of the “gaslighting effect” is “You’re too sensitive; I never said that.” If such evidence is presented in isolation, it may be just misjudged as “a minor conflict between couples.” Judges who lack awareness of PUA tactics may interpret strategic statements as ordinary communication, resulting in a failure to appropriately apply the evidence. Additionally, the intent behind certain chat records can only be judged alongside the long-term interaction patterns between the two parties, while victims often find it difficult to collect complete related evidence because they are in a “controlled” state, leading to an incomplete evidence chain. On the other hand, the fragility of electronic evidence exacerbates the difficulty of proof. A significant amount of evidence is stored in social media, location software, and other electronic devices, and data can be easily altered or deleted, making it common for PUA spiritual violence evidence to be difficult to discover, retrieve, and restore in a timely manner, thus raising higher technical demands on evidence collection methods.

3.3. The concealment of behavior leading to the obfuscation of evidence

The concealment of behavior is manifested in the following three aspects. First, spatial concealment. PUA behaviors often occur in private settings, with no third-party witnesses, such as chat logs and call recordings. Therefore, others cannot determine whether it is “concern” or “denigration and control.” Second, emotional disguise. The perpetrator habitually mixes caring phrases like “I’m doing this for your own good” in the chat records, wrapping the violent core in emotional candy, which obscures the violent nature of the behavior. This makes it very difficult for judges to distinguish whether such evidence pertains to an emotional dispute or “psychological

violence”, and even harder to timely search and determine the correlation of potentially key evidence. Third, the internal nature of harm. The harm from PUA is “psychological trauma”, and there are no obvious external physical traces. The lack of traditional physical evidence, along with insufficient psychological assessment systems, makes it difficult for psychological trauma to be converted into “legal evidence”, ultimately leading to the obfuscation of evidence content, which is detrimental to the realization of victims’ rights and interests protection claims. At the same time, core evidence is often mixed in the vast and trivial daily exchanges of information, making it extremely time-consuming and slow to rely on manual searches alone. Therefore, there is a demand for intelligent judicial evidence analysis, necessitating the use of deep learning methods to construct a hierarchical recognition model of violent discourse.

4. Legislative experiences from the perspective of international comparison

4.1. United States

The United States has continuously increased the degree of public authority’s intervention in domestic violence. This is primarily reflected in the following three aspects. First, the police’s mandatory arrest system. Once the police receive a report of domestic violence, they must immediately respond to the scene ^[3]. If the investigation reveals a clear suspicion of domestic violence, they have the right to make an arrest without a warrant. Second, the “preponderance of evidence” rule ^[4]. Victims only need to provide evidence that they have previously experienced domestic violence and that such behavior has met the legal standard, while perpetrators must present sufficient contrary evidence to justify their actions, or they will bear the adverse consequences of failing to prove their case. Furthermore, due to the special nature of domestic violence cases, judges may appropriately consider evidence pertaining to the character of the perpetrator and hearsay evidence in determining domestic violence ^[5]. Third, the “no-drop prosecution” policy. This means that the decision to continue prosecution or drop charges is not solely in the hands of the victim. This policy demonstrates the state’s proactive intervention in domestic violence cases, although the judicial community generally believes that its implementation should be more tempered and take into account the true wishes of the victim.

4.2. United Kingdom

The UK’s domestic violence forensic rules focus on multi-agency cooperation and systematic support services. It is mainly reflected in the following three aspects. First, the operating mechanism of multi-agency cooperation against domestic violence ^[6]. Most police stations currently have special anti-domestic violence agencies, and various agencies and organizations coordinate and cooperate with each other. Second, the police and prosecutors actively promote domestic violence crimes to enter the criminal process. The police have the right to directly exercise the right to arrest the perpetrators who meet the statutory circumstances after receiving an investigation, which plays a good role in fixing evidence related to domestic violence and guiding victims to actively exercise their rights to legal remedies. However, it is up to the prosecutor to decide whether to continue to pursue the criminal responsibility of the perpetrator, and if the prosecutor decides to stop, the victim can seek civil relief, which is determined by the practice of the British Crown Prosecutor on domestic violence, that is, criminal proceedings should be initiated in all possible circumstances. This allows victims of learned helpless PUA emotional violence to protect their legitimate rights under the strong impetus of the state’s public power, but it also leads to the possibility that a single civil remedy is insufficient if they cannot directly enter the criminal proceedings. The

third is to strengthen the protection of victims. The law does not allow the defendant to personally question the victim during the cross-examination stage to avoid the victim from being “secondary harm”; Meanwhile, hearsay evidence can be used as evidence in domestic violence cases when necessary, which gives judges greater discretion and reduces the burden of proof on the victim, while also giving rise to disputes about the impact of judicial subjective discretion on the fairness and justice of the case.

4.3. Taiwan region

Based on the traditional Chinese cultural system and combined with advanced evidence rules from abroad, the Taiwan region has immense reference value for mainland China. The main features are as follows: First, the moderate prosecution strength of the police and the prosecution authorities. The police only have the right to “arrest directly” when there is significant suspicion against the perpetrator and a danger of continuing the harm; the prosecution does not have a mandatory prosecution power for domestic violence crimes as per law, but respects the wishes of the parties involved and takes protective measures based on the victim’s safety, which greatly differs from the compulsory prosecution methods of public authorities in the United States ^[7]. Second, testimonies from minor children can be used as evidence. The testimony of the perpetrator’s or victim’s minor children is permitted in domestic violence cases, but it must be supplemented by other evidence to enhance its probative power. This aligns with the evidence rules required by Taiwan region’s criminal procedure law, because the legislation does not impose restrictive regulations on the types of evidence. Third, strengthening judges’ responsibilities for investigation. Although the criminal procedure law adopts a combination of party principle and authority principle regarding the distribution of the burden of proof, Article 13 of Taiwan region’s “Notices for Courts Handling Domestic Violence Cases” emphasizes the judge’s responsibility for investigation in the protection order procedures, requiring them to comprehensively consider the statements and opinions of relevant agencies and personnel, thus uncovering the truth of the case ^[8].

5. The improvement path of evidence rules for “psychological control” in domestic violence

According to the experience of various countries, a Chinese Mainland’s three-dimensional evidence rule system can be formed that embodies procedural legitimacy, technical adaptability, and social inclusiveness, reflecting the wisdom of international governance while showcasing local judicial characteristics.

5.1. Institutional guarantees

Improve the evidence rules for domestic mental violence. First, strengthen police intervention and enhance the ability of police and individuals to collect and secure evidence. The role of police in domestic violence cases is crucial; the robust stance taken by state authorities against domestic violence has a direct and noticeable impact on improving public awareness of domestic violence.

Second, to ascertain the facts of the case, it may be necessary to increase the types of evidence that can be accepted. Due to the gradual, technical, and covert nature of domestic mental violence, investigating the truth of a case not only consumes a vast amount of judicial resources but may still be insufficient for a conclusive determination. It is recommended to include hearsay evidence, character evidence, testimony from minors, expert testimony on battered woman syndrome, etc., within the scope considered by judicial authorities. At the same time, it is important to permit the collection of electronic evidence like the location data from the abuser’s

communication devices and original data packets from instant messaging software, and to collect such evidence cautiously based on the victim's consent, thereby ensuring a balance between judicial fairness and human rights protection. At the level of judicial effectiveness, a scientifically unified victim psychological assessment system should be established to avoid inconsistent verdicts in the same case.

Thirdly, establish a dynamic burden of proof mechanism. First, the victim needs to provide basic evidence, and the judicial authority must timely preserve the evidence. Second, the perpetrator must prove the reasonableness of their actions and meet the standard of proof that excludes reasonable doubt. At the same time, the judicial authority has the right to cross-examine relevant witnesses when necessary. Additionally, due to the covert nature of domestic psychological violence, the judicial authority should collaborate with local community organizations or women's rights protection organizations to conduct long-term follow-ups and, based on a respectful understanding of the victim's true intentions, not abandon prosecution, effectively ensuring the enforcement of litigation outcomes or guaranteeing fair treatment for potential victims. This system design fully considers the phased characteristics of new psychological control methods like PUA. This reduces the burden of proof on the victim, which helps to resolve the dilemma of inadequate evidence while avoiding excessive judicial intrusions into private domains and enhancing the credibility of the judiciary.

5.2. Technological empowerment

On the one hand, establish a mechanism for sharing information related to domestic violence. The communication and sharing mechanism for domestic violence information in Shanghai's digital court serves as a model, and its innovative practice of breaking down regional barriers through a scenarized data platform is worth promoting ^[10]. This mechanism operates on a platform-based model, enabling real-time synchronization and dynamic tracking of domestic violence information. Therefore, Chinese Mainland can use this example to build regional electronic evidence databases for domestic violence. Additionally, it is suggested to ensure the immutability of evidence through smart contracts.

On the other hand, enhance AI semantic analysis capabilities and deepen the quantitative assessment of emotional violence indices by judicial authorities. The focus is on the precise identification of potential psychological control behaviors, which can be aided by feature enhancement algorithms and focusing on graph structure features. For example, by further deconstructing the hidden structure of PUA behavioral paths in conjunction with time-series data analysis techniques. Ultimately, this will form a unified evaluation report that includes emotional indices, violence levels, and danger warnings, thereby increasing the efficiency of evidence collection and investigation by judicial authorities.

5.3. Social collaboration

Domestic violence is a widespread social phenomenon, and its core resolution relies on the collective efforts of society as a whole. On the one hand, a collaborative electronic evidence system involving both public and private sectors should be established. A government-society interactive service platform can be built. This may include creating a joint system among Public Security, Court, Prosecution, and Women's Federation, promoting a 24-hour intelligent service platform that integrates electronic evidence blockchain systems with psychological support AI consulting modules. On the other hand, innovative digital educational intervention models should be created to intensify awareness of anti-domestic violence across society. Relevant short videos on topics should be released via platforms like Douyin and Kuaishou, guiding victims to use screen recording and screenshot functions to

secure evidence and enhance their self-protection awareness.

Disclosure statement

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Role Construction and Conflict Among Policy Implementation Actors: A Study on Policy Adaptation from the Perspective of Role Theory

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Abstract: Public policy implementation is a complex process transforming ideal texts into real-world actions, involving the interaction of multiple factors. Traditional research has predominantly focused on objective dimensions such as policy instruments, implementation environments, and institutional design, relatively neglecting the psychological and behavioral mechanisms of policy implementers, thereby falling into the theoretical dilemma of “de-subjectification.” As agents with agency, policy implementers’ role perceptions, behavioral strategies, and value preferences constitute critical variables influencing policy outcomes. Yet these remain marginalized due to their elusive quantifiability. Originating in social psychology, role theory emphasizes how individuals’ positional identities within social structures shape their behavior, offering systematic conceptual tools for understanding policy implementers’ actions. This paper constructs a typological framework for policy adaptation centered on the analytical thread of “role construction—role conflict—role adjustment”, categorizing policy adaptation into seven ideal types. Using case studies of task force mechanisms in grassroots policy implementation, it dissects the behavioral logic and adaptation strategies of implementers navigating multiple role tensions. The study demonstrates that role theory not only effectively identifies the causes and types of policy adaptation but also provides an actionable analytical pathway for policy implementation research, partially addressing existing research gaps.

Keywords: Role theory; Policy implementation actors; Policy adaptation; Task force mechanism; Grassroots governance

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1. Research origins and problem statement

Policy implementation studies emerged in the 1970s, marked by Pressman and Wildavsky’s *The Implementation of Policy: How Washington’s Best Intentions Fail in Oakland* ^[1]. This work prompted academic recognition of the significant gap between policy texts and implementation outcomes. Over the subsequent decades, research paradigms underwent three generations of evolution ^[2]: The first generation emphasized top-down implementation models, focusing on command-obedience relationships within bureaucratic structures. Scholars like Derthick, Pressman, and Wildavsky, while keenly noting the nonlinear nature of implementation processes, relied

excessively on case studies and lacked theoretical generalizability. Second-generation research shifted toward a bottom-up perspective, emphasizing the discretionary power of frontline officials and policy renegotiation processes. Theories such as Lipsky's "street-level bureaucracy" and Sabatier's policy coalition framework sought to reveal the interactive and adjustment mechanisms within implementation. Third-generation research seeks to integrate these perspectives by introducing concepts of intergovernmental relations and policy networks. Models like Goggin's "Intergovernmental Implementation Model" and Matland's "Ambiguity-Conflict Model" emphasize the dynamic and context-dependent nature of implementation ^[3].

Despite continuous deepening and expansion of research, existing literature still exhibits significant blind spots: most studies excessively focus on objective factors such as institutions, tools, and environments, while relatively neglecting the subjective agency of policy implementers and their psychological behavioral mechanisms. As noted by new public service theorist Denhardt, policy implementation failures often stem not from management techniques or tool selection, but from implementers' cognitive and behavioral patterns ^[4]. However, due to the strong subjectivity and situational dependency of implementers' psychology and behavior, these elements are difficult to directly observe and measure, rendering them a "black box" in policy implementation research and trapping academia in the so-called "measurement dilemma."

Role theory emerged as a branch of symbolic interactionism. Its conceptual framework was developed and disseminated by Blumer, J.L. Moreno (1934), R. Linton (1936), T. Newcomb (1950), and T.R. Sarbin (1954) ^[5]. Social psychologist G.H. Mead first introduced the concept of "role" into social psychology, defining it as the shared behaviors exhibited by different individuals within the same context. R. Linton (1936) defined "role" as the process by which individuals, within their social positions, rationally exercise the rights and fulfill the obligations within their scope, thereby assuming specific roles. H.H. Kelly and J.W. Tibbetts (1959) proposed that a role is a system of expectations regarding the social behavior of individuals in a given social position, as perceived by stakeholders and by the individuals themselves. L. Buyeva (1968) argued that the social psychological analysis of roles should emphasize subjective factors while integrating them with objective factors—namely, the social relationships inherent in roles. She asserted that "social role" is synonymous with "social function" ^[6]. In summary, Role Theory originates from social production practices, emphasizing the crucial value of social relations in shaping human behavioral orientations. It posits that the social attributes inherent in roles profoundly influence the value judgments of behavioral agents and impact action outcomes ^[5]. Its core concepts include role construction, role conflict, role strain, and role overlap. Among these, role construction serves as the fundamental premise for role analysis, providing an operational theoretical framework for examining individual behavior within social structures. Public policy implementers are essentially individuals assuming public roles within specific institutional environments. Their actions are constrained by role norms while also influenced by personal cognition and external expectations. Thus, role theory offers new possibilities for unlocking the "black box" of policy implementation. This paper attempts to introduce this theory into policy implementation research, constructing an explanatory framework for policy adaptation. Using the grassroots task force mechanism as a case study, it tests the theory's explanatory power within the Chinese policy implementation context.

2. Conceptualization of policy adaptation and explanatory framework under role theory

Public policy implementation is a process of translating textual forms into action outcomes within a specific

discourse system. Policy adaptation represents deviant implementation behaviors resulting from intense conflicts among the will of the implementing agent, organizational will, and public will ^[7-9]. It may manifest as passive evasion and distortion or as active adjustment and innovation, carrying neutral theoretical implications. Role theory situates individuals within social relational networks, using role-related concepts to reveal the motivations and constraints behind behavior, thereby offering a new theoretical perspective for policy adaptation research.

2.1. Construction level: Role construction and policy adaptation

Role construction refers to the process by which individuals develop role perceptions, emotional commitments, and behavioral patterns within specific social relationships. Policy implementers' role construction exhibits publicness, plurality, and embeddedness: publicness requires alignment with the public interest; plurality manifests as implementers frequently responding to diverse stakeholders' expectations; embeddedness signifies roles deeply rooted in organizational networks and institutional environments. Specifically, role construction operates through the following mechanisms:

- (1) Role selection: Implementers form their role perceptions and behavioral strategies by observing and drawing from the behavioral patterns of similar roles (e.g., implementers in other regions or departments), a process steeped in empiricism.
- (2) Role performance: Based on external expectations and personal interpretations, implementers exhibit role behaviors during actual execution. This serves both as an outcome of role internalization and a means of role adjustment.
- (3) Role embedding: Actors locate their position within organizational networks, integrate resources, and communicate information to achieve effective alignment between their roles and the environment.

Through these mechanisms, policy implementers gradually develop stable role identification and behavioral tendencies, providing the psychological and behavioral foundation for policy adaptation.

2.2. Conflict layer: Role conflict and policy adaptation

Role conflict serves as the primary catalyst for policy adaptation. Based on its origins, it can be categorized into intra-role conflict and inter-role conflict:

- (1) Intra-role conflict: Psychological contradictions arising from inconsistent internal/external expectations or insufficient resources/capabilities within a single role. Specifically: First, "role failure" due to discrepancies between ideal and actual roles, where implementers cannot meet role requirements; Second, "role overload" caused by shortages of time, material, or capability resources, where responsibilities exceed resource capacity.
- (2) Inter-role conflict: This refers to conflicting expectations and behavioral contradictions faced by the same actor when assuming multiple roles. Specific manifestations include: First, "role strain", which is psychological pressure and behavioral conflict arising from overlapping roles and responsibilities; Second, "role ambiguity", where insufficient information or unclear expectations lead to confusion in role perception; Third, "role overload", where excessive external expectations or overwhelming tasks exceed an individual's capacity.

Role conflict occurs not only at the individual level but can also extend to the organizational level, explaining meso-level phenomena such as inter-governmental conflicts, departmental self-interest, and central-local relations.

2.3. Interaction level: Role interaction and policy adaptation

Role interaction is a dynamic process of adjusting between role expectations and role perception. Policy implementers must continually balance discrepancies between superior directives, public expectations, organizational objectives, and their own cognitive frameworks. When role expectations (society's or other actors' behavioral demands on implementers) diverge from role perception (implementers' understanding and grasp of their own roles), implementers often alleviate tensions through policy adaptation. For instance, policy beneficiaries may expect implementers to “advocate for the people”, while implementers themselves prioritize “bureaucratic advancement.” This gap between expectations and perception forms the psychological basis for adaptive behavior.

2.4. Output layer: Seven types of policy deviation and theoretical framework

Based on the core concepts of role theory, this paper constructs seven ideal types of policy adaptation (**Table 1**), each corresponding to specific causes, participating actors, and stages of occurrence:

Table 1. Types of policy adaptation and their characteristics

Type of policy deviation	Conceptual definition	Nature	Actors involved	Triggering key variables
Role Transition Type	Adaptive behavior resulting from the continuation of past behavioral patterns due to role succession or job changes	Neutral	Former role holder	Institutional/ Organizational Culture/ Tradition
Role Conflict Type	Adaptive behavior involving proactive policy adjustments to pursue personal or organizational interests	Malicious	Stakeholders	Personal interests/ organizational interests
Role Failure Type	Unintended adaptation triggered by role failure due to cognitive biases or capability gaps	Malicious	None	Performer's cognition/ capability
Role-load type	Adaptive coping behaviors are adopted due to limited time or material resources	Neutral	Implementation Hierarchy	Time/Material Resources
Role Strain Type	Adaptive behavior arising from role conflicts due to multiple roles and unclear authority/responsibilities	Neutral	Superiors and Subordinates	Role Authority and Responsibility
Role Expectation Type	Adaptive behaviors undertaken to respond to the expectations and pressures of external entities (superiors, the public, etc.)	Neutral	External Expectation Holders	External Expectations
Role Ambiguity Type	Unconscious adaptation due to information bottlenecks or ambiguous understanding	Malignant	Inter-departmental and external environment	Policy Information Flow Level

To enhance the operability of the analysis, this paper further constructs a four-tier analytical model: “Access Set—Variable Set—Problem Set—Interaction Set.” The Access Set defines the embedded relationship between actors and roles; the Variable Set extracts seven key variables (such as interests, resources, expectations, etc.); The problem set identifies adaptation types based on variable combinations; the interaction set employs Kahn's “overlapping role group model” to reveal the interactive structure of role networks, providing an organizational context for adaptation analysis.

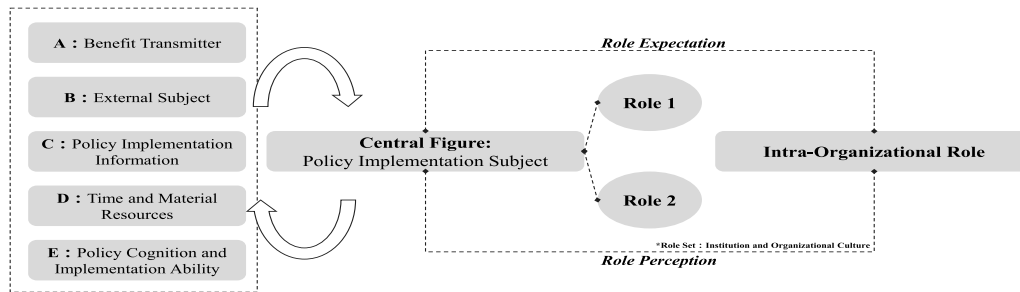


Figure 1. Theoretical framework

3. Reinterpreting the case: Policy adaptation in task force mechanisms

Task force mechanisms represent a distinctive organizational form in China’s grassroots policy implementation. Designed as temporary, cross-departmental, and cross-level structures, they aim to break through bureaucratic barriers and enhance policy execution efficiency. Drawing on Ding Huang and Wei Shaohua’s (2024) case study of the task force for G Village’s photovoltaic power generation project, this paper applies the role theory framework to analyze its policy adaptation behaviors ^[10].

The G Village photovoltaic project was a key initiative for rural revitalization in C Town, involving multiple tasks such as power array construction, land coordination, and benefit compensation. During implementation, C Town established a task force under the guidance of the district command center, comprising members from different departments who held multiple roles. The case involved three significant policy adaptations:

First Adaptation (Role Change & Role Strain Type): The task force leader, concurrently serving as C Town’s mayor, faced role strain from balancing daily town management duties with project advancement. To alleviate pressure, the task force conducted a study tour to Lu’an, Anhui (Role Selection), adapting local implementation plans based on external experiences (Role Playing). This demonstrated proactive adaptation amid role inheritance and strain, exhibiting a neutral nature with variables involving organizational tradition and role authority.

Second Adaptation (Role Failure Type): When tea farmers protested against solar panel installations, the task force faced role overload due to limited authority and could not make direct decisions, leading to role failure. To prevent escalation, the task force escalated the issue to the district command center (risk transfer). Higher authorities intervened and adjusted policies for stability maintenance. This adaptation was detrimental, driven by insufficient executive authority and resource misallocation.

Third Adaptation (Role Expectation Type): Driven by both higher-level stability expectations and tea farmers’ interests, the task force reached a compensation agreement through informal negotiations (e.g., tea tree relocation, profit sharing), unifying role expectations with implementation. This adaptation is neutral, occurring during policy re-decision-making, with external expectation input as the variable.

Case analysis demonstrates that the role theory framework systematically reveals the underlying mechanisms of policy adaptation, highlighting implementers’ behavioral adjustment strategies under multiple role pressures. This provides valuable insights for understanding policy implementation in the Chinese context.

4. Conclusions and outlook

This paper introduces role theory to construct a theoretical framework for analyzing policy implementers’ behavior,

categorizing policy adaptation into seven types, and validating its explanatory power through task force case studies. The research demonstrates that policy implementers are not passive recipients of institutional constraints but active agents who proactively seek strategic equilibrium through role construction, conflict, and interaction. Role theory, equipped with operational conceptual tools, partially resolves the “measurement dilemma” in analyzing implementers’ behavior, offering a new theoretical pathway for policy implementation studies.

The value of this study manifests in three key aspects: First, it unifies the analytical perspective on policy adaptation, avoiding fragmentation from multiple theoretical frameworks. Second, it emphasizes the full lifecycle nature and behavioral continuity of policy implementation, overcoming the limitations of static analysis. Third, it re-centers the implementing actors in research, offering feasible solutions for measuring their behavior.

However, this study retains certain limitations: First, role theory cannot fully cover all policy adaptation scenarios, particularly when explaining irrational behaviors. Second, practical policy implementation involves information black boxes and multiple interfering factors, necessitating further refinement of the model’s application. Finally, the case selection remains relatively narrow; future research could expand to different policy domains and organizational contexts. Subsequent research could deepen the integration of role theory with other disciplines (such as organizational behavior and game theory) to enhance the model’s universality and predictive power, thereby further enriching the “toolkit” for public policy analysis.

Disclosure statement

The authors declare no conflict of interest.

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Research on the Training Scheme of Innovative Foreign Language Talents in the Era of Artificial Intelligence: Based on Job Market Data from Guangdong

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Abstract: The rapid growth of Artificial Intelligence (AI) is fundamentally changing the demand for foreign language skills, displacing traditional professions while also creating new opportunities for individuals with diverse skill sets. Based on human capital theory and a constructivist learning approach, this empirical study analyzes 2,824 job advertisements (2022–2023) from a large recruitment platform in Guangdong, China, to investigate these changing demands and offer an innovative training program. Quantitative content analysis reveals a significant market movement away from pure linguistic competency and toward a model of compound knowledge. According to key findings, high-frequency demands now combine advanced language skills (English first and Japanese second) with technical competencies in programming (Python, Java), AI applications (machine learning, NLP), and industry-specific knowledge (e.g., mechanical engineering, international trade), as well as essential soft skills such as intercultural communication. Explicit mentions of AI-related talents confirm the technology’s penetration into the industry. A large gap exists between these diverse market needs and the output of traditional language-centric systems. In response, the study proposes a unique training structure based on the “Foreign Language + Professions + AI” curriculum. This strategy combines multidisciplinary knowledge, embedded AI literacy, and hands-on project-based learning to develop future-ready professionals capable of prospering in a technologically driven global economy.

Keywords: Artificial intelligence; Compound foreign language talents; Job market analysis; Talent training scheme; Guangdong province

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1. Research background, objectives, and significance

The emergence of artificial intelligence (AI) has initiated substantial changes across various sectors, including language services. Technologies such as machine translation, natural language processing, and automated speech

recognition have achieved significant accuracy, reducing reliance on traditional language-related tasks like translation and language instruction. At the same time, national strategies such as “Made in China 2025” and the “Belt and Road Initiative” have heightened the need for talent with international competencies, especially in economically active regions like Guangdong Province—a critical hub for global trade and cross-cultural engagement.

These developments make the re-evaluation and innovation of foreign languages a top priority. While the demand for language skills remains, today’s employers are looking for people with technical, business, engineering, or other skills as well as virtues such as cultural communication and critical thinking ^[1]. AI is automating routine language tasks, allowing human professionals to focus on creative and valuable activities that require emotional intelligence and strategic understanding.

This study aims to systematically investigate the specific demands and evolving trends within Guangdong’s job market for foreign language talents. This study examines 2,824 job advertisements published between October 2022 and June 2023. It investigates the required skills, knowledge frameworks, and remuneration levels. The analysis pays particular attention to artificial intelligence, compound foreign language talents, job market analysis, and talent training schemes. In addition, the study also shows a serious difference between the current market demand and the outputs of conventional foreign language education programs. Finally, it proposes an innovative, AI-era-appropriate training framework that includes curriculum redesign, considering curriculum redesign and teacher development strategies.

This study has both theoretical and practical significance. In theory, it combines perspectives on foreign linguistics, education and labor economics, educational technology, and labor economics, offering a new framework for educating foreign language professionals with multidisciplinary competencies. The study offers practical insights for educational institutions to update their curriculum and teaching methods. It helps better prepare students for a changing job market. Additionally, it supports policymakers and employers in strategic planning and recruitment. By linking foreign languages to economic goals and technology trends, the study supports China’s broader goals of expanding international communication capabilities and cultural influence.

2. Research questions

To achieve the above objectives, this study seeks to answer the following questions:

RQ1: What are the key characteristics of job postings for foreign language talents in Guangdong?

RQ2: What are the specific linguistic requirements and the non-linguistic competency requirements stated in these job postings?

RQ3: How do these requirements, especially the emerging ones related to AI and interdisciplinary knowledge, reflect the impact of the AI era on the language services industry?

RQ4: Based on the identified gaps between market needs and current educational output, how should an innovative training model be appropriate for foreign language talents in the AI era?

3. Literature review

3.1. The changing landscape: AI’s impact on language services

Scholars have extensively documented the disruptive influence of AI on translation and language learning. Bowker points out that machine translation works well for ordinary jobs ^[2]. However, people are now more important in

jobs that need human skills. For example, they must check the text before and after translation. They also have to handle projects that are difficult or involve different cultures. Similarly, in education, AI-powered tools can provide personalized learning experiences for students. Because of this, the role of the teacher is changing. Teachers are no longer mainly responsible for transferring knowledge. Instead, they are becoming facilitators who help students develop critical thinking and communication skills ^[3].

3.2. The evolving demand for compound talents

The concept of “compound talents” or “T-shaped professionals” is central to modern talent discourse. Neeley emphasizes that global business communication requires deep cultural intelligence (CQ) alongside linguistic skill ^[4]. Furthermore, research by the European Commission on the future of translation highlights a growing demand for specialists who combine language skills with expertise in a specific technical or business domain ^[5]. Employers require employees to have strong language abilities. They also expect workers to be knowledgeable in professional fields. These fields include office administration, international trade, accounting, and law. This situation is especially clear in the Guangdong-Hong Kong-Macao Greater Bay Area. Because this area is developing quickly, companies now highly value international talent. These talents need to understand local industry features. They must also have the ability to communicate technical information across different cultures.

3.3. Current reforms in foreign language education

In response, universities are exploring reforms. Many are introducing “Language + X” programs, where “X” represents a field like business, law, or technology ^[6]. There is also a push to integrate technology into the curriculum, teaching students to use CAT tools, MT post-editing (MTPE), and corpus linguistics ^[7]. However, these reforms are often new and not widespread. They are not put in place in a consistent way across all institutions.

3.4. Research gap

Previous studies have often relied on theoretical discussions or small-scale surveys. A significant gap exists in large-scale, empirical analysis of real-time job market data to ground these discussions in concrete evidence. Most studies are national in scope, lacking a regional focus on dynamic economic hubs like Guangdong. This study tries to address this lack. It uses a data-driven method to analyze job advertisements from a leading recruitment platform. The goal is to give a detailed picture of local employer demands. Based on this, we can make more specific suggestions for updating education programs.

4. Theoretical foundation

This study is based on two important theories. These theories provide a way to understand job market information. They also help to create an education plan that can change based on what is learned. Human Capital Theory explains what skills employers need. Constructivist Learning Theory provides the educational basis. This basis helps create training programs that meet those needs.

Human Capital Theory was first developed by economists such as Schultz and Becker ^[8-9]. This theory views knowledge, skills, and abilities as a type of capital. Individuals can invest in this capital through education and training. This investment is expected to yield results in the future. The expected benefits of this investment will lead to future returns. These returns will come in the form of higher productivity, which will bring greater economic rewards. These rewards include higher wages and better job opportunities. From an

organizational perspective, hiring skilled workers is an investment in human capital. This investment aims to improve competitiveness. This study uses this theory as a macroeconomic framework to analyze labor market signals in Guangdong. Certain wage levels reflect the market value of human resources. For instance, fluency in English, knowledge of international trade, and the ability to use CAT tools demonstrate. Through this pattern analysis, the research can determine the most valuable composite skill sets in the AI era. These findings guide educational institutions in allocating resources toward helping students develop human capital that enhances their competitiveness. This supports the economic rationale for educational investment.

However, understanding what is being taught is only half the answer; people also need a theory for how to teach it effectively. This is where Constructivist Learning Theory becomes essential. Constructivism has its origins in theories from Piaget, Vygotsky, and Dewey^[10–12]. It affirms that students should accumulate knowledge through experience and social interaction. They do not just receive information passively. Learning is seen as a social, contextual, and inquiry-driven process. This theory provides the basis for the design of new training programs. Skills such as critical thinking, problem solving, and adaptation are critical to innovation. These skills go beyond memorization or traditional teaching methods. They require new approaches that involve learners in developing skills through real-world contexts. According to constructivism, the new curriculum should center on situated learning within authentic contexts. It must include collaborative projects that reflect real professional situations. It should encourage independent research and allow students to use artificial intelligence tools to solve complex problems. This approach changes the teacher's role. Instead of transmitting knowledge, the teacher now facilitates learning.

These two theories work together. Human Capital Theory shows why the foreign language curriculum should change. It identifies what skills the market needs from an economic perspective. Constructivist Learning Theory offers a way to make this change in teaching. Together, they link market needs to educational methods. This helps ensure that the training program is useful in practice and effective in teaching.

5. Research design

This study takes a mixed-methods approach, with quantitative content analysis as the primary instrument, supplemented with qualitative theme analysis to capture more nuanced details. The quantitative analysis uncovers macro-level trends and salient features through systematic data mining and statistical examination of job postings, whereas the qualitative analysis involves coding and interpreting specific descriptions within job requirements to identify complex competencies and qualities that cannot be fully captured by numerical data alone.

The research data were gathered from job postings on mainland China's biggest recruitment platforms, such as Zhaopin and 51job, between October 2022 and June 2023. There were 2,824 job ads in Guangdong Province that explicitly needed foreign language skills. These data span a wide range of industries, employment types, and business sizes, ensuring significant representativeness and timeliness.

During the data processing step, the raw data were subjected to an initial purification technique that removed duplicate postings, irrelevant entries (e.g., occupations that did not require language abilities), and samples with key missing information in order to ensure validity and analytical correctness. A systematic coding framework was then created utilizing Excel and SPSS tools to annotate and extract each job ad across many dimensions. Coding factors included basic job information (e.g., job title, firm name, industry, location, number of openings, and salary range), linguistic requirements (e.g., target languages, proficiency levels, and certification needs),

and non-linguistic competencies. The latter were further classified into technical skills (e.g., computer-assisted translation tools, office software, machine translation post-editing, Python programming), industry knowledge (e.g., international trade, e-commerce, logistics, law), soft skills (e.g., communication, teamwork, problem-solving, intercultural competence), and explicit AI-related skill demands (e.g., direct mentions of keywords such as “artificial intelligence”).

This systematic data processing and encoding method offered a solid platform for moving the study from descriptive observations to in-depth data-driven inferences.

6. Findings and discussions

This study conducts a quantitative analysis of 2,824 job advertisements published between October 2022 and June 2023 to systematically examine the characteristics and trends of the foreign language talent recruitment market in Guangdong Province, using in-depth data mining and high-frequency word analysis. According to the findings, the market is transitioning from a focus solely on linguistic abilities to a composite model of “language proficiency + professional expertise + technical competencies.” The main force behind this change is the development of artificial intelligence (AI) technology, which offers strong support for four main research questions.

6.1. For RQ1 (Key characteristics)

According to data research, the Guangdong foreign language talent recruiting market demonstrates a unique blend of high concentration and diversification with respect to RQ1. Technical positions make up 45.8% of the sector distribution (general positions make up 54.2%, totaling 1,531 posts), with the highest demand being seen in mechanical engineering (631 posts) and programming technology (391 posts), while healthcare roles are relatively rare (111 posts). This distribution is consistent with Guangdong’s industrial structure as a manufacturing and digital economy hub. Full-time employment makes up the majority of employment kinds (96.56%, 2,525 posts), while internships and part-time jobs make up only 3.44% (90 posts). This indicates that companies strongly desire steady, specialized foreign language specialists with diverse competencies. With an average monthly income of ¥9,049 (median ¥7,500), the mechanical engineering sector leads the wage distribution, with programming technology coming in second at ¥8,154. On the other hand, the healthcare industry pays ¥5,721 a month, which is somewhat less competitive. General positions have the largest compensation range (¥4,000–18,000), which suggests that market valuations for skills in various disciplines varied significantly.

6.2. For RQ2 (Competency requirements)

Results for RQ2 show that work needs have significantly moved away from traditional, exclusively linguistic skills and toward a composite competency model that includes “linguistic foundation + professional depth + technical literacy + soft skills.” English is 4.3 times more common than Japanese (313 occurrences, 13.0%), with 1,359 occurrences (56.3%), indicating complete dominance in linguistic proficiency. Spanish (163 occurrences), Russian (154), Chinese (145), French (144), Korean (118), and German (116) are in the middle tier, with Portuguese (69) and Arabic (59) in lower demand. Arabic jobs require the most composite language skills (around 68%). Portuguese jobs require bilingual skills in roughly 55% of situations, and English jobs require the most monolingual skills (82%). Language proficiency is certified through dual certification systems: local (e.g., TEM-4/TEM-8), international (e.g., IELTS/TOEFL), and Japanese Language Proficiency Test levels N1/N2.

Even more crucially, non-linguistic skills become determining factors:

According to a technical needs analysis, the demand for general technologies (313) is 3.6 times more than that for AI technologies (87), with the demand for C++ (92) alone surpassing the demand for all AI technologies. In particular, deep learning (28) > machine learning (26) > natural language processing (17) are the top AI technologies, while C++ (92) > Python (78) > Java (75) are the top three general technologies. There are significant differences in concentration levels: the demand for AI technologies is fairly balanced (deep learning makes up 32.2% of AI categories), while the demand for general technologies shows a long-tail distribution (C++ makes up 29.4%). The most common pairing of skills is C++ and Java in general technologies (48 occurrences), but deep learning and computer vision (CV) are most frequently coupled in AI technologies (12 occurrences). Database abilities (SQL, 68) are more in demand in commercial applications than any other AI technologies. Both the general (62%) and artificial intelligence (100%) domains highly value Python. The demand for computer vision (16) has surpassed that for natural language processing (17), while traditional programming languages (C++/Java) continue to account for 38.3% of technical requirements.

The second is industry-specific knowledge, which emphasizes experience with “technology” (8,911 occurrences), “products”, and “clients” (6,250 occurrences). This includes knowledge of products, technologies, and technologies of particular industries like e-commerce, international trade, and mechanical engineering.

In terms of soft skills, communication is exceptional (5,375 instances), highlighting its vital role in cross-cultural teamwork.

Fourth, degree requirements favor bachelor’s degrees (10,057 occurrences); master’s degrees (5,412 occurrences) are required for some occupations.

6.3. For RQ3 ((Impact of the AI era)

Job advertisements immediately attest to the fact that AI technologies are significantly altering the language services industry’s value chain and talent requirements with regard to RQ3. AI is now a part of some employment requirements rather than just an abstract idea. The industry is moving away from “human processing” and toward “human-machine collaboration” and even “algorithm-driven” operations, as seen by explicit needs for key AI technologies like computer vision (32), natural language processing (34), and PyTorch (28), as well as TensorFlow (24). Despite the rapid advancement of AI technologies, the industry is currently in a transitional phase where traditional and AI technologies coexist, as evidenced by the fact that the overall demand for general technologies is still 3.6 times that of AI technologies. Machine translation post-editing (MTPE) models are replacing traditional, repetitive language tasks (e.g., basic translation), refocusing value creation on advanced capabilities such as mastering AI tools, managing complex contexts, and engaging in creative expression and strategic decision-making. In the AI era, foreign language professionals must therefore develop into “new-type specialists” who understand technical logic, make use of technological tools, and work well with technology.

6.4. For RQ4 (Training program innovation)

With respect to RQ4, this study unequivocally shows a substantial discrepancy between the results of contemporary foreign language instruction and the multifaceted needs of the market. Traditional curriculum focusing on language and literature is insufficient for developing the composite talent with “language + technology + industry” knowledge that the market urgently requires. To bridge this gap, a novel training program for the AI era must combine the following fundamental elements.

6.4.1. Curriculum restructuring

Implement a “Foreign Language + X + AI” curriculum reform, where “X” refers to a specific professional domain (e.g., smart manufacturing, international commerce, digital media) and “AI” refers to overall technical literacy. Curriculum should include interdisciplinary modules such as “Computational Linguistics”, “Localization Project Management”, and “Cross-cultural Data Analysis.” Differentiated technical learning paths should be established for distinct job trajectories. AI developers should focus on Python, deep learning, and domain applications (CV/NLP), while systems engineers should prioritize C++, Java, and database systems.

6.4.2. Teaching model transformation

Switch from knowledge transmission to constructivist-driven experiential learning. Encourage project-based learning (PBL), which involves students in real-world corporate scenarios and employs AI tools to tackle multilingual and multicultural problems, encouraging critical thinking, cooperation, and creativity abilities.

6.4.3. Evaluation system expansion

In order to match their competency credentials with market signals, encourage students to earn “1+X” certificates, which stand for “language proficiency certificates + industry/technical qualifications” (CATTI + Python programming certificate or international trade practitioner certificate, for example).

In order to develop faculty and ecosystem, it is recommended to enhance industry-academia cooperation, bring in industry mentors, co-create courses and real-world platforms, make sure that the learning materials are current and relevant, and create an ecosystem for iterative talent development.

6.4.4. Recruitment strategy adjustment

Corporate recruiting tactics should be adjusted in response to technology demand differences. AI positions should clearly distinguish between theoretical research and engineering implementation requirements, whereas fundamental development roles should prioritize coordinated assessment of C++/Java abilities. Due to the 41% demand for English+German in mechanical engineering, educational institutions should include German elective courses in mechanical engineering programs; job seekers should learn English+Japanese combinations, which cover 85% of technical positions; and healthcare organizations should give priority to French proficiency (27% demand in this sector).

The development of foreign language human resources in the age of artificial intelligence necessitates a fundamental shift from theory to practice. This shift aims to train creative international professionals with access to technology, entrepreneurial skills, and effective communication, meeting the strategic needs of the Guangdong-Hong Kong-Macao Greater Bay Area for highly linguistically skilled labor as well as the global economy for top-tier language service talent.

7. Conclusion

This research deciphers a fundamental paradigm shift in competency requirements within Guangdong’s foreign language job market. The core of this transformation lies in the shift from a narrow emphasis on purely linguistic competencies toward an integrated model that values the synergy of language proficiency, domain-specific knowledge, and technical literacy. The authors argue that this balance is largely due to advances in artificial intelligence, which pose major challenges for higher education and industry.

An analysis of employment characteristics (RQ1) shows that the market is closely related to the regional economic strategies. The obvious concentration of opportunities in the fields of mechanical engineering and programming, coupled with a decline in demand from sectors such as healthcare, shows that regional industrial policy has a major impact on labor dynamics. In addition, the overwhelming preference for full-time work and the observed salary scale also reflect the market value for the stable and multidimensional skills of technical and language professionals.

In terms of competency frameworks (RQ2), language abilities still play an important role, but now they act as a foundation for building more important competencies. The dominance of English persists, yet the elevated requirements for bilingual capabilities in languages such as Arabic and Portuguese underscore the growing importance of communicative versatility. In addition to language, technical capabilities, including programming, artificial intelligence applications, and data management, have become important decisive factors for competitiveness. Similarly, industry knowledge and soft skills such as communication and cross-cultural coordination carry considerable weight in employer requests.

The disruptive impact of artificial intelligence (RQ3) on language-related professions is particularly noteworthy. The findings suggest that the current situation is in a transitional phase, with the potential for traditional technology to continue to link to emerging artificial intelligence tools. This signals an imperative for future language professionals not only to adeptly utilize AI technologies but also to solve problems in a creative way, and their expertise in other areas remains an important factor in the field of senior decision-making.

In response to these changes (RQ4), it is argued that current training paradigms for foreign language talents require comprehensive reform. The courses should be reorganized within the framework of “Foreign Language + X + AI”, emphasizing interdisciplinary integration and technology sensitivity. Instructional methodologies require a fundamental shift from information dissemination to project-based, context-rich experiential models that cultivate innovative thinking and teamwork capabilities. To guarantee ongoing congruence between educational outputs and changing market demands, institutional structures like industry-academia partnerships and the “1+X” accreditation system should also be reinforced.

To sum up, schools, businesses, and legislators must work together to create a future-focused system for developing transdisciplinary language skills in order to meet the difficulties of the AI era. A program like this will help the Guangdong-Hong Kong-Macao Greater Bay Area grow strategically and improve China’s ability to compete successfully in the global digital economy.

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Authors' contributions

Ling Liang conceived the idea of the study, analyzed the data, and wrote the paper. Jiayi Zhong co-authored the literature review and theoretical foundation. Hualing Huang revised the research design and conclusion. Siyang Zhu and Xiang Zhao collected the data set.

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A Human-Machine Collaborative Prompt Model for Audio Description of Local Cultural Promotional Videos

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Abstract: This study explores the development of an automated audio description (AD) framework for local cultural promotional videos using a human-machine collaborative approach. The proposed framework integrates a multimodal large language model, Doubao, with human expertise to enhance AD production, particularly for videos featuring culturally rich content. By focusing on the example of the Fujian-based video “Where There Are Dreams, There Is Fu”, the study addresses two primary challenges in AD: cross-frame coherence and accurate cultural symbol interpretation. Through iterative human-machine collaboration, the model generates coherent, culturally grounded AD scripts that align with the cognitive patterns of visually impaired audiences. This research highlights the potential of GenAI-driven solutions in creating accessible content for public welfare organizations while maintaining cultural authenticity. The proposed framework offers a scalable, cost-effective approach to improving accessibility and promoting cultural heritage for visually impaired individuals.

Keywords: Audio description; Human-machine collaboration; Multimodal large language models; Cultural heritage

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1. Introduction

The growing demand for accessible media has intensified the need for visually impaired individuals to access information embedded in visual content, including videos, images, and short-form media. Audio description (AD) has consequently emerged as a critical medium for ensuring equitable access to cultural services. Audio description refers to a cultural service that translates key visual elements, such as environmental settings, character actions, facial expressions, and on-screen text, into auditory narratives for visually impaired audiences. This process facilitates comprehension of visual content, enabling equitable information access and cultural participation. Its primary function is to help blind and low-vision viewers auditorily perceive visual content, thereby enhancing their quality of life and promoting social inclusion. It has been found that audio description provides linguistically

formulated visual information that supports film comprehension for visually impaired audiences, noting that AD is more visual and capable of accurately describing on-screen content rather than merely relating pre-scripted narratives ^[1].

Current AD production faces dual challenges. For one thing, traditional manual production relies on professional collaboration, demonstrating low efficiency, high costs, and an inability to support large-scale accessibility conversion. For another, automated AD exploration primarily focuses on developing large language models specifically for AD generation, requiring substantial funding, time, and ongoing maintenance costs for model iteration, rendering this approach largely infeasible for most public service accessibility organizations. Moreover, automated AD struggles with maintaining scene coherence and character tracking, with particular difficulties in culturally symbolic interpretation, accurate translation, and cognitive adaptation for visually impaired audiences. Recent research has shown that multimodal large models are capable of integrating heterogeneous data from multiple sources, such as text, images, audio, and video, by leveraging cross-modal semantic understanding and knowledge association. This enables the construction of comprehensive and multidimensional cultural heritage knowledge bases, which contextualize previously fragmented cultural elements to support more coherent and enriched interpretation ^[2]. Moreover, intelligent cross-media content generation and integrated presentation can significantly enrich cultural heritage expressiveness.

This study focuses on integrating local cultural promotional videos with multimodal large language models (LLM), aiming to develop an automated AD generation framework based on human-machine collaboration that utilizes existing multimodal large language model products to produce accessible verbal descriptions aligned with visually impaired cognitive patterns.

2. Human-machine collaborative audio description framework

2.1. Operational principles of large language models

Large language models constitute a fundamental component of GenAI. Based on the Transformer architecture, they capture complex linguistic relationships within text through multi-layered structures that progressively learn textual features from basic syntax to deep semantics. The process involves pre-training on extensive text corpora to acquire fundamental language rules, followed by task-specific fine-tuning for practical application adaptation. It has been found that generative large language models, exemplified by ChatGPT, demonstrate exceptional capabilities in natural language understanding, intent recognition, reasoning, contextual modeling, language generation, and general problem-solving ^[3]. These strengths, attributable to their massive parameter size and deep network structures, position such models as significant pathways toward artificial general intelligence.

Natural language processing advancements provide a foundation for human-machine collaboration in AD. For instance, in human-machine collaborative automated advertising, multimodal large language models are employed to automatically generate initial ad drafts by leveraging their capabilities in natural language generation and video-language semantic matching. This process involves intelligent analysis of video scenes and emotional tones, followed by professional linguistic refinement and narrative optimization performed by human experts. The drafts are further perfected through multi-dimensional validation tools to enhance the overall expressiveness and quality of the advertisement. Previous research has argued that although system-generated scripts require human modification, they provide valuable references for professional narrators, enhancing AD production efficiency ^[4]. This indicates that machines can efficiently bridge visual-textual associations and generate standardized drafts,

thereby forming efficient complementarity and collaborative cooperation with humans in enhancing AD script creation efficiency and quality.

2.2. Challenges in manual AD production and LLM limitations

Manual AD production requires frame-by-frame video analysis, scriptwriting, and voice recording, leading to limited efficiency, extended production cycles, high reliance on specialized professionals, and significant labor costs. Moreover, variations in cognitive and expressive styles among different creators often result in inconsistent interpretations of cultural symbols and linguistic representations when describing the same video content. Such inconsistencies may adversely affect the experience of visually impaired audiences. Furthermore, due to constraints in time and human resources, it remains challenging to develop customized AD content tailored to the diverse cognitive needs of different visually impaired groups.

Conversely, large language models face challenges in accurately interpreting implicit cultural symbols and in capturing nuanced emotional expressions. These limitations often lead to a loss of the humanistic essence within the content. They may also misjudge character relationships or overlook subtle contextual details. Furthermore, current large language models lack the capacity to actively perceive feedback from visually impaired audiences, adapt flexibly in linguistic style, or provide personalized adaptations. It is argued that although technological advances, including machine translation and speech recognition, have enhanced operational efficiency, the integration of multimodal information and cultural adaptation remains dependent on human input ^[5]. Effective resolution of these issues thus requires collaborative efforts between translators and technology developers to explore integrative solutions. In addition, traditional audio description (AD) production requires substantial professional human resources, while existing automated methods necessitate extensive training to effectively integrate multimodal inputs and adapt output styles ^[6].

2.3. Key research questions

Significant limitations remain in automated AD for local cultural promotional videos. First, a lack of cross-frame coherence undermines entity tracking. Automated systems often produce fragmented descriptions with weak continuity across segments ^[7]. Second, cultural symbol interpretation is insufficient. While large language models can detect visual elements such as the Fu (福) character, they often overlook context-dependent meanings, stylistic variations, and the cultural specificity embedded in regional practices.

These shortcomings underscore the necessity of designing human-machine collaborative frameworks that can generate coherent, character-aware, and culturally nuanced AD scripts. Local cultural promotional videos, particularly those highlighting the Fu culture of Fujian province, present a distinctive challenge because they combine dynamic visual storytelling with layered cultural symbolism. Without effective cross-frame tracking and symbol interpretation, the resulting AD risks fragmenting narrative logic and weakening cultural heritage transmission.

Accordingly, this study focuses on two central research questions:

How can human-machine collaboration improve cross-frame coherence in AD scripts, particularly in maintaining character continuity and narrative integrity?

In what ways can human-machine collaborative prompting enhance the interpretation of culturally significant symbols, such as the red Fu character, beyond surface-level recognition?

By addressing these questions, the study aims to contribute a framework that leverages the efficiency of

multimodal AI while incorporating human expertise to achieve accessible and culturally grounded AD for local promotional videos.

3. Research methodology

3.1. Criteria for video selection

The video titled “Where There Are Dreams, There Is Fu”, produced in 2017 by Haixia Television under the Fujian Radio and Television Group, was chosen based on two principal considerations. First, its high production quality and meticulously composed visual frames supply ample material for interpretation, offering perceptible and analyzable information for visually impaired audiences. Second, the video thoroughly embodies distinctive elements of Fujian culture, vividly portraying local traditions and everyday atmosphere, which supports an immersive cultural experience through auditory means.

3.2. Procedure of human-machine collaboration

This study employs the large language model of Doubao, selected for its free accessibility and multimodal capabilities suitable for audio description tasks. The procedure comprised two phases. The first phase focused on human-machine collaboration, including video selection, key frame identification, and cultural symbol queries to support machine recognition and interpretation. Key frames were then processed for frame-by-frame description, followed by machine extraction of cross-frame elements, such as characters, scenes, and narrative logic, leading to preliminary AD script generation through draft prompt input. The second phase is interactive validation. LLM-generated scripts were reviewed by experts and visually impaired participants, with draft prompts refined accordingly. Revised prompts were subsequently used by the large language model to regenerate AD scripts through iterative optimization cycles.

3.3. Preliminary question design

Key frames were extracted from a 36–54 second segment at 2-second intervals because this segment contains continuous plotlines for character tracking and key cultural elements of Fu, with 2-second intervals ensuring plot coherence. Preliminary questions targeted cultural symbols (e.g., red Fu character) are designed to establish cultural background understanding for subsequent accurate interpretation. For example, questions may include: What are the cultural connotations of the Fu character? What symbolic meaning is conveyed by presenting the Fu character to individuals upon departure?

4. Data analysis

4.1. Overview of key frames

Figure 1 shows key frames of 36–54 seconds. These segments require coherent tracking of the same man across four frames and the continuous event of “coloring the Fu character” followed by “delivering the Fu character.” Specifically, 36–40 seconds depict the man coloring a red Fu character at a table, while 41–46 seconds show the same man presenting the Fu character at a dock. The 46–48 seconds show the sea under the sunlight, with the waves gently shimmering. Subsequently, during 48–54 seconds, the frame first presents a window with colorful railings adorned with a vivid red Fu character, followed by a wall of a traditional white-wall-and-black-tile building featuring a red Fu character. Associating character features across these appearances was essential to

maintain the integrity of the event chain. A primary challenge, however, was the LLM Doubao's initial failure to track the same man across frames through cross-frame recognition, resulting in narrative discontinuity.



Figure 1. Key frames from “Where There Are Dreams, There Is Fu”; The video of “Where There Are Dreams, There Is Fu” was published on August 26, 2017, accessed on August 15, 2025, <https://m.news.cntv.cn/2017/08/26/VIDEm9BGRleRKCHYpeuo7FOR170826.shtml>

The red Fu character further illustrates the difficulty of cultural interpretation. For Chinese audiences, red symbolizes auspiciousness and festivity, while Fu denotes life blessings. Beyond general well-wishing, it reflects the heritage of local Fu culture and embodies familial concerns, as exemplified in practices of gifting Fu. However, the LLM Doubao remained limited to surface-level visual recognition, lacking the capacity to interpret contextual meanings of blessings or familial concerns, and unable to differentiate the unique symbolic values embedded in localized Fu character styles.

4.2. Draft prompt analyses

The initial draft prompt instructed: You are a professional video and audio description expert. Your task is to write accurate audio descriptions for the provided video clip, targeting visually impaired audiences. The workflow is as follows. First, context review: recall preliminary questions. Second, video review: examine images in chronological order. Third, description: detail each frame's content while noting continuous events across frames. Fourth, summary: use frame descriptions and visual cues from 10 images to generate a sequential audio description script.

Testing revealed two main limitations. First, inadequate cross-frame coherence impeded entity tracking, as the system failed to associate the man coloring a Fu character with the same man delivering it at the dock, disrupting the continuity of the “coloring Fu to dock delivery” sequence. This weakness in temporal coherence directly undermines narrative integrity and diminishes the audience's ability to follow character-centered events. Second, the interpretation of cultural symbols was superficial, confined to visual recognition without regional grounding. For example, the system identified a “red object” but failed to connect it to the cultural significance of red in Chinese traditions or to the heritage of Fujian Fu culture. The inability to capture these layered meanings limits cultural expressiveness and risks reducing complex heritage symbols to simplistic visual markers, thereby weakening the communicative and inclusive function of AD for visually impaired audiences.

4.3. Revised prompt analyses

The revised prompt specified: You are a professional video and audio description expert. Your task is to write accurate audio descriptions for the provided video clip, targeting visually impaired audiences. The workflow is as follows. First, context review: recall preliminary questions for cultural understanding. Second, video review:

examine images in 2-second intervals, identifying persons by appearance. Third, description: detail frame-by-frame occurrences while noting persistent events. Fourth, summary: integrate cultural background and visual cues from 10 images to generate a 16-second description within 48 words (40–54 second segment). Output format: xx-xx seconds (X characters), textual description.

Optimizations included standardized output with time and word count labels, explicit word limits, appearance-based character identification, and omission of the first 4 seconds with firecracker sounds. These adjustments improved the performance of the LLM Doubao by enabling consistent identification of the same man across four frames, presenting the full “coloring to delivering” sequence, and incorporating culturally grounded interpretations of the Fu character as symbolizing auspiciousness, celebration, blessings, and familial concerns. The outputs aligned more closely with the cognitive habits of visually impaired audiences, ensuring both informational accuracy and cultural nuance. Moreover, the revised prompt design demonstrated the feasibility of combining machine efficiency with human cultural guidance, showing that prompt engineering can directly enhance the interpretive depth and narrative coherence of AD. This not only contributes to methodological innovation in accessibility research but also provides a scalable solution for producing culturally sensitive AD across different types of visual media.

5. A human-machine prompt model for audio description

Based on the discussions, we propose a human-machine collaborative prompt model. The model integrates human expertise with the large language model to enhance both the coherence and cultural accuracy of audio description scripts.

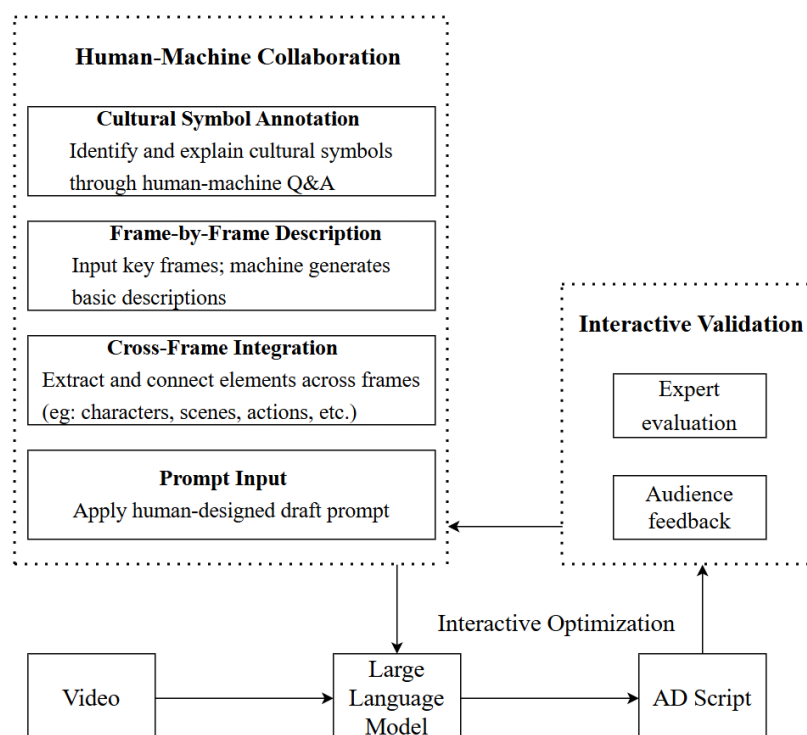


Figure 2. A human-machine collaborative prompt model

Figure 2 presents a Human-Machine Prompt Model integrating implementation steps and prompt optimization logic to visualize human-machine collaborative AD script generation through prompt-language model interaction. The flowchart illustrates LLM-based AD script generation through human-AI collaboration and iterative validation. Using video as source material, human-AI collaboration extracts core elements for LLM queries to enable cultural symbol recognition and interpretation, followed by frame-by-frame description, cross-frame element integration, and draft prompt input for AD script generation. Generated scripts are refined through expert and audience feedback, continuously optimizing prompts and collaboration until final validation.

Results demonstrate that this collaborative solution addresses two core deficiencies of multimodal AI in local cultural promotional video AD: inadequate character tracking and limited cultural symbol interpretation. In response to the first research question, human-machine collaboration improves cross-frame coherence by ensuring entity continuity, for example, linking the man painting a Fu character with the same man later delivering it at the dock, thereby maintaining narrative integrity. In response to the second research question, human-machine collaborative prompting enhances cultural symbol interpretation by guiding the system to connect surface visual recognition of the red Fu character with its deeper connotations of auspiciousness, blessings, and local cultural heritage. Personalized prompting compensates by enabling cross-frame entity association (e.g., identifying the man painting and delivering Fu as the same person) and targeted cultural questioning (e.g., exploring the connotations of Fu) that incorporate meanings beyond surface recognition.

The model has two key features. First, it leverages existing machine learning tools and datasets to analyze footage and automatically identify key visual elements, establishing a foundation for narrative transformation. Second, it allows flexible adjustment of outputs through dialogic collaboration, aligning descriptions with the cognitive habits of visually impaired audiences while embedding cultural specificity. Unlike conventional large-model pre-training, this approach provides adaptive, user-centered interaction and cultural sensitivity. The framework employs existing LLM via draft prompt queries and iterative human optimization to produce qualified AD scripts, finalized through expert integration. It offers an efficient, cost-effective solution, particularly suitable for public welfare organizations seeking accessible conversion of cultural videos. Nonetheless, it requires human scaffolding. Individuals must recognize cultural symbols to pose effective questions, while obscure local symbols remain challenging. To enhance adaptability, simple feedback mechanisms could be incorporated, involving visually impaired users as evaluators of coherence, cultural clarity, and character tracking. Feedback on identity confusion or insufficient cultural interpretation would trigger targeted prompt adjustments, continuously improving alignment with user needs. As recent research argues, human-machine collaborative creation positions humans at the ideological core, such as value construction and experiential integration, while machines contribute to expressive functions, such as symbol design and narrative structuring, achieving synergy through a division of labor between human creativity and machine scalability^[8].

6. Conclusion

This study developed a model of human-machine collaboration combined with an existing multimodal LLM to provide an automated AD solution for local cultural promotional videos. Using the video case of “Where There Are Dreams, There Is Fu”, the model demonstrated its capacity to generate AD scripts that achieve character tracking and cultural interpretation while aligning with the cognitive habits of visually impaired audiences. The approach requires neither high financial investment nor advanced technical infrastructure, thus enabling public

welfare organizations to produce AD for local cultural promotional videos efficiently and at low cost. In doing so, it supports visually impaired communities in accessing cultural representations of their hometowns, thereby fostering belonging and cultural pride. Moreover, the framework offers a reference for extending accessibility transformation to other video genres such as documentaries and short videos. Future research could incorporate broader feedback from visually impaired individuals across regions and with diverse cognitive profiles to further enhance the adaptability of the scripts.

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Disclosure statement

The authors declare no conflict of interest.

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Dialectical Narrative and Ideological Critique in Terry Eagleton's *Disappearances*

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Abstract: Terry Eagleton's *Disappearances* represents a significant innovation in modern dramatic narration. By structuring its narrative around a dialectical (thesis-antithesis-synthesis) framework infused with ideology, the play creates a subversive movement between surface and deep narrative layers. Through this narrative practice, Eagleton not only enriches theatrical form by opening a nuanced space for ideological discourse but also offers a profound Western Marxist critique of the paths to individual emancipation.

Keywords: Dialectical narrative; Ideology; Terry Eagleton; *Disappearances*

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1. Introduction

Terry Eagleton, a world-renowned Marxist theorist, is unique for his foray into playwriting, a practice that allows him to enact his theoretical concepts creatively. His play *Disappearances* is precisely such an enactment: a deliberate and sophisticated effort not merely to write about ideology, but to stage it, rendering its abstract processes visceral within the dramatic form. To achieve this, Eagleton employs a dialectical narrative structure—rooted in the Hegelian-Marxist model of thesis-antithesis-synthesis—as his primary dramatic mechanism, using it to generate a subversive interplay between the surface-level plot and a deeper ideological inquiry.

This paper argues that the dialectical narrative in Eagleton's work functions as a subversive engine, generating a critical collision between the surface plot and a deeper ideological subtext. Through this mechanism, Eagleton not only revitalizes theatrical form but also mounts a profound critique of the fraught and contradictory pursuit of individual emancipation. The analysis will proceed in three parts: first, by establishing a theoretical framework that defines the dialectic as a dynamic process of conflict and resolution, outlining its function as Eagleton's essential tool for dramatizing ideological struggle. Second, it will perform a close reading of the narrative architecture of his play to trace how this dialectical engine operates as its structural core, propelling the continuous motion between plot event and ideological inquiry. Finally, it will interpret the effects of this method, contending that the

dialectical form itself functions as the critique—one that exposes the complexities of self-liberation and implicates the audience in its unresolved tensions. Thus, this paper positions *Disappearances* as a seminal work wherein Eagleton's theoretical and creative projects seamlessly converge, proposing a new model for political playwriting.

2. The dialectic as a dramatic principle

The dialectical method, which Marx famously characterized in the afterword to the second German edition of *Capital* as a process where he “openly avowed myself the pupil of that mighty thinker (Hegel)” and “coquetted with the modes of expression peculiar to him” while inverting Hegel's idealism into a materialist framework, constitutes a model of development through immanent contradiction ^[1]. Inherited from Hegel and radicalized by Marx, the dialectic posits progress as an emergent property of conflict. A given state of affairs or concept (the thesis) inevitably generates its own negation (the antithesis). Their collision yields not a null result but a synthesis—a new, more complex formation that sublates (*aufheben*) its antecedents, simultaneously negating, preserving, and elevating their elements. This synthesis, inherently unstable, becomes a new thesis, perpetuating the cycle. This process functions not as a clean, teleological progression but as a continuous engine of development driven by internal contradiction, forming for Marxism the deep structure of historical and ideological materiality. This aligns with Fredric Jameson's description of dialectical thinking as “an intensification of the normal thought processes such that a renewal of light washes over the object of their exasperation” ^[2]. It is precisely this capacity for “intensification” and conceptual “renewal” that Terry Eagleton seeks to harness and dramatize.

For Eagleton, a theoretical commitment to the dialectic necessitates a corresponding aesthetic form—one capable of capturing ideology not as a static set of doctrines but as a lived, material process that functions to “denote the interests of specific social groups rather than, say, someone's insatiable hankering for haddock” ^[3]. Traditional realist narrative invests in linear causality, psychological consistency, and narrative closure. This very investment risks ratifying the ideological structures it might critique, as it naturalizes complex social relations. Consequently, the dialectic emerges not merely as an analytic tool but as the requisite dramatic principle for a genuinely Marxist dramaturgy. Inherently process-oriented, this form stages the very movement of ideological conflict. It is internally disruptive, structurally resisting its own propositions and foreclosing simplistic resolutions. This strategy is directly akin to Brecht's *Gestus*: a technique for creating “significant stage groupings” that functioned not as mere aesthetic effects but as the foundation for “a hugely conceived theatre for the new social order”. For Brecht, such techniques were impossible without a “deep understanding and passionate support of the new structure of human relations” ^[4]. Like *Gestus*, Eagleton's dialectical form is designed to disrupt audience complacency and expose the constructed nature of the social world. Ultimately, it is generative; its operational logic actively produces new understandings and contradictions.

Therefore, in *Disappearances*, Eagleton transcends the mere thematic application of dialectics to enact a full methodological synthesis. Here, the dialectic is not just a subject but the genetic code of the narrative itself. The play is engineered as a dramatic vessel that is both a product of and a performance in Marxist analysis. Its entire architecture—the collision of scenes, character development, and the sequencing of events—is meticulously calibrated to mimic the internal dynamics of ideological struggle. This strategic fusion of form and content ensures the audience experiences the contradictions of liberation not as abstract propositions, but as the visceral, unfolding logic of its plot. The following analysis will trace the mechanics of this dialectical engine, examining how its triadic rhythm of thesis, antithesis, and synthesis structures the narrative to generate ideological force.

3. The triadic structure of self-subversion

In *Disappearances*, Terry Eagleton operationalizes the Hegelian-Marxist dialectic, transforming it from an abstract philosophical concept into the very architecture of his narrative. He deploys the triadic model of thesis, antithesis, and synthesis not as a mere thematic backdrop but as the generative structural principle that orchestrates the protagonist's transformation. This narrative strategy ensures that the evolution of Kaman's consciousness—through recognition, reversal, and ultimate self-subversion—enacts the dialectical process itself, thereby performing the ideological critique central to Eagleton's project.

3.1. Thesis: the intellectual in exile

Kaman's initial position constitutes the dramatic thesis: that of the intellectual who has retreated from overt political action into the ostensibly apolitical sanctum of art. Eagleton immediately foregrounds the constitutive contradiction of this subjective stance in Kaman's inaugural conversation with Mann. This dialogue operates as a microcosm of his self-subversive logic, wherein his asserted principles inherently contain the seeds of their own negation.

Mann: So you still see your work as committed?

Kaman: ...Poetry is the taste of words on the tongue. That's a kind of politics.

Mann: So you see your art as trying to change things?

Kaman: Of course not. There is nothing more useless than poetry, except perhaps for the Pentagon. That's why it's so subversive.

Mann: I'm sorry, I don't get it

Kaman: Art exists for its own sake, and so should we—if only United Fruit would let us. It reminds us of a world where things might manage to rhyme—like us, for instance. (ActI:126) ^[5]

Kaman's exilic thesis is founded on a deliberate paradox. He asserts the absolute autonomy of poetry ("exists for its own sake") while simultaneously claiming that its very uselessness is the source of its "subversive" political power. This is not a logical failure but a defense mechanism, a coherent philosophical position within his exilic framework. For Kaman, poetry functions as a sanctified space of linguistic order and imaginative freedom, consciously juxtaposed against the material chaos and injustice represented by "the Pentagon" and "United Fruit." It is a refuge where the intellectual can preserve his identity against a hostile political reality. However, as Eagleton the theorist knows, this position is untenable. The moment Kaman claims his art is "a kind of politics" and "subversive", he re-politicizes the very autonomy he seeks to defend. His thesis is thus inherently unstable, already gesturing toward its antithesis.

This instability is further pressurized in his exchange with his former comrade Raan, who embodies the external antithesis against which Kaman defines himself.

Raan: We need you to speak out against Janda. When the right moment comes...

Kaman: Look Raan; there's one place left where we can still play a little, and it's called art. It's thin margin, but it's all we've got...My job is to redeem words from history, so we can still have a currency of sorts.

Raan: You know what real politics is about. Your were tortured back there.

Kaman: Torture's like art--it's a world apart. Its rules don't relate to this one. (ActI:139) ^[5]

This exchange is a critical defense of his thesis, built on three key pillars that reveal its profound fragility:

Firstly, Kaman frames art as a sanctified space, a realm of “play” explicitly opposed to the instrumental “work” of politics. His description of this space as a “thin margin” is crucial, for it implicitly acknowledges the overwhelming pressure of the very world it seeks to exclude, revealing the fragility of his refuge from the outset.

Secondly, he elevates this retreat into a project of aesthetic redemption, casting himself as a “linguistic savior”. His mission to redeem words “from the wreckage” of history is not merely aesthetic but ethical, an attempt to preserve a pure “currency” of meaning. Yet, this very objective undermines his thesis, as the need for redemption admits that language is already politically contaminated and thus can never be truly autonomous.

Finally, and most radically, Kaman makes his ultimate defense: a metaphysical rejection of the political itself. In a desperate act of intellectual compartmentalization, he equates torture and art as equivalent transcendent realms (“a world apart”). This equation attempts to neutralize his trauma and invalidate Raan’s argument by placing both experiences beyond mundane political logic. However, this strategy proves to be the profound undoing of his thesis. Rather than successfully segregating the spheres, this explosive analogy forges a volatile, untenable bond between them, creating the very conceptual linkage that the narrative will exploit to force his eventual confrontation with the political reality he denies.

Kaman’s conflict exemplifies the central paradox of the post-Kantian aesthetic: his retreat into disinterest is a Kantian strategy to create a purified cultural sphere, “partially separating culture from the terrain of political institutions”^[6]. Yet, Eagleton employs a fundamentally Hegelian dramatic structure to dismantle this separation. The narrative forcibly collides Kaman’s abstract aesthetic principles with the material politics he escapes, transforming his internal contradiction—that disinterested art is subversive—from a personal flaw into the philosophical crisis that propels him toward the necessary antithesis.

3.2. Antithesis: The immanent critique

The antithesis to Kaman’s exilic thesis emerges not as an external assault, but as an immanent critique—a negation generated from the internal contradictions of his own beliefs, manifesting through his unintended political consequences. This critique is embodied not by the intellectual Raan, but by his servant, Salah, whose simple act of recitation delivers a more powerful refutation than any debate could.

Salah: (Moving forward) You have words, sir. You great man, Mr Kaman. You put music in our mouths. You take words and make them dance. You give us words to be free, We know your words, we sing them. (Begins to recite.).....

Kaman: You learn that?

Salah: I learn back home, sir. You write poems of freedom. My family, we sing them together.

Kaman:(After a pause)Well, maybe one day I’ll write like that again. Maybe I will, one day. (ActII:167)^[5].

Salah’s intervention operates as a profound immanent critique in three crucial ways, forcing Kaman to confront the failure of his own philosophy:

First, Salah materializes Kaman’s “useless” art. Kaman’s theory that poetry is subversive precisely because it is “useless” is shattered by the tangible reality of Salah’s experience. The poems were not preserved in an autonomous realm; they were memorized, sung, and integrated into the collective resistance of an oppressed community (“My family, we sing them together”). Kaman’s art has not been redeemed from history; it is actively

being used within history, transforming his aesthetic refuge into a tool of political solidarity.

Second, Salah reflects Kaman's repressed political self. He hails Kaman not as a detached aesthete but as "the great man" who writes "poems of freedom." This forces Kaman to confront the gap between his past identity as a committed poet and his present persona as an exile. The praise—"You put music in our mouths"—highlights the potent agency Kaman has abandoned, framing his retreat not as a philosophical stance but as a dereliction of a sacred, communal duty.

Third, and most significantly, Kaman's own response signals the success of the critique. His paused, hesitant concession—"Well, maybe one day I'll write like that again"—marks the first crack in his ideological armor. The repetition of "maybe" and "one day" reveals a consciousness grappling with its own fragmentation. This moment exemplifies what Bakhtin describes as the awakening of consciousness within "a world of alien discourses surrounding it" ^[7]. Kaman is no longer the sole author of his identity; Salah's discourse has invaded and destabilized it.

Therefore, Salah functions not as a debater but as the embodied antithesis. He does not argue; he performs the living contradiction of Kaman's thesis. This scene is the quiet, devastating moment where the walls of Kaman's exile crumble from within, proving that no art can truly be "a world apart." His project to "redeem words from history" is exposed as an attempt to purify language for a different kind of struggle—an ideological one. The fundamental dissonance between his theory of political language and his doctrine of aesthetic autonomy constitutes the site of his inner conflict, a dialectical tension that propels him toward a necessary synthesis.

Despite his professed doctrine of aesthetic disengagement, Kaman remains deeply entangled in the political sphere through his poetic practice. This contradiction is not merely observed but is performed through his work. His servant Salah's acknowledgment that he writes "poems of freedom" provides external testimony, but Kaman's own theoretical insight—that "language is how the oppressed conceal their thoughts from their masters"—reveals his acute awareness of language's inherent political utility. Consequently, his project to "redeem words from history" is exposed not as a flight from politics, but as an attempt to purify and weaponize language for a different kind of struggle—an ideological one. Thus, poetry becomes for him the ultimate subversive act: a means to confront chaos and injustice by mastering the very medium through which power and resistance are articulated. This fundamental dissonance—between the theorist of political language and the proponent of art-for-art's-sake—constitutes the primary site of his inner conflict, a dialectical tension that his consciousness cannot resolve.

3.3. Synthesis: Moral transformation

The culminating synthesis is achieved not through intellectual revelation but through a violent, personal collision that forces an ethical crisis. The threat to his daughter's safety acts as the material force that shatters the abstract conflict between Kaman's ideals, demanding a profound self-subversion. The thesis of the intellectual's fortress—his commitment to spiritual autonomy—collapses under the irreducible weight of paternal love. This internal cataclysm is encapsulated in his agonized monologue:

Well, what can you do?what's the point of trying to look after everyone else if you can't take care of your own? Come on, what are you asking me to do, ruin my own daughter?..... I may not be courageous but at least I'm consistent. Somewhat I'm trying to say-the point I'm trying to make -what it all comes down to is: immorality begins at home. (ActII: 166-167) ^[5].

This speech is the linguistic performance of Kaman's ideological self-subversion. Through a series of rhetorical reversals, he systematically dismantles his exiled identity.

First, he negates the universal for the particular. The Marxist principle of collective solidarity ("looking after everyone else") is subverted by the devastatingly personal question: "What's the point... if you can't take care of your own?" The abstract revolution is rendered meaningless against the concrete reality of familial duty.

Second, he redefines his core virtue as a vice. His prized "consistency" is recast as a cowardly refusal to engage with moral complexity. The declaration, "I may not be courageous but at least I'm consistent", is saturated with tragic irony, exposing his adherence to principle as a rigid, selfish attachment to an abstract ideal.

The climax of this subversion is the paradoxical inversion of a moral maxim: "immorality begins at home." Kaman argues that to betray his daughter for a political cause is the root of ethical failure. This is not selfishness but a radical redefinition of morality itself, prioritizing immediate, responsible care over distant ideological purity.

This monologue is the moment of *Aufhebung* (sublation), where Kaman's thesis (the intellectual in exile) and its antithesis (the call to political action) are simultaneously negated and preserved in a higher synthesis. His pure artistic autonomy is destroyed, just as his identity as a purely public political actor is relinquished. What is preserved—and elevated to a new, tragic plane—is his desire for a moral life. The resulting synthesis is paternal love reconfigured as the ultimate subversive political act—a conscious choice to embrace the "immorality" of collaboration to achieve the higher morality of protection.

This process of sublation is powerfully illuminated by M. Bakhtin's insight that "consciousness awakens to independent ideological life precisely in a world of alien discourses surrounding it"^[7]. Kaman's new consciousness is not born from solitary reflection but is decisively shaped by a collision with external "alien discourses": the primal call of parental love and the brutal reality of political threat. It is precisely his surrender to these forces—the negation of his ideological purity—that constitutes his awakening. Thus, the *Aufhebung* is achieved dialogically; Kaman's independent moral self is forged only through a transformative engagement with the very world he sought to exclude. This transformation exemplifies what Eagleton identifies as the foundation of true morality: "To meditate on one's mortality is to have an opportunity to become truly moral"^[8]. Faced with the potential mortality of his child, Kaman sacrifices his ideological purity, an act that is both a devastating loss and a moral ascent.

In conclusion, Eagleton's dialectical narrative uses Kaman's personal tragedy as a synecdoche for the collective struggle of a colonized people. The play demonstrates that grand historical narratives are inevitably experienced and negotiated within the intimate sphere of individual ethical consciousness, revealing the profound, often tragic, collisions between the personal and the political.

4. Ideological critique

In *Disappearances*, Eagleton's dialectical narrative structure functions not merely as a formal strategy but as a powerful mode of ideological critique, directly interrogating the material and discursive conditions of neocolonialism. The play itself constitutes what Lucien Goldmann terms a "significant structure"—a narrative form that encodes fundamental historical and social contradictions^[9]. By synthesizing the personal with the political, this structure renders visible the intertwined economic, juridical, and subjective dimensions of contemporary coloniality. In doing so, Eagleton's play performs the core task of ideological analysis that Fredric Jameson advocates: "the reinterpretation of a particular narrative trait... within its social, historical, or political context"^[10]. The play *Disappearances* undertakes precisely this reinterpretation, using its dramatic form to expose

how neocolonial power perpetuates itself through economic dependency, legal corruption, and the fragmentation of political subjectivity.

The play situates itself within what Fredric Jameson describes as the “global colonial network” of modernity, here manifested in the neocolonial entanglement of a West African nation with foreign capital ^[11]. Eagleton stages this reality through a dramatic narrative that explores the dialectic of resistance and complicity, particularly through the figure of Kaman. His trajectory embodies the materialist axiom that “The mode of production of material life conditions the general process of social, political and intellectual life” ^[12]. This materialist critique is rendered with acute clarity in his dialogue with Raan:

Kaman: So you oust Janda. Then what? Expropriate foreign capital?

Raan: ...We can't survive outside the world market.

Kaman: You can't survive inside it either. So what changes? The new President wears a collar and tie rather than looking like something out of Star Wars?

Raan: We see off a gang of thugs who bleed the people dry.

Kaman: And substitute a bunch of Cambridge graduates who'll bleed them white...

Raan: We've got to start from where we are. We're talking about 78 per cent illiteracy, Kaman. We're talking about three-quarters of a million people living in quarries...

Kaman: You can't skin a tiger claw by claw... what about the debt, for God's sake?... They'll stuff you with military bases..... (Act I: 137-138) ^[5].

This exchange distills the core paradox of neocolonial sovereignty: political independence remains circumscribed by economic subjugation. Raan's revolutionary agenda is pre-emptively contained by what Kaman identifies as the inescapable logic of capital—the material realities of “illiteracy”, “the debt”, and “the IMF.” Eagleton demonstrates that the “world market” is not a neutral arena but the fundamental determinant of the political superstructure, ensuring that even revolutionary regime change merely reproduces dependency. Kaman's cynical conclusion—that the difference is cosmetic, “a collar and tie” instead of a “Star Wars” costume—reveals a tragic insight: under neocolonialism, political transformations are often superficial, masking the continuous economic extraction orchestrated by global capital.

Eagleton further reveals how economic control corrupts the legal and social order. The involvement of the CIA and “major American finance corporations” in drug trafficking illustrates the collapse of juridical integrity under external manipulation:

Raan: [Janda is] a dab hand in drug trafficking, with a spot of support from the Company.

Richard: What company?

Raan: The CIA. ...

Kaman: My dear Richard, where have you been hiding? So are some of the big American finance corporations. (Act II: 147) ^[5].

Here, Eagleton demonstrates that law is not suspended but instrumentalized by power. The “Company” signifies the convergence of state and corporate interests in perpetuating illegality as a mode of control. The Janda government's symbiosis with foreign entities exemplifies what happens when political agency is hollowed out: the

state becomes a puppet, enforcing disorder rather than order.

Within this suffocating matrix, characters struggle to retain discursive and ethical agency. As Bakhtin argues, “an independent, responsible and active discourse is the fundamental indicator of an ethical, legal and political human being”^[7]. Yet in *Disappearances*, even dialogue is contaminated. Kaman’s withdrawal into poetry represents an attempt to preserve a space of linguistic and moral autonomy, but his ultimate compromise—collaborating with British authorities to save his daughter—signals the impossibility of purity under neocolonial conditions. He becomes what Eagleton, elsewhere analyzing the scapegoat, describes as a figure who “incarnates dirt, deformity, madness and criminality”, simultaneously “shunned and regarded with respectful awe”^[13]. Kaman is both a critic and a product of the system he condemns.

Through these layered engagements, *Disappearances* offers a broader critique of neocolonial subjectivity. The play illustrates how economic predation manufactures political powerlessness, which in turn distorts social relations and fractures individual conscience. Crucially, Eagleton does not resolve these contradictions but holds them in a sustained dialectical tension, using the very structure of the play as his primary medium of ideological revelation. In doing so, he affirms Goldmann’s belief that significant aesthetic forms can render visible the deepest structures of social life—and implicates the audience by challenging them to recognize their own role within the global networks of power the play critiques.

In conclusion, Terry Eagleton’s *Disappearances* stands as a seminal work of political theatre by making its innovative form its most profound ideological statement. The masterstroke of this play is its synthesis of dramatic narrative with a rigorous Hegelian-Marxist dialectic; Eagleton does not merely narrate a story of neocolonialism but stages its very logic. The triadic structure of thesis, antithesis, and synthesis functions as the narrative engine, driving a relentless critique that generates complex perspectives and refuses simplistic resolutions. This formal strategy seamlessly bridges the surface-level drama of individual choice with the deep structure of ideological inquiry, organically fusing Kaman’s personal tragedy with the collective predicament of his nation. Ultimately, *Disappearances* offers a searing examination of universal modern dilemmas—from economic exploitation and compromised political agency to the spiritual costs of survival—radically redefining the capacity of dramatic form to interrogate the most pressing material and ethical contradictions of the contemporary era.

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Enlightenment of Excellent Chinese Traditional Culture Based on Confucianism, Buddhism, and Taoism on the Development of Modern and Contemporary Hypnosis Techniques

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Abstract: *Objective:* To explore the enlightenment of excellent Chinese traditional culture based on Confucianism, Buddhism, and Taoism on the development of modern and contemporary hypnosis techniques. *Methods:* Using literature review and theoretical analysis, the relationship between the core content of Confucianism, Buddhism, Taoism, and modern and contemporary hypnosis techniques was systematically sorted out. *Results:* The Confucian thoughts of benevolence and the golden mean, the Buddhist wisdom of emptiness and Zen metaphor, and the Taoist naturalness and purity bring deep inspiration to the reconstruction of modern and contemporary hypnosis relationships, technical improvement, understanding of essence, and healing influence. While improving the development of Western scientific hypnosis techniques, including the difficulty of integrating hypnosis theories, it further promotes the construction of a Chinese hypnosis technique system that emphasizes integrity and harmonious balance. *Conclusion:* The excellent Chinese traditional culture based on Confucianism, Buddhism, and Taoism brings profound theoretical guidance and effective practical guidance to the development of modern and contemporary hypnosis techniques.

Keywords: Traditional culture; Hypnosis; Review

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1. Introduction

Chinese hypnosis, with a long history, is an indispensable part of world hypnosis research. Historically, hypnotic practices can be traced back to ancient China, and the “Zhuyou technique” during the Shang and Zhou dynasties is considered the earliest form of Chinese hypnosis with evidence available ^[1]. In terms of content, excellent traditional Chinese culture, dominated by Confucianism, Buddhism, and Taoism, contains abundant hypnotic ideas, concepts, theories, and techniques (collectively referred to as hypnotic methods). By the end of the Qing

Dynasty and the beginning of the Republic of China, individuals such as Tao Chengzhang, Yu Pingke, and Bao Fangzhou, based on excellent traditional Chinese culture, pushed the development of Chinese hypnosis to a historical peak^[2]. However, just as research on Chinese hypnosis was becoming more refined, the hypnotic theory that had developed in the West for over 500 years encountered an insoluble contradiction: “There is an endless debate between statisticians who emphasize altered states of consciousness under hypnosis and non-statisticians who hold the opposite view, and consensus on the question of ‘what is hypnosis’ remains elusive”^[3]. Nevertheless, when researchers break free from conventional thinking and reconsider this contradiction through the lens of excellent traditional Chinese culture, particularly the inclusive wisdom of harmony, they discover a solution: The Confucian doctrine of the mean suggests that researchers should avoid a binary opposition of “either this or that” — statism and non-statism may not be mutually exclusive within the framework of traditional Chinese culture: Buddhist wisdom of emptiness encourages researchers not to fixate on states — “both can be seen as deep communication or influence characterized by trance”: while Taoist governance by non-action indicates that healing can occur even without defining or naming hypnosis - natural law gives birth to vitality^[3-4].

2. Confucianism

2.1. Reconstructing hypnotic relationships through the idea of benevolence

As the core value of Confucianism, the idea of benevolence emphasizes loving others as oneself and extending oneself to others^[5]. Confucius often answered his disciples’ doubts with a gentle and patient attitude, while Mencius said, “Respect my elders and extend this respect to the elders of others: love my children and extend this love to the children of others.” This not only profoundly influences social ethical concepts but also provides strong support for the reconstruction of hypnotic relationships in modern and contemporary times. According to traditional Western views on hypnosis, hypnosis occurs primarily based on the hypnotist “controlling” or “dominating” the hypnotized individual^[6]. However, the idea of benevolence, based on deep compassion and respect, brings a new understanding: simple “control” and “being controlled”, “domination”, and “being dominated” no longer align with contemporary values and aesthetics. Instead, hypnosis shifts from a one-way “control” or “domination” to an equal two-way dialogue, and communication transforms from verbal instructions to negotiated co-construction. Similarly, psychologist Abraham Maslow’s humanistic theory advocates that therapists should unconditionally focus on clients, fully stimulate their potential, and help them realize their values. However, compared to the idea of benevolence, which aims to construct a harmonious life order through the dual interaction of internal and external environments and shape an ideal moral realm of “universal benevolence”, providing a new source of value for achieving individual and social perfection and happiness, the latter obviously emphasizes both ethical guidance and the cultivation of social responsibility, with a broader horizon and deeper foundation^[7]. The hypnotic relationship derived from this, with a strong humanistic care, will also surpass the contractual connection under the traditional treatment model. In other words, the new relationship shaped based on the empathy of hypnotic participants will be smoother and last in emotional resonance and spiritual connection. Facts have also proven that when the empathy of hypnotic participants is awakened, hypnosis becomes more effective, and healing is more powerful^[8].

2.2. The doctrine of the mean balances the scale of hypnotherapy

The Doctrine of the Mean is a Confucian classic on how to conduct oneself in life. It “embodies the practical

wisdom of ‘adapting to changing times’ and reflects the careful consideration, weighing, and grasp of the universe’s order and proper behavior by the ancestors of the Chinese nation... Only by acting differently according to the times and taking action at the right time can one achieve the best practical results”^[5]. This provides inspiration for the scale of hypnotherapy. In the context of hypnosis, traditional Western viewpoints suggest that deeper levels of hypnosis lead to better therapeutic effects^[9]. However, this contradicts the Doctrine of the Mean. The Doctrine of the Mean emphasizes handling issues just right, meaning that deeper hypnosis is not necessarily better, as too much can be as bad as too little. In fact, when a person enters a too-deep hypnotic state, they may not be able to better recall relevant details, and the therapeutic effect may not be ideal, sometimes even counterproductive. Similarly, if the depth is not enough, the effect is often difficult to manifest^[10]. The Doctrine of the Mean also suggests that the intensity of hypnosis should be moderate — it is necessary to provide a moderately intense therapeutic strategy based on the severity of symptoms while avoiding secondary trauma and over-defense caused by excessive exploration; and the therapeutic impact should be sustainable — proposing unbiased countermeasures based on the individualized and diverse issues of different clients, and allowing them to maintain good psychological resilience and corrective inertia after leaving the hypnosis room. In this regard, Western psychotherapy systems also value the art of “balance.” Systematic desensitization is a therapy that grasps the “balance” well. It is worth noting that the Doctrine of the Mean brings not just a technique or speculative guidance to hypnotherapy, but more of a systematic wisdom of balance.

3. Buddhist interpretation

3.1. Insight into the true nature of hypnosis through the wisdom of emptiness

“Emptiness” is a fundamental concept and core category of Buddhist philosophy, and it is also the highest category of Buddhist doctrine^[11]. The wisdom of emptiness emphasizes that all things arise from causes and conditions and cease to exist when these causes and conditions dissipate, and there is no fixed and unchanging entity. Although different sects within Buddhism have different views on this, the non-attachment to emptiness is commonly recognized by them. So, does hypnosis have an entity? Is it an attachment to use the wisdom of emptiness to gain insight into the true nature of hypnosis? For the former, hypnosis, as a phenomenon, seems to have an “entity” in form, but its understanding as an “entity” of communication or influence is relative and changeable, belonging to “emptiness.” Conversely, hypnosis is also “emptiness.” For the latter, it is worthwhile as long as we do not obsess over the form itself, but seek to understand the impermanence and egolessness of things by pursuing answers. Next, how to pursue “emptiness”? In the “koan” teaching of Zen classics such as “Bi Yan Lu” and “Wu Men Guan”, Zen masters often guide their disciples to break through attachments and understand the true meaning (inspire insight) through a series of seemingly absurd questions and answers (activate confusion). This unique and profound perspective (confusion-insight) helps to transcend the surface of things and reach the true nature. Hypnotic guidance for cognitive and experiential reconstruction shares a similar approach. Under highly focused hypnotic guidance and state maintenance, external words or suggestions can penetrate deeply into the mind of the hypnotized person, triggering insights of varying degrees. The hypnotic confusion technique, originated by Erickson, has the effect of insight^[12–13]. This orientation and process, which emphasizes the reconstruction of individual experience, is often understood by Western researchers as constructivism. However, compared to constructivism, the wisdom of emptiness provides a broader perspective that emphasizes both construction and deconstruction. This helps to reveal the true nature behind the phenomenon of hypnosis: impermanence

and change — different contexts correspond to different hypnotic states, hypnotic roles often change due to uncertainty, and the object of hypnotic healing is not always the hypnotized person, etc. At the same time, the application of hypnosis from the perspective of emptiness is not limited to the field of life or healing, but rather, hypnosis is everywhere in life. Thus, the Buddhist concept of emptiness brings a deeper Chinese wisdom to hypnotic techniques and interactions.

3.2. Meditation metaphors enhance hypnosis techniques

The Zen meditation metaphor is an important practice method in Buddhism. Zen meditation emphasizes cultivating inner peace, awareness, and concentration through methods such as sitting meditation, breath control, and the simultaneous practice of “stopping and observing” (止 觀), thereby purifying the mind and enhancing self-control. This shares significant commonalities with the process of hypnosis, which guides individuals into a relaxed state, improves concentration, and adjusts physical and mental states. Similarly, mindfulness training also bears a high degree of resemblance. Studies have found that mindfulness training is effective in reducing negative emotions and improving sleep quality, and the treatment effect is even better when combined with hypnosis^[14-16]. Interestingly, mindfulness originates from Zen meditation^[17]. As a result, modern hypnosis research seems to have returned to the ancient exploration of meditation. In fact, this is not surprising, as more and more Western scholars view the essence of traditional Chinese culture, such as Tai Chi and Qigong, as “ancient wisdom” that can be used for reference in physical and mental healthcare^[18]. Of course, the enlightenment of meditation on the development of modern hypnosis techniques not only focuses on clear thinking and concentrated attention, but also emphasizes holistic physical and mental adjustment, and provides deep spiritual growth and wisdom, such as the concepts of “impermanence” and “no-self.” These can also provide new perspectives and solutions for dealing with phenomena such as resistance and post-hypnotic suggestion that may arise during the process of hypnosis. In terms of metaphor, Buddhist metaphors and hypnosis metaphors are highly similar. The former has existed since ancient times and is rich and profound, while the latter was pioneered by Erickson in the field of hypnosis and focuses on psychological treatment, especially the treatment of mental illness. Anyway, the countless meditation metaphors in Chinese history will continue to provide endless inspiration and motivation for the development of modern hypnosis techniques in terms of content and form.

4. Taoism

4.1. The natural way of Taoism lays a solid foundation for hypnosis

The natural way of Taoism, as the cornerstone of Taoist philosophy, emphasizes that all things follow natural laws and coexist harmoniously. Its inspiration for modern hypnosis techniques first lies in the concept of “letting nature take its course.” This is one of the core philosophies of hypnosis, highlighting the artistic expression of hypnosis and focusing on the timing, circumstances, and trends of its occurrence^[13]. For example, in hypnotherapy, when an individual’s conscious activity decreases and subconscious activity increases, the therapist should guide them to recognize problems and make changes naturally and non-coercively, based on the unique psychological needs of each client, rather than controlling the individual or the change. This is also one of the classic hypnosis techniques of Erickson, who was not understood by his contemporaries but was followed by later generations. In the treatment of Betty, Erickson profoundly and brilliantly demonstrated the thought and power of the natural way of Taoism: using natural laws to adjust the deviated mind and body of humans^[19]. In this regard, the Western Acceptance and

Commitment Therapy (ACT) is widely known. ACT encourages people to accept facts or feelings that cannot be changed while focusing their attention on controllable aspects and achieving personal values through positive action. Secondly, the natural way of Taoism brings ecological factors to hypnosis techniques. The “nature” in the natural way of Taoism refers to the domain opened up by Tao, heaven, earth, and humans, which connects them ^[20]. This suggests that hypnosis does not only occur between humans but also between humans and objects, animals, environments, cultures, etc. This brings a non-traditional rebirth to traditional hypnosis, which previously lacked an “ecological soul.” This is also the focus of the first author of this article: based on the previous definition of “hypnosis as a deep communication characterized by trance, further proposing “hypnosis as a deep influence characterized by trance” ^[3-4]. The third principle is “governance by non-action.” Taoist philosophy believes that the best way to manage is through “non-action” — not inactivity, but rather not forcing intervention and allowing things to develop naturally. In the practice of hypnosis, allowing the hypnotized person to self-discover and self-grow in a natural state, and finally achieve an optimal physical and mental state, is a more advanced form of healing. Finally, Taoism’s emphasis on naturalness also reminds us that hypnosis and its healing process are sometimes not achieved immediately and often involve uncertainty. By following the natural way of Taoism, people can avoid getting lost.

4.2. Purity and virtue facilitate the improvement of hypnosis

“Purity is the uprightness of the world” comes from the Tao Te Ching, resonating like a loud bell. Taoists believe that reducing selfish desires, eliminating distracting thoughts, and pursuing peace can lead to purity. “This is a very profound state, or what could be called the ‘sage’s realm’, because purity fosters inner virtue, allowing one to follow the nature of all things and respond to the changes of all events” ^[21]. The state of purity is very similar to the state of deep hypnosis in a form, with the former manifesting as “maintaining oneness” and the latter as “single-mindedness.” In terms of content, both have distinct characteristics and strengths. The state of deep hypnosis puts the individual in a highly sensitive state with reduced conscious alertness, which is conducive to accepting suggestions and implications, while the state of purity emphasizes harmony between consciousness and subconsciousness, facilitating the individual’s ability to see through the surface and essence of things. The former tends to be passive, while the latter tends to be active. The inspiration from this is that allowing the hypnotized person to experience more states of purity can aid in healing, or combining the state of hypnosis with purity can also have positive effects. Numerous studies have shown that hypnosis is suitable for combination with other therapies or states to enhance healing ^[22-24]. Additionally, if the hypnotist experiences more states of purity, it can also facilitate the transmission and influence of positive values. This is related to professional ethics and morality, which Taoism emphasizes as the importance of virtue. In Taoist philosophy, virtue is the carrier and concretization of the Tao, “the implementation of the ‘Tao’ in human beings, mainly including tolerance, acceptance, gentleness, and non-contention” ^[25]. It is the foundation of personal self-cultivation and the standard of social atmosphere. If those skilled in hypnosis can also value virtue, incidents like the Heidelberg hypnosis crime are bound not to occur, and the continuously improving hypnosis techniques will also become purer.

5. Others

Besides Confucianism, Buddhism, and Taoism, traditional Chinese medicine (TCM), as an excellent traditional culture, has also brought important enlightenment to the improvement of hypnotic theory and technology.

Theoretically, the Yin-Yang theory believes that the growth and decline of Yin and Yang, which maintains a dynamic balance within a certain scope, limit, and time and space, is one of the forms of Yin-Yang movement and change. It can guide the prevention, diagnosis, and treatment of diseases^[26]. That is, when the balance of Yin and Yang in the human body is lost, it not only causes physiological diseases but also triggers psychological imbalances, such as anxiety, depression, and other emotional disorders. The “anger hurts the liver, joy hurts the heart, thinking hurts the spleen, sadness hurts the lungs, and fear hurts the kidneys” in the “Yellow Emperor’s Inner Canon” refers to the fact that excessive emotions destroy the Yin-Yang balance of the internal organs and cause diseases. In this regard, the health concept of TCM advocates a holistic view of “harmony between nature and humanity”, a harmonious view of “integration of body and spirit”, a people-oriented value, and a balanced view of Qi, blood, Yin, and Yang. Then it can prevent diseases, regulate emotions, and follow nature^[27]. This Chinese therapy, which restores physical and mental harmony by adjusting the balance of Yin and Yang, provides a reference for modern and contemporary hypnosis: whether it is for therapeutic or non-therapeutic (communication or influence) functional orientations, it is advisable to improve the balance between consciousness and subconsciousness, hypnotic and non-hypnotic states, hypnotic participants, and their culture. Technically, based on the meridian theory of TCM and combined with the popular hypnotic techniques at that time, Dr. Ma Weixiang innovatively proposed the meridian hypnotic technique. This technique has been tested over many years of practice and has shown certain efficacy. It is an innovation and contribution to cultural confidence in the field of hypnotic therapy. At the same time, many frontline hypnotists have begun to pay attention to acupuncture hypnotism and have made a lot of attempts from a practical level.

6. Summary and outlook

The excellent traditional Chinese culture, dominated by Confucianism, Buddhism, and Taoism, contains abundant hypnotic techniques. However, in ancient times, it had not yet formed a “system” in the eyes of Western scientific psychology researchers. Therefore, we cannot simply judge Chinese hypnotic techniques based on Western modern and contemporary hypnotic standards. The Western hypnotic system is mainly established based on logical reasoning and scientific experiments, while the Chinese hypnotic system is primarily built on intuitive insights. It is worth noting that although the paths are different, the ultimate truths are interconnected. From the perspectives of research objects, theories, techniques, state expressions, and healing effects, Western hypnotic researchers represented by Erickson have intentionally or unintentionally constructed a set of hypnotic techniques that implicitly align with the essence of excellent traditional Chinese culture in nearly a century of exploration. Conversely, the profound thoughts, especially the unity of heaven and humanity, in the excellent traditional Chinese culture dominated by Confucianism, Buddhism, and Taoism, can provide rich nourishment and profound guidance for Western scientific hypnotic techniques. Therefore, mutual learning between the two is extremely beneficial for future in-depth hypnotic research. Additionally, with increasingly frequent and deep cross-cultural exchanges, we can fully draw on the latest research achievements in fields such as Western cognitive neuroscience and brain science, combine the essence of Confucianism, Buddhism, and Taoism, and explore hypnotic theoretical models that are more aligned with human psychological development laws. Furthermore, people can innovate at the technical level: develop hypnotic guidance techniques based on emotional resonance by combining Confucian benevolence, enhance the depth and quality of hypnotic experiences through Buddhist meditation, and design more natural and smooth hypnotic moderate control strategies by drawing on the Taoist concept of governing by non-action.

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Analysis of Spatiotemporal Evolution and Impediments in the Coupling Coordination between High-Quality Tourism Development and Urban Resilience in Chongqing

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Abstract: In the context of a complex and volatile global environment and the post-pandemic era, tourism, as a vital engine for urban economic development, its high-quality development and the concurrent building of urban resilience against risk shocks have become pivotal for sustainable urban development. This study aims to systematically investigate the coupling and coordination relationship between high-quality tourism development and urban resilience in Chongqing, and to identify key factors constraining their synergistic advancement. Quantitative analysis was conducted using the entropy method, a coupling coordination index model, and an obstacle degree model. Key findings reveal that between 2019 and 2023, the coupling coordination degree between high-quality tourism development and urban resilience in Chongqing's "One Zone and Two Clusters" exhibited a fluctuating upward trend. However, significant regional disparities exist, and each area faces distinct primary obstacles. Based on these findings, this study proposes targeted policy recommendations, including optimizing top-level design, strengthening resilience building, promoting tourism transformation and upgrading, and implementing differentiated development strategies. These recommendations aim to provide a scientific basis and decision-making references for the sustainable development of Chongqing's tourism industry and the enhancement of urban resilience.

Keywords: Urban resilience; High-quality tourism development; Coupling coordination; Impediments; Chongqing Municipality

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1. Introduction

1.1. Research context

Currently, China is vigorously promoting high-quality development and resilient city construction. As a vital

engine of the national economy, the sustainability and risk resilience of tourism are intrinsically linked to urban resilience building. Despite its rapid growth, Chongqing's tourism sector has exhibited systemic vulnerabilities when subjected to external shocks, underscoring the critical role of resilience building in safeguarding its high-quality development. Given their mutually reinforcing relationship, this study focuses on the unique period from 2019 to 2023. It deeply analyzes the coupling coordination, spatiotemporal evolution, regional disparities, and impediments between high-quality tourism development and urban resilience within Chongqing's "One Zone and Two Clusters" framework, aiming to provide scientific evidence.

1.2. Research significance

1.2.1. Theoretical significance

By thoroughly examining the coupling coordination between high-quality tourism development and urban resilience in Chongqing's "One Zone and Two Clusters" strategy, this study aims to enrich the theoretical framework for their synergistic advancement. By constructing a more comprehensive and timely indicator system and employing quantitative analysis using coupling coordination and obstacle models, this study will provide new empirical evidence for revealing the interaction mechanisms and constraints between tourism and urban resilience. This will further refine theories concerning sustainable urban development and tourism resource integration.

1.2.2. Practical significance

The findings will provide scientific decision-making support for Chongqing's tourism development planning, optimization of resource allocation, enhancement of infrastructure, ecological conservation, and strengthening of risk prevention capabilities within the "One Zone and Two Clusters" framework. By identifying key impediments across regions, this research enables Chongqing to formulate tailored development strategies, thereby advancing the synergistic enhancement of high-quality tourism development and urban resilience. Furthermore, this research offers valuable experience and policy references for other Chinese cities with similar regional characteristics in advancing sustainable tourism development and urban resilience construction.

1.3. Literature review

1.3.1. Urban resilience research

The concept of "resilience" originated in engineering before expanding into ecological, social, and economic domains, subsequently being introduced into urban studies ^[1]. Overseas research has evolved from engineering resilience to socio-ecological resilience, emphasizing the integrated nature of urban systems. This evolution has led to the development of mature assessment frameworks and indicator systems by organizations such as the Rockefeller Foundation and Cutter et al. ^[2-3]. Furthermore, big data technologies are extensively applied ^[4]. Domestic research on urban resilience has developed rapidly, yielding significant outcomes in theoretical exploration, evaluation frameworks, and influencing factors. Scholars such as Shao Yiwen and Xu Jiang, and Zhang Shiju et al. have actively systematized theories and developed evaluation frameworks ^[5-6]. Specifically for Chongqing Municipality, Hu You et al. have conducted spatiotemporal evolution analyses ^[7].

1.3.2. Research on high-quality tourism development

The significance of tourism in global and regional economies continues to grow ^[8]. International research emphasizes tourism efficiency and sustainable development, extensively employing SFA, DEA, and their modified models to measure efficiency, while examining developmental efficiency from a sustainability perspective ^[9-12].

Research exhibits diversity in scale, data, and methodology. Domestically, against the backdrop of high-quality development principles and deep integration with cultural tourism, high-quality tourism development has become an academic hotspot. Scholars interpret its connotations and construct evaluation systems from dimensions such as innovation, coordination, greenness, openness, and sharing, as exemplified by Peng Shuzhen et al. and He Jianmin ^[13–14]. Moreover, specific evaluation systems for different tourism formats and regions have been developed, such as by He Yanbing et al. and Yan Youbing and Ouyang Min ^[15–16]. Regarding influencing factors, Zuo Xin et al. have examined impediments ^[17].

1.3.3. Research and review on urban resilience and tourism

Within the interdisciplinary field of urban resilience and tourism, existing research has preliminarily examined tourism's recovery capacity following disaster impacts and the significance of urban resilience for tourism destination development. Fan Ningning examined the coupling and driving factors between high-quality tourism development and urban resilience in the Middle Yangtze River Urban Agglomeration, while Hu Qi explored the spatiotemporal evolution characteristics and influencing factors of urban resilience in the Wanjiang Urban Belt ^[18–19]. However, existing domestic and international research exhibits shortcomings, including insufficient systematic quantitative analysis, scarcity of studies addressing regional variations, and limited case studies. This study aims to address these gaps by focusing on the unique period of profound COVID-19 impact from 2019 to 2023, delving into the interactive evolution of two systems—high-quality tourism development and urban resilience—under external shocks. By constructing a more scientifically comprehensive multidimensional indicator system and employing multiple quantitative analysis methods—including the entropy method, the coupling coordination degree model, and the obstacle degree model—this study conducts refined spatiotemporal evolution and regional disparity analyses using Chongqing's "One Zone and Two Clusters" as the research unit. It identifies key impediments constraining the synergistic development of these systems, thereby providing scientific grounds for formulating tailored policies suited to Chongqing's specific context.

2. Research design and methodology

2.1. Study area and data sources

This study examines Chongqing's "One Zone and Two Clusters" over the period 2019–2023 to analyse pre- and post-pandemic coupling characteristics. Data primarily derive from the Chongqing Statistical Yearbook and publicly available government sources. Missing indicators were supplemented through regional aggregation or proportional allocation to ensure completeness and reliability.

2.2. Construction of the evaluation indicator system

2.2.1. Urban resilience evaluation indicator system

Urban resilience denotes a city system's capacity to effectively withstand, adapt to, recover from, and transform in response to external shocks. To facilitate scientific evaluation, this study adheres to principles of scientific rigour, systematic approach, and operational feasibility. An indicator framework comprising four dimensions—economic resilience, social resilience, ecological resilience, and infrastructure resilience—has been established (**Table 1**), aiming to comprehensively assess urban resilience levels.

Table 1. Urban resilience evaluation indicator system

Indicator	Dimension	Specific indicator	Indicator meaning	Attribute	Reference Source
Urban Resilience	Economic Resilience	Per capita GDP	Reflects regional economic development levels and per capita income, and to some extent indicates the economy's capacity to withstand risks.	Positive	Zhang Shiju et al. ^[6]
		Share of Tertiary Sector in GDP	This indicator reflects the proportion of the tertiary sector within the economic structure. A higher proportion indicates a more rational regional economic structure and greater stability in economic development.	Positive	Zhang Shiju et al. ^[6]
	Social resilience	Ageing rate	The ageing rate reflects the proportion of elderly individuals within the total population. Higher values may exert pressure on social security, healthcare services, and labour supply.	Negative	Yang Bihong et al. ^[20]
		Year-end balance of personal savings deposits (billion yuan)	This indicator reflects residents' economic resilience and risk-bearing capacity.	Positive	Zhang Shiju et al. ^[6]
	Ecological resilience	Total wastewater discharge × (Total tourism revenue / GDP)	This indicator reflects the combined impact of wastewater discharge pressure on the ecological environment and the level of tourism development. A lower value is preferable, indicating reduced pollution pressure on the ecological environment alongside economic growth.	Negative	Hu You et al. ^[7]
		Total exhaust emissions × (Total tourism revenue / GDP)	This indicator reflects the combined impact of exhaust gas emissions on the ecological environment and the level of tourism development. A lower value is preferable, indicating that economic development is accompanied by less pollution pressure on the ecological environment.	Negative	Hu You et al. ^[7]
	Infrastructure Resilience	Road area per capita	This metric reflects the level of regional transport infrastructure development, which, to some extent, indicates economic development and logistics capabilities.	Positive	Zhang Shiju et al. ^[6]
		Urban road length	Reflects the scale of the urban road network and, to some extent, indicates the sophistication of urban transport infrastructure and transportation capacity.	Positive	Hu Qi ^[19]

2.2.2. Evaluation Indicator System for High-Quality Tourism Development

High-quality tourism development embodies the new development philosophy within the tourism sector, emphasizing innovation, coordination, green development, openness, and shared benefits. This study constructs an indicator system encompassing five dimensions—innovation, coordination, green development, openness, and shared benefits (**Table 2**)—tailored to regional realities and data availability, aiming to comprehensively reflect the level of high-quality tourism development.

Table 2. Evaluation indicator system for high-quality tourism development in Chongqing

Indicator	Dimension	Specific Indicator	Indicator Meaning	Relevance	Reference Source
High-Quality Development of the Tourism Industry	Innovation	Share of Tourism Revenue in GDP	The proportion of tourism revenue in GDP reflects the tourism industry's standing and contribution within the national economy, demonstrating its role in driving overall economic growth.	Positive	Fan Ningning ^[18]
		Proportion of Tourism Employment in Total Employment	This metric reflects the tourism sector's contribution to employment, indicating the industry's vitality and developmental prospects.	Positive	Peng Shuzhen et al. ^[13]
	Coordination	Number of star-rated hotels	Reflects the scale and development level of the tourism service sector, demonstrating the supporting facilities and service quality of the tourism industry.	Positive	Fan Ningning ^[18]
		Number of Travel Agencies	Reflects the scale and development level of the tourism service industry, demonstrating the supporting facilities and service quality of the tourism sector.	Positive	Fan Ningning ^[18]
	Green Development	Ratio of days with good air quality	Reflects the level of urban greening and ecological environment quality, embodying the sustainable development philosophy of the tourism industry.	Positive	Wei Zijun et al. ^[21]
		Energy consumption per ten thousand yuan of GDP	Reflects the energy efficiency and resource consumption levels of regional economic development.	Negative	Wei Zijun et al. ^[21]
	Openness	Inbound tourist proportion	Reflects the attractiveness to international visitors, indicating the openness and internationalization level of the tourism industry.	Positive	Fan Ningning ^[18]
		Per capita tourism foreign exchange earnings	Reflects the consumption level of inbound tourists and the added value of tourism products, serving as a key indicator for measuring the foreign exchange earnings efficiency of the tourism industry in the international market.	Positive	Fan Ningning ^[18]
	Shared Benefits	Cultural Tourism, Sports, and Media Expenditure	Government investment in public services, particularly in areas closely linked to residents' quality of life and tourism experiences, such as culture, tourism, sports, and media.	Positive	Wang Jinwei et al. ^[22]
		Subject distribution of students in secondary vocational education institutions, Number of graduates (tourism category)	Regional capacity and outcomes in cultivating tourism professionals.	Positive	Zhang Nian ^[23]

2.2.3. Determination of indicator weights

To objectively reflect the importance of each indicator, this study employs the entropy weighting method. This approach determines weights based on the information content of indicators, thereby avoiding subjective bias. Weights for regional indicators are calculated independently and remain stable between 2019 and 2023 (Tables 3 and 4).

Table 3. Weighting table for urban resilience evaluation indicators

Dimension	Specific indicator	Metropolitan area weight	Three Gorges reservoir area weight	Wuling mountain region weight
Economic Resilience	Per capita GDP (yuan)	0.153723	0.139071	0.128488
	Tertiary Industry Share of GDP	0.160279	0.105869	0.189011
Social resilience	Ageing rate	0.087156	0.099329	0.130495
	Year-end balance of personal savings deposits (billion yuan)	0.127164	0.130465	0.145488
Ecological Resilience	Tourism wastewater discharge intensity	0.085447	0.102784	0.073528
	Tourism Waste Gas Emission Intensity	0.115809	0.133021	0.103443
Infrastructure resilience	Road area per capita	0.165205	0.160157	0.137515
	Urban road length	0.105217	0.129304	0.092032
Total		1.000000	1.000000	1.000000

Table 4. Weighting table for tourism high-quality development evaluation indicators

Dimension	Specific indicator	Metropolitan area weight	Three Gorges Reservoir area weight	Wuling mountain region weight
Innovation	Tourism Revenue as % of GDP	0.051208	0.053337	0.060846
	Percentage of tourism employment relative to total employment	0.085043	0.052397	0.045697
Coordination	Number of star-rated hotels	0.045785	0.050529	0.061417
	Number of travel agencies	0.081021	0.099209	0.134411
Green Development	Percentage of days with good air quality	0.053858	0.104519	0.039985
	Energy consumption per ten thousand yuan of GDP	0.051498	0.082753	0.05446
Openness	Proportion of inbound tourists	0.185468	0.18641	0.200175
	Per capita tourism foreign exchange earnings	0.164905	0.160252	0.181622
Shared Benefits	Expenditure on Culture, Tourism, Sport, and Media	0.121124	0.056741	0.100567
	Number of Graduates by Subject Area in Secondary Vocational Education Institutions (Tourism Category)	0.16009	0.153853	0.12082
Total		1.000000	1.000000	1.000000

2.3. Research methodology

2.3.1. Entropy method

The entropy weighting method is an objective weighting approach that determines weights based on the information content of indicators, thereby avoiding subjective bias. This study employs this method to weight indicators for urban resilience and high-quality tourism development, with weights calculated independently for each region (Tables 3 and 4).

(1) Coupling Coordination Degree Model

1: Calculating Coupling Degree (C)

$$C = \frac{U_1 \cdot U_2}{[\frac{(U_1 + U_2)}{2}]^2} \quad (1)$$

U1: Comprehensive urban resilience score

U2: Tourism high-quality development composite score

2: Calculate Coordination Degree (T)

$$T = \alpha U_1 + \beta U_2 \quad (2)$$

3: Calculate Coupling Coordination (D)

$$D = \sqrt{C \cdot T} \quad (3)$$

4: Coupling Coordination Grading (Table 5)

Table 5. Classification criteria for coupling coordination levels

Classification range	Degree of coordination	Coordination effect
$D > 0.8$	Highly Coordinated	The system exhibits a high degree of coordinated development.
$0.5 \leq D \leq 0.8$	Moderate Coordination	The system exhibits a certain degree of coordinated development.
$0.3 \leq D < 0.5$	Mild Coordination	The system exhibits certain contradictions.
$0 \leq D < 0.3$	Lack of Coordination	The system exhibits significant contradictions.

(2) Barrier Degree Model

1: Calculate the deviation degree of indicators (I_{ij})

$$I_{ij} = 1 - X'_{ij} \quad (4)$$

Where, I_{ij} denotes the deviation degree of the i th indicator in the year j ; X'_{ij} denotes the standardised value of the i th indicator in the year j , typically ranging between $[0,1]$. A higher value indicates greater deviation from the optimal state and stronger constraints on system development.

2: Calculating indicator contribution

$$W'_j = w_j \quad (5)$$

Where W'_j denotes the contribution of the j th indicator to its respective system (urban resilience or high-quality tourism development), i.e., the indicator's weight; w_j represents the weight of the j th indicator calculated using the entropy method.

3: Calculating the indicator's degree of difficulty (O_{ij})

$$O_{ij} = \frac{I_{ij} \cdot w_j}{\sum_{j=1}^n (I_{ij} \cdot w_j)} \times 100\% \quad (6)$$

Where: O_{ij} represents the obstacle level for the i th indicator in the year j ; I_{ij} denotes the indicator deviation; W_j

represents the indicator weight; $\sum_{j=1}^n (I_{ij} \cdot w_j)$ indicates the sum of all indicator deviation-weight products.

4: Obstacle Degree Analysis

Identify indicators with high obstacle degrees, representing key constraints to coordinated development. Analyze the causes of these obstacles and propose targeted policy recommendations.

2.3.2. Spatio-temporal analysis method

By comparing the coupling coordination degree and obstacle degree across different years and regions, the study analyzes their spatio-temporal evolution characteristics and regional disparities.

3. Spatiotemporal analysis of coupling coordination between high-quality tourism development and urban resilience in Chongqing Municipality (2019–2023)

3.1. Temporal evolution analysis of urban resilience, high-quality tourism development, and coupling coordination

During the study period, the coupling coordination degree between urban resilience and high-quality tourism development in Chongqing’s “One Zone and Two Clusters” generally exhibited characteristics of “a widespread trough under external shocks followed by resilient recovery, accompanied by significant regional imbalances.” From 2019 to 2021, the pandemic shock led to a widespread decline or stagnation at low levels in coordination across all regions, with tourism vulnerability being particularly pronounced. However, urban resilience generally strengthened during this period, providing a foundation for subsequent recovery. Between 2022 and 2023, coordination levels across regions recovered actively, with the metropolitan area being the first to achieve “good coordination.” Although the Dasanxia (Three Gorges) and Dawuling (Wuling) regions demonstrated significant resilience gains, their coordination levels improved relatively slowly, largely remaining at “initial coordination” or “barely coordinated” stages. This regional disparity highlights differences in how areas at varying developmental stages respond to external shocks and pursue coordinated development, underscoring the need for tailored future strategies (Figures 1–3)

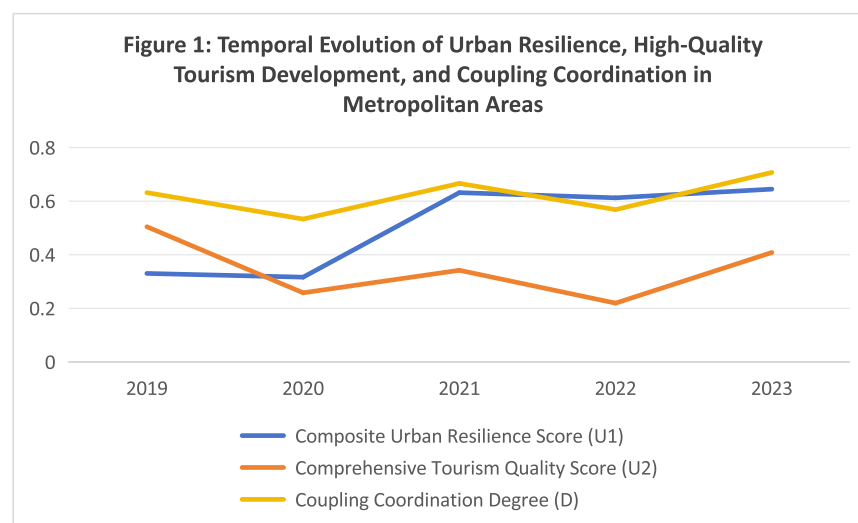


Figure 1. Temporal evolution of urban resilience, high-quality tourism development, and coupling coordination in metropolitan areas

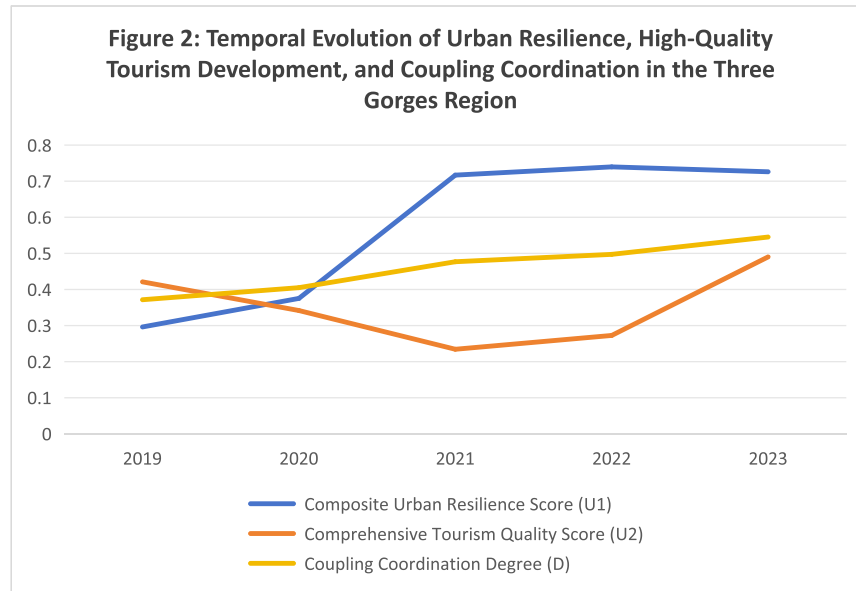


Figure 2. Temporal evolution of urban resilience, high-quality tourism development, and coupling coordination in the Three Gorges region

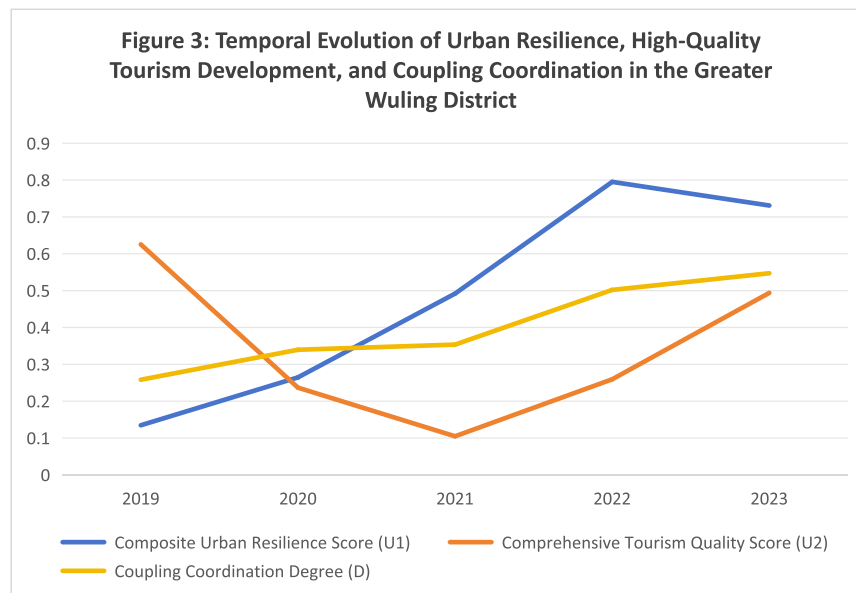


Figure 3. Temporal evolution of urban resilience, high-quality tourism development, and coupling coordination in the Greater Wuling District

3.2. Regional variations in coupling coordination

The coupling coordination degree (D) between urban resilience and high-quality tourism development across Chongqing Municipality’s “One Zone and Two Clusters” exhibited pronounced regional disparities from 2019 to 2023, reflecting differing capacities to withstand external shocks and divergent development trajectories (Figures 4–8). In 2019, the Metropolitan Area demonstrated a moderate level of coordination, with relatively high scores for both resilience and tourism development. The Greater Wuling Area recorded the lowest Dvalue, indicating lagging resilience. During the initial phase of the COVID-19 pandemic (2020), coordination declined across all regions:

the Metropolitan Area experienced the largest tourism shock, whereas resilience in the Greater Three Gorges Area remained comparatively stable. Throughout the prolonged pandemic period (2021–2022), the Metropolitan Area’s resilience improved substantially, and it led the recovery of tourism; although resilience in the Greater Three Gorges and Greater Wuling areas reached peak levels, persistent damage to their tourism sectors continued to constrain their coupling coordination. By 2023, as pandemic impacts waned, the Metropolitan Area achieved a high level of coordination; the Greater Three Gorges and Greater Wuling areas’ Dvalues rose to a marginally coordinated level, with notable improvements in both resilience and tourism development that narrowed—but did not eliminate—the gap with the Metropolitan Area. This pattern, in which core areas attain high-level coordination earlier while less developed regions show pronounced resilience but lagging tourism, underscores the need for differentiated, targeted strategies to promote higher-level, balanced coordination across the municipality.

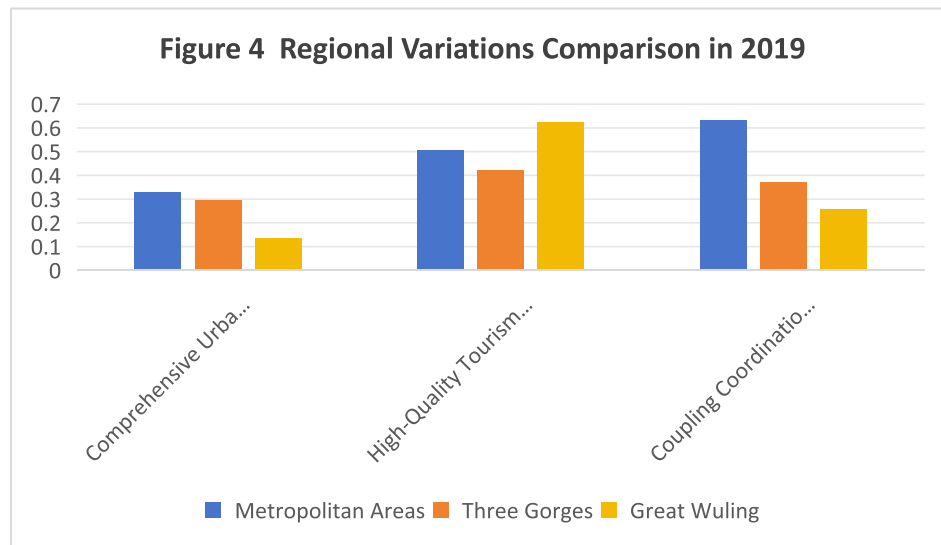


Figure 4. Regional variations comparison in 2019

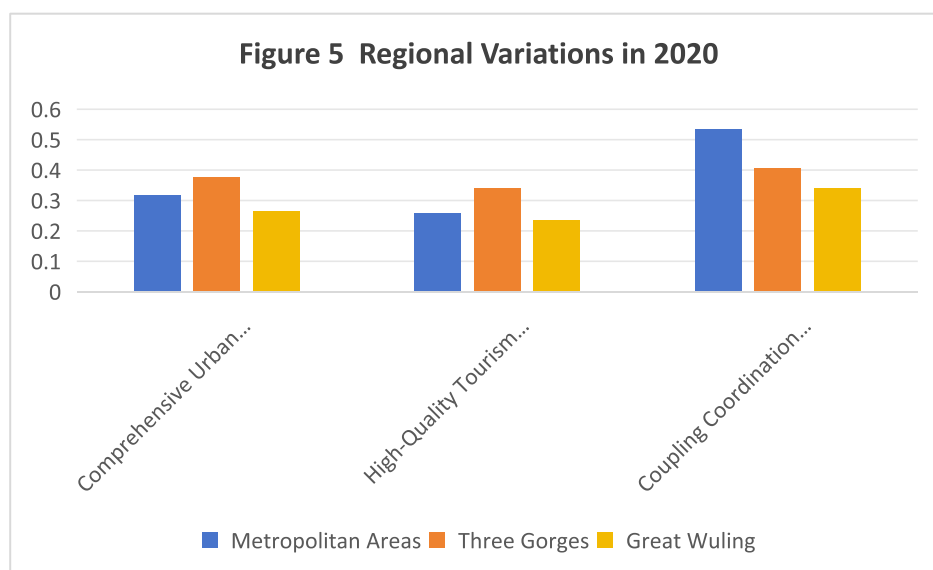


Figure 5. Regional variations in 2020

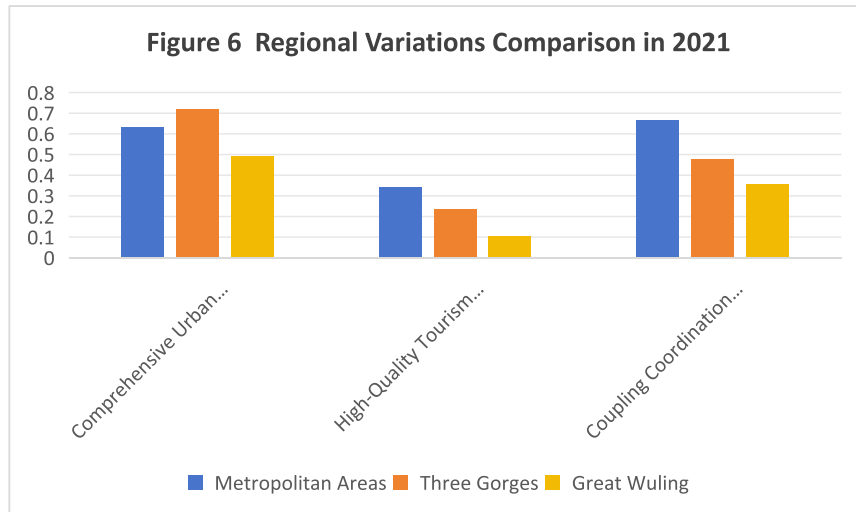


Figure 6. Regional variations comparison in 2021

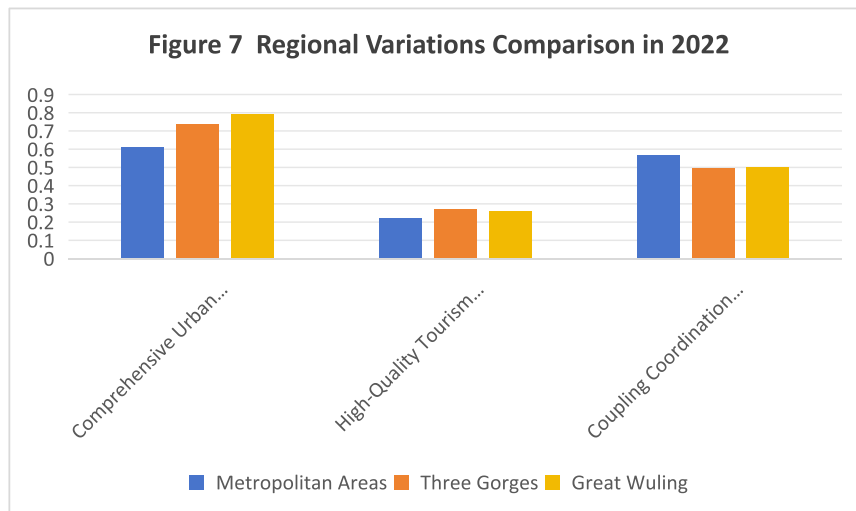


Figure 7. Regional variations comparison in 2022

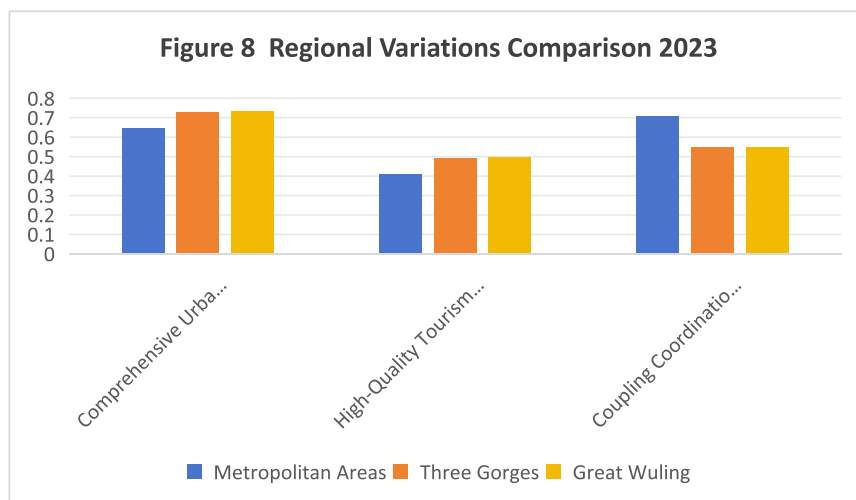


Figure 8. Regional variations comparison 2023

4. Analysis of barriers to coupling coordination between high-quality tourism development and urban resilience in Chongqing’s “one zone, two clusters” framework (2019–2023)

4.1. Analysis of urban resilience system barriers

Barriers to urban resilience within Chongqing Municipality’s “One Zone and Two Clusters” exhibit significant regional heterogeneity. In the Metropolitan Area, primary constraints have shifted from economic development and public service provision toward the coordination of ecological protection and social stability. The Greater Three Gorges Area faces persistent shortcomings in infrastructure and innovation capacity, alongside mounting pressures for ecological conservation. As a less-developed region, the Greater Wuling Area continues to confront core resilience challenges, including low economic development, inadequate public services, outmigration, and shortages of skilled personnel. Although economic development levels and public service provision are common obstacles across the “One Zone and Two Clusters”, each region presents distinct critical issues, underscoring the need for tailored, place-based resilience-building measures.

4.2. Analysis of systemic barriers to high-quality tourism development

The impediments to high-quality tourism development within Chongqing Municipality’s “One Zone and Two Clusters” exhibit distinct regional characteristics and dynamic evolution. In the Metropolitan Area, primary obstacles have shifted from the initial pandemic-induced sharp decline in market size and tourism revenues to insufficient tourism product innovation and difficulties in improving service quality, indicating the need for in-depth, quality-oriented development. As an ecological tourism zone, the Greater Three Gorges Area has long faced lagging infrastructure and limited brand recognition, driven by poor transportation accessibility, inadequate promotion, and overreliance on a single natural resource base. The Greater Wuling Area confronts severe challenges due to a single-industry structure, shortages of skilled personnel, and inadequate supporting infrastructure, with these vulnerabilities becoming especially evident during the pandemic. Across the “One Zone and Two Clusters”, lagging market adaptability and product innovation are common problems; however, each region exhibits distinct weaknesses in infrastructure, brand building, and talent cultivation, underscoring the need for differentiated, place-based strategies.

4.3. Comprehensive analysis of coupling coordination barriers

A comprehensive analysis of impediments within the urban resilience and high-quality tourism systems indicates that Chongqing Municipality’s “One Zone and Two Clusters” face core barriers stemming from the interaction of systemic shortcomings and factor misallocation driven by regional development imbalances. Less-developed areas, notably the Greater Three Gorges Area and the Greater Wuling Area, encounter resilience constraints—such as low economic development and inadequate public services—that directly restrict tourism infrastructure, industrial upgrading, and talent attraction, causing high-quality tourism development to lag and further undermining regional economic vitality. Weak infrastructure reduces tourism accessibility, and shortages of skilled personnel limit product innovation. Even in the Metropolitan Area, unresolved higher-order resilience challenges—including ecological quality and social stability—can weaken tourism appeal. These interlinked obstacles jointly hinder high-level coupling coordination between urban resilience and high-quality tourism development.

5. Conclusions and policy recommendations

5.1. Research findings

This study reveals the spatiotemporal evolution of the coupling coordination degree (D) between urban resilience and high-quality tourism development across Chongqing Municipality's "One Zone and Two Clusters." During the study period, coordination levels in all regions experienced a general downturn under external shocks followed by resilience-driven recovery, with most areas returning to or exceeding pre-pandemic levels by 2023. Concurrently, significant regional disparities emerged: the Metropolitan Area achieved high-level coordination first and demonstrated stronger resilience, whereas the Greater Three Gorges and Greater Wuling areas—despite marked improvements in urban resilience—registered relatively slower coordination gains due to lagging tourism recovery and structural developmental differences. Comprehensive impediment analysis indicates that underdeveloped regions primarily face systemic shortcomings in urban resilience (for example, low economic development and insufficient public service provision) together with factor misallocation in tourism infrastructure and human capital; these constraints interact and mutually reinforce one another. The Metropolitan Area, in contrast, encounters higher-order resilience challenges—notably ecological quality and social stability—as well as pressures to innovate tourism offerings and enhance service quality. Overall, against the backdrop of regional development imbalances, the interaction of systemic shortcomings and factor misallocation jointly impedes high-level coupling coordination between urban resilience and high-quality tourism development.

5.2. Policy recommendations

To achieve high-level coupling coordination between high-quality tourism development and urban resilience in Chongqing Municipality's "One Zone and Two Clusters," policy formulation must strengthen integrated top-level planning and collaborative mechanisms. Enhancing urban resilience requires optimizing industrial structures, improving social security, strengthening ecological conservation (especially in high-emission areas), and sustaining infrastructure investment, particularly to address road deficiencies. Promoting high-quality tourism involves fostering innovation in products and business models to enhance value-added (for high-energy-consumption, low-revenue areas), optimizing service facilities and boosting international appeal (for regions with low inbound visitors and foreign exchange earnings), increasing cultural and sports expenditure, strengthening talent cultivation, and ensuring inclusive benefit sharing. Differentiated strategies are crucial: the Metropolitan Area should focus on high-end services, innovation, and ecological governance, while the Greater Three Gorges and Greater Wuling regions must prioritize addressing deficiencies in infrastructure, public services, and talent, vigorously developing eco-tourism for endogenous growth.

5.3. Research outlook and limitations

This study has made progress in analyzing the coupling and coordination between urban resilience and high-quality tourism development within Chongqing Municipality's "One Zone and Two Clusters" framework, yet certain limitations remain. Future research could expand the time series and research scope to include more cities or districts, incorporate additional models such as geographic detectors to analyze driving factors, or conduct more micro-level case studies. Key shortcomings primarily include potential limitations in data acquisition due to data availability and statistical caliber, possible under-representation of all influencing dimensions in indicator selection, and the inherent constraints of coupling coordination models in elucidating specific mechanisms and impact pathways.

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Disclosure statement

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CW-HRNet: Constrained Deformable Sampling and Wavelet-Guided Enhancement for Lightweight Crack Segmentation

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Abstract: This paper presents CW-HRNet, a high-resolution, lightweight crack segmentation network designed to address challenges in complex scenes with slender, deformable, and blurred crack structures. The model incorporates two key modules: Constrained Deformable Convolution (CDC), which stabilizes geometric alignment by applying a tanh limiter and learnable scaling factor to the predicted offsets, and the Wavelet Frequency Enhancement Module (WFEM), which decomposes features using Haar wavelets to preserve low-frequency structures while enhancing high-frequency boundaries and textures. Evaluations on the CrackSeg9k benchmark demonstrate CW-HRNet's superior performance, achieving 82.39% mIoU with only 7.49M parameters and 10.34 GFLOPs, outperforming HrSegNet-B48 by 1.83% in segmentation accuracy with minimal complexity overhead. The model also shows strong cross-dataset generalization, achieving 60.01% mIoU and 66.22% F1 on Asphalt3k without fine-tuning. These results highlight CW-HRNet's favorable accuracy-efficiency trade-off for real-world crack segmentation tasks.

Keywords: Crack segmentation; Lightweight semantic segmentation; Deformable convolution; Wavelet transform; Road infrastructure

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1. Introduction

Crack detection is a critical task in road infrastructure maintenance, as road cracks are among the most common and hazardous pavement defects ^[1]. Accurate segmentation directly impacts the development of maintenance strategies and the long-term safety of transportation systems. Traditional manual inspection, while reliable to some extent, suffers from high labor costs, low efficiency, and strong subjectivity, making it increasingly unsuitable for modern, intelligent maintenance workflows ^[2].

Before the advent of deep learning, crack segmentation primarily relied on handcrafted features and classical machine learning methods. Typical approaches included edge operators, texture statistics, and descriptors such

as HOG or LBP, combined with classifiers like SVM, random forest, or K-means clustering^[3]. While effective under low-noise and homogeneous conditions, these methods lacked robustness and generalizability in the face of complex materials, lighting conditions, and diverse crack shapes, due to their limited representational capacity.

With the rise of deep learning, convolutional neural networks have become the dominant paradigm for crack detection and segmentation. End-to-end pixel-wise training significantly improves robustness under complex imaging conditions^[4]. Contextual modeling via feature pyramids and multi-scale fusion/attention strategies enhances the network's adaptability to cluttered backgrounds^[5]. Architectures such as UNet, which utilize encoder-decoder frameworks with skip connections, effectively integrate fine-grained details and high-level semantics, thereby improving crack boundary sharpness and structural continuity^[6]. Recent works further optimize the consistency and efficiency of feature learning by introducing dense feature aggregation and multi-level skip connections^[7].

Despite these advances, two major challenges remain: First, in terms of geometric alignment, traditional convolutions with fixed sampling locations struggle to adapt to the irregular, slender, and bifurcated nature of cracks. While deformable convolutions introduce learnable offsets for enhanced shape modeling, unconstrained offsets may lead to instability, such as excessive deformation or irrelevant region sampling, resulting in distorted features and training difficulty. To address this, the study proposes Constrained Deformable Convolution (CDC), which introduces a tanh-based offset limiter and a learnable scaling factor to adaptively control sampling magnitudes, thereby achieving stable and precise alignment of complex crack structures^[8]. Second, in the frequency domain, repeated downsampling in CNNs tends to erase high-frequency details, leading to blurred boundaries and poor texture representation. Purely spatial convolutions also struggle to jointly capture low-frequency global topology and high-frequency fine edges. To bridge this gap, we design the Wavelet Frequency Enhancement Module (WFEM), which decomposes feature maps into low-frequency (LL) and high-frequency (LH/HL/HH) subbands via Haar wavelets. Each subband undergoes lightweight convolutional projection and cross-subband residual modeling for information interaction, followed by an inverse wavelet transform to reconstruct the full-resolution feature map. This enables the network to preserve global topology while enhancing boundary and texture fidelity.

In summary, this paper addresses two critical limitations—unstable geometric alignment and loss of high-frequency details—through the integration of CDC and WFEM in a high-resolution, lightweight architecture, providing a principled foundation for the design and evaluation of the proposed network in subsequent sections.

2. Related work

Deformable convolution augments standard convolution by introducing learnable spatial offsets that relax the constraint of a fixed sampling grid, thereby increasing the network's capacity to model geometric variation. By predicting offsets with an auxiliary branch and applying bilinear interpolation at displaced locations, the effective receptive field becomes content-adaptive rather than purely grid-bound. This property has made deformable operators highly effective in dense prediction tasks—particularly object detection and semantic/instance segmentation—where target shapes may be elongated, multi-scale, or discontinuous. In essence, the kernel is no longer tied to a rigid lattice; it can bend toward informative structures and away from distractors, improving coverage of thin filaments, junctions, and tortuous boundaries.

In crack segmentation, this adaptivity is especially valuable: cracks are typically slender, irregular, and

branched, with low contrast and significant texture interference from surrounding materials. Vanilla deformable convolutions, however, come with a notable caveat. When the offset field is unconstrained, the model may push sampling points far beyond the neighborhood where the underlying features are reliable. Such excessive displacements or drifts into irrelevant regions lead to distorted local evidence, noisy gradients, and training instability. The risk is amplified along crack boundaries, where subtle misplacement can blur edges or fragment topology.

To counter these effects, we introduce Constrained Deformable Convolution (CDC), which explicitly regularizes the offset magnitude during generation. Concretely, CDC applies a tanh-based limiter followed by a learnable scaling factor s , mapping raw offsets into a bounded range that still permits meaningful deformation. The tanh operation suppresses extreme values symmetrically, while s adapts the allowable offset scale to local statistics and task difficulty. This adaptive upper bound curbs erratic sampling without reverting to a rigid grid, striking a practical balance between flexibility and stability.

The resulting offset field is smoother, better conditioned, and less prone to outliers, which in turn improves boundary alignment and feature fidelity near thin, branching structures. Empirically, CDC stabilizes optimization, reduces artifacts linked to offset explosion, and yields cleaner gradients for the backbone. In downstream decoding, features produced by CDC exhibit crisper edges and more coherent topology, enabling the overall network to maintain high-resolution detail while remaining robust to geometric variability and background clutter.

3. Wavelet transform and frequency-domain feature fusion

The wavelet transform offers a distinctive balance between spatial locality and frequency resolution, enabling simultaneous representation of structural context and detailed variations. Recently, wavelet-based approaches have gained attention in deep learning as both an alternative to conventional downsampling/upsampling layers and as a feature enhancement tool ^[9]. Compared to max-pooling or strided convolutions, which often discard fine details, wavelet decomposition retains richer structural cues by explicitly separating low-frequency and high-frequency components. This property is particularly beneficial for segmentation tasks, where subtle edge continuity and texture fidelity are critical for accurate predictions. By preserving edges and textures through multiple downsampling stages, wavelet-based modules allow networks to sustain fine-grained representation capacity that standard CNN architectures often fail to maintain ^[10]. Typical strategies in prior work have leveraged the discrete wavelet transform (DWT) to replace pooling operations, and its inverse counterpart (IDWT) to replace upsampling layers. Another common design decomposes feature maps into a low-frequency subband (LL) that captures overall structure and several high-frequency subbands (LH, HL, HH) that emphasize edges and fine patterns. These components are then recombined in various ways to enrich feature hierarchies and strengthen boundary localization. Despite their promise, most existing implementations suffer from two notable limitations. First, decomposition is often restricted to low-resolution stages, thereby neglecting early and mid-level features where much of the fine-grained information resides. Second, subbands are frequently handled in a simplistic manner, such as direct concatenation, without explicit modeling of inter-subband dependencies. As a result, these approaches may underutilize complementary relationships between frequency components, leading to boundary blurring, detail loss, and limited robustness.

To address these shortcomings, we propose the Wavelet Frequency Enhancement Module (WFEM). In WFEM, input features are decomposed using fixed Haar wavelets into one LL and three HF subbands. Each

subband is then projected through lightweight 1×1 convolutions with normalization and nonlinearity, ensuring compactness and recalibration of channel responses. The processed subbands are concatenated along the channel dimension, followed by cross-subband residual modeling, which explicitly enables information flow and interaction across LL and HF components. Finally, the refined features are reconstructed using IDWT to restore spatial resolution. This design simultaneously preserves low-frequency topological connectivity and enhances high-frequency boundary sharpness and texture richness, effectively overcoming the deficiencies of pure decomposition or naive concatenation strategies.

4. Methodology

4.1. Overall network architecture

CW-HRNet follows a dual-path encoder–multi-scale fusion–progressive decoder design to preserve high-resolution representations while effectively integrating global semantics with fine crack details, as illustrated in **Figure 1**. The input is first processed by shallow convolutions and normalization to obtain unified-scale features. In the dual-path encoder, the high-resolution branch stacks multiple CDC layers, which progressively apply constrained geometric adaptation to sampling positions. This stabilizes the alignment of elongated, branched, and tortuous crack boundaries while retaining shallow textures and fine-grained structures. In parallel, the low-resolution branch enlarges the receptive field to capture global context and complements the high-resolution pathway through cross-scale fusion and semantic interaction.

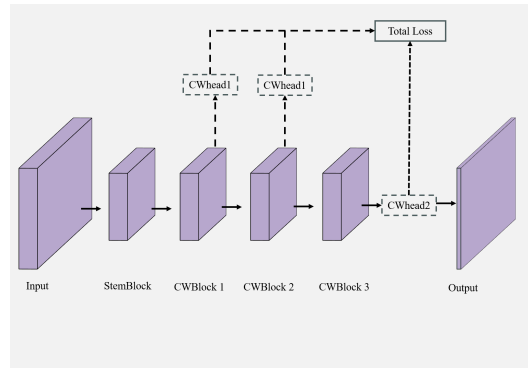


Figure 1. Overall architecture of CW-HRNet

To compensate for high-frequency loss caused by downsampling, the high-resolution branch incorporates the Wavelet Frequency Enhancement Module (WFEM) after CDC. Specifically, Haar wavelets are employed to decompose features into LL/LH/HL/HH subbands. Each subband undergoes lightweight projection and cross-subband residual modeling to enable effective information interaction, followed by inverse DWT reconstruction. This design achieves “topology preservation in low frequency and boundary strengthening in high frequency”, thereby enhancing feature representation in the frequency domain.

During the decoding stage, cascaded convolutions and progressive upsampling gradually restore spatial resolution, while skip connections mitigate detail degradation. A final 1×1 convolution maps features into pixel-wise crack probability maps, optimized jointly with a standard binary classification loss.

In summary, CW-HRNet introduces targeted modifications to the classical high-resolution framework along two complementary dimensions: CDC constrains offset drift and improves boundary alignment stability, while

WFEM explicitly models cross-subband dependencies to recover high-frequency details. Their synergy enables the network to achieve a superior balance between accuracy and efficiency, while maintaining robustness in complex crack segmentation scenarios.

4.2. Deformable convolution enhancement module

In real-world scenarios, cracks often appear irregular, slender, and branched. Standard convolutions, constrained by fixed sampling locations, struggle to adapt to such complex geometries. Although the original deformable convolution introduces learnable offsets, the absence of proper constraints may lead to excessive deformations and boundary drift, causing training instability. To address this, the study proposes the Constrained Deformable Convolution (CDC) module. As illustrated in **Figure 2**, the offset generation stage replaces conventional convolutions with an OffsetConvBlock, which progressively extracts geometric cues and enhances the discriminability and stability of offset prediction. Furthermore, we design an Offset Regulation Module (ORM), which imposes adaptive constraints on the offset magnitude by combining a tanh-based limiter with a learnable scaling factor. This mechanism suppresses structural distortion at the source by preventing extreme sampling.

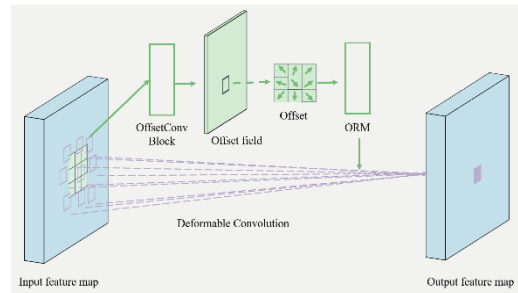


Figure 2. Structure of the constrained deformable convolution module

In the CDC, each convolutional sampling point k is associated with a learnable offset. The ORM constraint is formulated as:

$$\Delta p_k^*(x) = s \cdot \tanh(\Delta p_k(x)) \quad (1)$$

where $\tanh(\cdot)$ compresses offsets into $[-1, 1]$ to suppress extreme values, and s is a learnable scaling factor that adaptively adjusts the offset magnitude. Based on the constrained offsets $\Delta p_k^*(x)$, the deformable convolution can be expressed as:

$$y(p_0) = \sum_{k=1}^K w_k \cdot x(p_0 + p_k + \Delta p_k^*(x)) \quad (2)$$

where p_0 denotes the convolution kernel center, $p_k \in \mathbb{Z}^2$ represents the regular sampling grid, and $x(\cdot)$ indicates bilinear interpolation sampling^[11].

Compared with the unconstrained DCN, the proposed CDC maintains geometric flexibility while significantly improving the stability of offset prediction and boundary alignment accuracy. When stacked in multiple layers within the high-resolution branch, CDC provides structurally coherent and edge-preserving geometric representations, thereby supplying the decoder with more reliable features and ultimately improving both segmentation accuracy and robustness^[12].

4.3. High–low frequency feature decoupling and fusion module

Cracks often exhibit slender, tortuous, or even branched patterns, with a high degree of similarity to background textures. This leads to significant differences in the statistical distribution of high-frequency details and low-frequency structures. Conventional convolutional networks tend to lose high-frequency information after multiple downsampling operations, while low-frequency global semantics are insufficiently captured due to limited receptive fields^[13]. As a result, boundaries become blurred, fine-grained textures are lost, and local topology is often disrupted. To overcome these limitations, we propose the Wavelet Frequency Enhancement Module (WFEM), which achieves joint enhancement of global and local features through frequency-domain decomposition and cross-subband modeling, as illustrated in **Figure 3**.

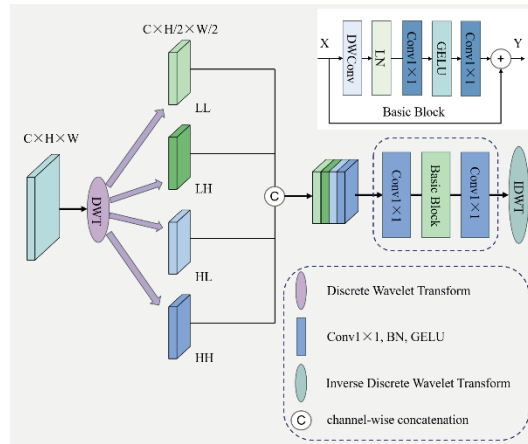


Figure 3. Structure of the wavelet frequency enhancement module

Specifically, WFEM employs fixed Haar wavelets to decompose input features via discrete wavelet transform (DWT), yielding a low-frequency subband (LL) and three high-frequency subbands (LH/HL/HH). The LL component encodes overall shape and connectivity, while the high-frequency subbands capture crack boundaries and texture details^[14]. Each subband is then passed through a lightweight projection composed of 1×1 convolution + BatchNorm + GELU, which recalibrates channel responses and aligns bandwidth. The four subbands are concatenated along the channel dimension, followed by a Residual Cross-Subband Block and a subsequent 1×1 compression layer. This explicitly models dependencies and complementarity between LL and high-frequency components, mitigating bias caused by the dominance of a single subband, thereby improving boundary localization and topological consistency. Finally, the processed features are re-split into four subbands and reconstructed to the original resolution using inverse wavelet transform (IDWT), producing a unified representation that preserves global topology in low frequencies while strengthening boundary details in high frequencies.

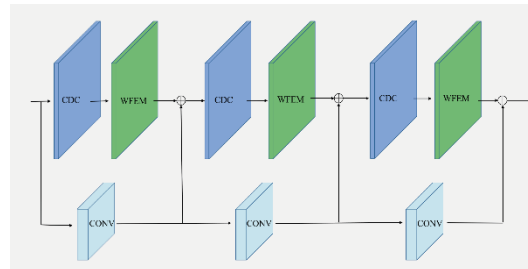


Figure 4. Structure of the CWBlock: Integration of CDC and WFEM modules

Within the overall network, WFEM is deployed in the high-resolution branch immediately after the CDC module: CDC first performs geometric alignment and stabilizes elongated or branched boundaries, after which WFEM restores and amplifies high-frequency details in the frequency domain while leveraging LL to enforce global connectivity. The synergy of these two modules enables CW-HRNet to maintain high-resolution representations while simultaneously achieving global topological modeling and fine-grained crack characterization, ultimately improving segmentation accuracy and robustness, as shown in **Figure 4**.

5. Experiments

5.1. Datasets

To evaluate the effectiveness of the proposed model, experiments are conducted on the CrackSeg9k dataset, representing mixed-scene cracks, and the Asphalt3k dataset, representing asphalt-specific cracks^[15–16].

CrackSeg9k is a medium-scale semantic segmentation dataset designed for crack detection and segmentation tasks. It contains approximately 8,751 high-quality images with cracks, covering diverse materials such as concrete, ceramics, and bricks. Each image has a resolution of 400×400 pixels, with two defined classes: crack and background. Following a fixed random seed, the dataset is split into 70% training, 10% validation, and 20% testing subsets.

Asphalt3k is a domain-specific dataset focusing on asphalt pavement cracks, derived from the public dataset originally released by Yang. The study preprocesses the raw samples by cropping and organizing them into 3,000 image–annotation pairs, which are randomly divided into training/validation/testing sets at a ratio of 6:1:3. Unless otherwise specified, both training and evaluation are performed under a single-scale setting, where images are centrally cropped or padded to 400×400 pixels. The class definitions and annotation protocols remain consistent with the original datasets.

5.2. Evaluation metrics

To comprehensively assess the performance of segmentation models with varying depths, the study employ four evaluation metrics: Precision (Pr), Recall (Re), F1-score, and mean Intersection-over-Union (mIoU). The definitions are as follows:

$$Pr = \frac{TP}{TP + FP} \quad (3)$$

$$Re = \frac{TP}{TP + FN} \quad (4)$$

$$F1 = 2 \cdot \frac{Pr \cdot Re}{Pr + Re} \quad (5)$$

$$mIoU = \text{mean} \left(\frac{TP}{TP + FP + FN} \right) \quad (6)$$

Where true positives (TP) denote correctly classified crack pixels, false positives (FP) represent background pixels incorrectly classified as cracks, and false negatives (FN) correspond to crack pixels misclassified as background.

In addition to segmentation accuracy, we also report GFLOPs (Giga Floating Point Operations) and Params (number of parameters) as measures of the model’s computational complexity and size, respectively.

5.3. Comparison with state-of-the-art models

This study focuses on the design of lightweight crack segmentation models. The study compares the proposed CW-HRNet against a variety of representative approaches, including classic high-accuracy models (UNet, PSPNet, OCRNet, DeepLabV3+[19]), mainstream lightweight architectures (BiSeNetv2, STDCSet, DDRNet), as well as crack-oriented models (UNet with Focal Loss, U2CrackNet, RUCNet) ^[6, 17–25]. All models are trained from scratch under identical conditions to ensure fairness.

Table 1 reports the comparative results. The UNet family achieves relatively high accuracy but suffers from large parameter sizes and heavy computational cost. RUCNet attains 80.47% mIoU, yet requires 115.49 GFLOPs, making deployment in resource-constrained environments impractical. The HrSegNet series demonstrates superior efficiency; for example, the B48 variant achieves 80.56% mIoU with only 5.43M parameters and 5.60 GFLOPs, highlighting strong scalability ^[26].

By contrast, CW-HRNet strikes a better balance between accuracy and complexity. With merely 7.49M parameters and 10.34 GFLOPs, it achieves 82.39% mIoU, 89.46% F1-score, 90.59% Precision, and 88.39% Recall, outperforming all competing methods. Compared with OCRNet, CW-HRNet improves mIoU by 1.49 percentage points while reducing parameters and computational cost by approximately 38% and 68%, respectively. Relative to HrSegNet-B48, CW-HRNet modestly increases complexity yet raises mIoU to 82.39%, significantly enhancing boundary delineation and fine crack representation.

Table 1. Comparisons with state-of-the-art on CrackSeg9k

Model	mIoU (%)	Pr (%)	Re (%)	F1 (%)	Params(M)	GFLOPs
UNet	79.15	89.82	84.75	87.21	13.40	75.87
PSPNet	76.78	87.57	83.33	85.39	21.07	54.20
BiSeNetv2	75.09	87.07	81.17	83.71	2.33	4.93
STDCSeg	78.48	88.24	84.60	86.65	8.28	5.22
DDRNet	76.77	89.10	82.10	85.45	20.18	11.11
OCRNet	80.90	88.26	88.58	88.41	12.12	32.40
DeeplabV3+	78.29	87.33	83.76	85.50	12.20	33.96
UNet(Focal Loss)	80.27	89.05	84.75	86.85	13.40	75.87
U2CrackNet	79.79	89.05	86.26	87.62	1.20	31.21
RUCNet	80.47	88.91	87.32	88.11	25.47	115.49
HrSegNet-B16	79.84	88.79	86.54	87.65	0.61	0.66
HrSegNet-B32	80.21	90.12	85.93	87.97	2.49	2.50
HrSegNet-B48	80.56	90.07	86.44	88.21	5.43	5.60
CW-HRNet	82.39	90.59	88.39	89.46	7.49	10.34

5.4. Ablation study

To investigate the contribution of each module to overall performance, we conduct ablation experiments on the CrackSeg9k dataset using HrSegNet-B48 as the baseline, and progressively introduce WFEM and CDC. The results are presented in **Table 2**.

Table 2. Ablation study

Method	mIoU (%)	Params (M)	GFLOPs
HrSegNet-B48	80.56	5.43	5.60
+ WFEM	81.64	5.53	8.72
+ CDC	81.71	6.11	7.21
CW-HRNet	82.39	7.49	10.34

As shown, incorporating WFEM into the baseline increases mIoU from 80.56% to 81.64%, a relative gain of 1.08 percentage points. The parameter count increases by only 0.10M, which is negligible; however, computational complexity rises considerably. This is mainly because WFEM introduces multi-subband parallel convolutions and IDWT reconstruction in the high-resolution branch, significantly expanding feature bandwidth and operator count, thereby incurring higher computational cost.

Further adding CDC raises mIoU to 81.71%, improving by 1.15 percentage points over the baseline, with an additional 0.68M parameters and 1.61 GFLOPs. The major overhead originates from the offset branch’s convolutional prediction and bilinear interpolation sampling.

When WFEM and CDC are combined, performance reaches the best outcome, with mIoU improved to 82.39%, representing a 1.83 percentage point gain over the baseline. This is achieved at a complexity of 7.49M parameters and 10.34 GFLOPs, demonstrating a favorable balance between accuracy and efficiency.

In summary, the two modules exhibit complementary roles: WFEM focuses on modeling high-frequency boundaries and fine-grained textures, while CDC enhances geometric alignment and structural robustness. Their synergy significantly boosts both segmentation accuracy and stability of the proposed model.

5.5. Generalization ability evaluation

To assess the cross-dataset generalization capability of the proposed model, we train CW-HRNet on CrackSeg9k and directly transfer it to the Asphalt3k dataset for testing without any fine-tuning. The comparative results on Asphalt3k are reported in **Table 3**.

It can be observed that CW-HRNet achieves the best performance in both mIoU and F1 metrics, reaching 60.01% mIoU and 66.22% F1, outperforming all other methods. Considering the severe class imbalance inherent in road crack segmentation, overall accuracy tends to be overestimated and shows limited differences across models. Thus, mIoU and F1 are more reliable indicators of practical detection performance.

These results demonstrate that CW-HRNet maintains stable structural recognition under challenging conditions such as complex textures and low-contrast backgrounds, highlighting its stronger cross-dataset generalization and robustness compared to competing approaches.

Table 3. Transfer to Asphalt3k

Model	BiSeNet	PSPNet	STDCSeg	U2CrackNet	HrSegNet	CW-HRNet
mIoU	55.10	54.24	55.53	54.80	58.27	60.01
F1	60.54	59.16	61.20	60.04	65.19	66.22
Params	2.33	21.07	8.28	1.20	5.43	7.49

6. Conclusion

This paper presents CW-HRNet, a lightweight crack segmentation network that integrates geometric adaptability with frequency-domain enhancement. In terms of methodological design, we introduce the Constrained Deformable Convolution (CDC), which employs a tanh-based limiter and a learnable scaling factor to effectively suppress offset drift, enabling stable alignment of slender and branched crack geometries. In parallel, we propose the Wavelet Frequency Enhancement Module (WFEM), which leverages Haar wavelet decomposition and cross-subband residual modeling to mitigate the high-frequency detail loss caused by convolutional downsampling. This design preserves low-frequency topological integrity while significantly strengthening boundary and texture representation.

Overall, the synergy between CDC and WFEM balances geometric modeling and frequency-domain enhancement, providing a new perspective for lightweight crack segmentation. In future work, the study plans to explore the integration of learnable wavelet bases with Transformer modules to further improve cross-scene adaptability. Moreover, the study aims to extend the model to broader infrastructure inspection tasks, such as bridges, tunnels, and airport runways, thereby advancing the intelligent maintenance of road and transportation engineering.

Disclosure statement

The author declares no conflict of interest.

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Practice and Response of China-Vietnam International Business Negotiation from the Perspective of Culture

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Abstract: With the deepening of globalization, the economic and trade cooperation between China and Vietnam has been continuously deepened, and the business exchanges have become increasingly frequent. As the key link of cooperation, the effectiveness of international business negotiation is closely related to the adaptation of the cultural characteristics of both sides. China and Vietnam have formed their own cultural characteristics in the long-term development, which have a direct impact on the negotiation process in the communication mode, cooperation goals, and other aspects. By analyzing the cultural characteristics in the commercial negotiations in the map, the paper puts forward the corresponding adaptive strategy, aiming to provide a reference for the enterprise's smooth business cooperation.

Keywords: China-Vietnam business negotiation; Cultural characteristics; Acculturation strategies

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1. Research background

As an important neighbor of China, Vietnam is located in the eastern part of the Indochina Peninsula. With its unique geographical advantages, Vietnam occupies an important position in regional economic cooperation. The trade between China and Vietnam has a long history. From the ancient border trade to the modern comprehensive economic and trade cooperation, the bilateral relations have been developing steadily through practical exchanges. From January to November 2023, Chinese tourists became the second largest source of tourists in Vietnam's tourism industry, demonstrating the friendly interaction and willingness to understand each other between the two peoples.

Such multi-level exchanges have laid a solid foundation for bilateral business cooperation and increased investment and cooperation opportunities between enterprises. As the key link of cooperation, the smoothness of business negotiation directly affects the effectiveness of cooperation. China and Vietnam have formed their own distinctive cultural traditions in the long-term development. These cultural characteristics naturally emerge

in business negotiations. Understanding and adapting to these characteristics can help reduce misunderstandings in communication and improve negotiation efficiency. At present, there is still room to expand the research on acculturation in China-Vietnam business negotiation. In-depth discussion on relevant topics can provide a certain reference value for promoting more efficient cooperation between enterprises of the two countries.

2. Cultural characteristics of China and Vietnam and their embodiments in business scenarios

2.1. Hierarchical concept in social structure

Both Chinese and Vietnamese cultures attach great importance to social hierarchy and collective order. In both social organizations and business environments, Chinese and Vietnamese people generally recognize and respect reasonable hierarchical relationships and believe that a clear division of roles is the basis for efficient collaboration. In this cultural atmosphere of China and Vietnam, the leadership position of authority figures is widely respected and accepted, and the low-status people are used to showing a high degree of obedience and respect to the high-status people. This culture is also regarded as a key factor in maintaining social stability and improving efficiency.

2.2. The value orientation of collective orientation

Both China and Vietnam, as countries deeply rooted in “collectivism culture”, emphasize the importance of collective interests and group cooperation. Although in recent years, with the acceleration of globalization and the arrival of the information age, some young people have begun to show their recognition and pursuit of individualistic values, the collectivism culture is still deeply rooted and dominates the core value system of the society. Therefore, in the work environment under this cultural background, employment decisions and employees’ promotion opportunities are often not only based on individual ability and performance, but also deeply affected by the internal dynamics of the employees’ group, which reflects a complex and subtle network of group relations.

2.3. Uncertainty avoidance

Uncertainty avoidance refers to the behavioral strategies adopted by individuals or organizations in the face of uncertainty and ambiguity. It reflects the social members to the threat of a feeling of an uncertain situation and their efforts to avoid such a situation. According to the cultures of China and Vietnam, both countries show strong adaptability and inclusiveness in the face of the unknown and change. In this culture, people tend to face the risks and the unknown while keeping a relaxed attitude, willing to embrace change and new challenges, as opportunities for growth and exploration. In addition, the rules and regulations of the society are relatively relaxed, and diversity and individual choice are encouraged, so that different fields of thought can be tolerated and ideas can go hand in hand. Vietnamese people are generally believed to be too bound by the rules of freedom; they tend to be flexible when necessary, rather than formalized accurately and on time. The cultural features of low uncertainty avoidance but also embodied in the relaxed attitude on planning for the future, reducing unnecessary anxiety and stress. The Chinese, on the other hand, are willing to accept ambiguity, and the Chinese language is full of ambiguities that are difficult for Westerners to understand. The Chinese are adaptable and entrepreneurial.

2.4. Long-term orientation and short-term orientation

Long-term oriented culture tends to emphasize the importance of persistence, frugality, and planning for the future, while short-term oriented culture focuses more on the value of timely enjoyment, encourages the focus on the

present, respect for tradition, and respect for past experience.

The value orientation of the culture on the time dimension of each has been particularly emphasized. Vietnam is a relatively practical country, where the people appreciate both long-standing culture and also recognize the need for progress and innovation. This flexible way of thinking allows them to easily integrate traditions into the ever-changing environment. China, on the other hand, is a typical long-term country, a pragmatist-oriented society in which people believe that truth depends largely on circumstances, context, and time. They can easily adapt their traditions to changing conditions, have a strong propensity to save and invest, be frugal, and persevere when results are achieved. They also pay great attention to the process of things and the establishment and maintenance of relationships, and like long-term and stable cooperation.

3. The influence of China-Vietnam cultural characteristics on business negotiations

3.1. The embodiment of the concept of hierarchy in business negotiations

Both Chinese and Vietnamese teams attach great importance to the division of roles and decision-making order within the team, and the position of the core decision maker is particularly prominent in the negotiation, whose opinions often play a key role in the negotiation trend. Negotiations began, and the two sides will use many ways to quickly understand the team's organizational structure and level within the negotiating teams. Leaders often accompanied by significant status symbols, such as the leaders arranged in the middle seat, provide limousine pick-up service, in the main negotiation outdoor set up exclusive lounge, etc. This kind of phenomenon occurs in all kinds of negotiations between the two countries. In countries with high power distance, such status symbols are particularly important, and both sides understand and adapt to such arrangements ^[2]. In the negotiation process, both sides often show a strong demand for status consistency. They will advance communication negotiations and participate at the level of personnel, especially the hierarchy of the other team leader, in order to make corresponding arrangements to ensure that their head attends the negotiations. In decision-making linked to business negotiations, the team leader on both sides has the final decision; the subordinate plays an auxiliary role, supporting the superior decision-making process. If the subordinate interferes too much with the superior's decision, it may be regarded as violating the privilege of the management.

3.2. Influence of collective orientation on business negotiation

Both China and Vietnam have typical collectivist cultural characteristics in business negotiations, and both put "harmonious relationship" and "group consensus" in an important position. In the dialogue, the two sides will usually speak in a more implicit, low-key, and indirect way. In the face of communication disorders, they can take a consideration for collective solutions. Due to the similarity between the two sides, the business negotiation between the two sides will be smoother and more conducive to the achievement of the goal of the negotiation ^[3].

"Face" is especially important in business negotiation occasions. There are different ways for the maintenance of face; one is the emphasis on the personal appearance of an outstanding professional. For example, in business communication, both Chinese and Vietnamese people attach great importance to dress on negotiation occasions. One of the basic forms of respect is business dress. On the other hand, it emphasizes respect for individuals, hoping that their prestige and status will be recognized and respected in the group ^[4]. Then, the behavior of "giving face" usually includes praise, appreciation, and respect, avoiding criticism and conflict. For the behavior of "face", the Chinese team usually does very well. After judging the psychological status of the negotiation opponent, a

euphemistic compliment is added in the negotiation to make the negotiation tone more gentle and not aggressive, and try to make the negotiation opponent in a state of disarming and keep the negotiation atmosphere in a harmonious state ^[5].

In the negotiation process, the Chinese side tries to avoid direct confrontation with the other side, and often expresses rejection and disapproval in euphemistic ways, such as “we still need to discuss” and “maybe you are right”, so as to keep the atmosphere in a harmonious state. Chinese teams in the process of negotiations seldom use the word “no” directly, because the blunt refusal in collectivist cultures is regarded as a very abrupt and self-righteous behavior. However, when using a “yes”, “good”, the clear words such as “yes”, the Chinese team is not actually expressing consent in the absolute, but rather a polite response ^[6]. Chinese people usually do not have a very firm “yes” or “no” attitude in formal negotiation situations that are not very intense, because the way Chinese people express themselves, whether negative or positive, is more implicit. Therefore, in the negotiation process, if interpreters do not understand the Chinese speaking style when translating from Chinese to Vietnamese, they will often miss the tone and behavior of the original speaker, making the Vietnamese side unable to accurately understand the meaning expressed by the Chinese side ^[7].

3.3. The practice of flexible and adaptable characteristics in business negotiations

A tolerant attitude towards the uncertainty in the culture makes both parties in a negotiation bring strong flexibility and adaptability. The details of the face are not the default; both parties do not stick to a rigid process, but tend to be “practical” in finding a solution. For example, if a clause is found to be difficult to implement during the negotiation, the two sides will make adaptations by adding explanations and adjusting additional conditions, rather than terminating the discussion because it “does not meet the preset requirements” ^[8].

This flexibility is also reflected in the acceptance of new modes of cooperation. For cooperation involving new technologies and new fields, the two sides pay more attention to practical feasibility than inherent experience, and reduce risks by inviting professionals to participate in communication and phased pilot projects. This open attitude provides possibilities for cross-field cooperation. At the same time, the negotiations of time “elastic” tolerance is more obvious, if an emergency needs to adjust their agenda negotiations, both sides often need to understand the attitude of the negotiations at the new time, and avoid the influence due to strictly abiding by the form ^[9].

3.4. The influence of long-term orientation and short-term orientation on business negotiation goals

In the negotiation process between the Chinese and Vietnamese teams, the two teams will have great differences in the goals of the project. China’s national team as a long-term orientation culture, pay more attention to the long-term value of cooperation, in the negotiations will focus on terms of the influence of several rounds of cooperation in the future, such as the price mechanism, the respect such as service cycle tend to set the elastic clause, adjust the leave room for long; Also according to the actual situation on the condition of the negotiations to make some concession or compromise, be willing in friendly relations and cooperation between the goals and temporarily reduce their own interests ^[10]. As a country with a short-term orientation culture, Vietnam pays more attention to the implementation of the current stage while attaching importance to long-term cooperation, and will clarify the path to achieve short-term goals in the negotiation, such as phased delivery nodes and acceptance standards. This difference in time horizon may promote the two sides to form a “combination of long and short” cooperation

plan in the negotiation ^[11]. For example, in project cooperation, the Chinese side may pay more attention to the long-term planning of technology transfer, while the Vietnamese side pays more attention to the implementation effect of initial training. Through communication, the consensus is finally reached that basic training should be completed first, and then technology upgrading should be gradually promoted.

4. Acculturation strategies in China-Vietnam business negotiations

4.1. Make preparations for cultural cognition in the early stage

The smooth progress of cross-cultural business negotiations begins with a deep understanding of the cultural characteristics of both sides. Before the talks can be through the system research, China understands the culture of Vietnam business scenarios and related core characteristics, such as social etiquette, communication habits, the idea of cooperation, a particular focus on local custom specification formed in long-term relationships, such as emphasis on teamwork, accepting flexibility, and avoiding misunderstanding caused by cultural cognitive biases ^[12]. At the same time, combining their own cultures and negotiation-related behavior, such as emphasis on long-term cooperation, respect for hierarchy, etc., they need to keep clear in cross-cultural settings, principles, and flexible adjustment of space. The appropriate negotiation team should be arranged in advance to ensure that members have cross-cultural communication awareness and can keenly capture the cultural signals of the other side, laying a foundation for smooth communication.

4.2. Uphold cultural respect and inclusiveness

Since ancient times in China, they have been known as a formal state, and for their beauty. Influenced by Confucian culture, many rituals and customs in Vietnam are very similar to those in China. In the negotiation process, when faced with euphemistic opinions, people can explore the real demands through patient inquiry and positive feedback, rather than conflict due to differences in expression methods ^[13]. At the same time, respect does not mean unprincipled compromise, but on the premise of sticking to the bottom line of cooperation, people should optimize cooperation paths by adjusting communication methods and so on, so that different cultural characteristics of countries can become a bridge rather than an obstacle to promote cooperation and understanding. China should also pay particular attention to showing respect in detail and conveying sincerity for cooperation through them ^[14].

4.3. Pay attention to the legal effect of contracts

The sustainability of business cooperation cannot be separated from the joint commitment to the spirit of the contract. After reaching a cooperation consensus, both parties should pay attention to the strictness of the contract text, ensure that the terms are clear, the rights and responsibilities are clear, and fully reflect the core demands and risk prevention mechanism in cooperation. The Chinese should pay special attention to the law of Vietnam's local environment and business practices, to contract in the execution of the standard, way of dispute resolution, such as content, communication with legal professionals in advance, and ensure compliance with local regulations ^[15]. At the same time, in the process of contract performance, the Chinese side should maintain continuous communication with the other party. When unexpected situations occur, the Chinese side should not only respect the contract provisions, but also flexibly negotiate to solve them. This is both the seriousness of the maintenance contracts, as well as Chinese culture's emphasis on relationship maintenance, implementation specification, and flexible balance.

5. Conclusion

This paper analyzes the cultural characteristics of China and Vietnam and their impacts on business negotiations, clarifying the similarities and differences between the two countries in terms of social hierarchy concepts, collective orientation, uncertainty avoidance, and time orientation, as well as their specific reflections in negotiation decision-making, communication methods, and goal-setting. The study finds that although Chinese and Vietnamese cultures are both influenced by concepts such as collectivism and share common ground in hierarchy respect and relationship maintenance, there are still differences in the emphasis on long-term cooperation planning versus short-term execution, and the practical scale of flexible adaptation. These characteristics collectively shape the unique logic of bilateral negotiations.

Based on this, the proposed cultural adaptation strategies emphasize pre-negotiation cognitive preparation as the foundation, respect and inclusiveness as the principle, and contract standardization as the guarantee, aiming to help enterprises of both sides resolve communication barriers caused by cultural differences. In the future, with the further deepening of China-Vietnam economic and trade cooperation, enterprises need to continuously strengthen their cross-cultural negotiation capabilities. They should not only leverage the common advantages in the two cultures to build trust but also rationally address differences to optimize cooperation plans. Only in this way can the potential of bilateral cooperation be fully tapped, and China-Vietnam business exchanges be promoted towards a more efficient and stable direction.

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A Study on Innovative Approaches to Using Sensory Integration Toys in Nursery Schools from a Play Perspective

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Abstract: Sensory integration training, as a vital educational method for promoting the coordinated physical and mental development of young children, has garnered significant attention in the field of early childhood education in recent years. Traditional sensory integration toys predominantly consist of standardized, functional equipment, whose usage is often confined to predetermined rules and fixed procedures, making it challenging to fully stimulate children's autonomy and creativity. This paper adopts a "play perspective" to explore innovative approaches to using sensory integration toys in kindergartens. It advocates integrating sensory integration training into free, open, and imaginative play activities to enhance the enjoyment, contextual relevance, and individual adaptability of sensory integration education. Through literature analysis, case studies, and educational observations, the paper proposes four innovative application models: "play-based reconstruction", "cross-domain integration", "role-driven engagement", and "environmental creation." These models are validated within practical teaching contexts. Findings indicate that employing sensory integration toys through a play-based approach not only effectively enhances children's sensory integration abilities but also fosters their social skills, creativity, and problem-solving capabilities. Finally, this paper offers optimization recommendations, providing kindergarten teachers with actionable teaching strategies to advance sensory integration education towards a more humanistic and child-centered approach.

Keywords: Game-based perspective; Sensory integration toys; Innovative application; Kindergarten; Sensory integration; Educational innovation

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1. Introduction

With the deepening of the "child-centered" educational philosophy, the holistic development of children has become the core objective of preschool education and practice, with particular emphasis placed on the development of sensory integration abilities. Sensory integration constitutes the critical process whereby the

brain synthesizes information from visual, auditory, olfactory, gustatory, tactile, vestibular, and proprioceptive systems to generate adaptive responses. Early childhood represents a crucial developmental window for this process; adequate sensory stimulation and motor experiences during this period may influence attention, emotional regulation, learning capacity, and even social adaptation. However, while kindergartens currently provide various sensory integration toys (such as balance beams, tactile boards, and stilts), their use often follows formulaic patterns that neglect children's active participation. This may stifle their initiative and creativity. Consequently, this study adopts a play-based perspective to explore novel approaches for employing sensory integration toys in kindergartens, aiming to guide innovative usage strategies that better serve children's holistic development ^[1-4].

2. Traditional usage patterns of sensory integration toys and their limitations

2.1. Characteristics of traditional usage patterns

Current sensory integration toy usage in kindergartens exhibits the following core characteristics: Firstly, a pronounced goal-oriented approach, where activity design centers on enhancing specific sensory integration abilities such as balance, tactile discrimination, and vestibular stimulation. Content is tightly aligned with predetermined objectives, reflecting a strong functional orientation. Secondly, clearly defined standardized procedures, with teachers typically establishing fixed activity sequences including warm-up preparation, main activities, and cool-down relaxation phases, emphasizing standardized movements and safety. Thirdly, strong teacher-led direction, with educators acting as organizers and guides during activities, while children predominantly participate passively, required to strictly follow instructions to complete tasks; Fourthly, fixed equipment functionality, where each sensory integration toy typically serves a specific purpose—such as stilts primarily for balance training or tactile boards for sensory stimulation—resulting in limited versatility and difficulty in adapting flexibly to individual children's needs; Fifthly, evaluation methods are singular, predominantly relying on accuracy, speed, or repetition of actions as metrics. There is insufficient attention to children's emotional experiences, cooperative behavior, and creative expression—key aspects of holistic development—failing to comprehensively reflect the actual efficacy of sensory integration training ^[5].

These characteristics reveal the limitations inherent in traditional sensory integration toy usage patterns, while also providing practical grounds for exploring subsequent gamified innovation pathways ^[6]. Breakthroughs are required in areas such as goal flexibility, process openness, role equality, functional diversity, and comprehensive evaluation to better realize the educational value of sensory integration toys.

2.2. Existing limitations

Whilst traditional sensory integration toys can enhance foundational sensory integration abilities to some extent, their limitations are increasingly apparent. On one hand, children exhibit insufficient initiative: under conventional approaches, they lack choice and decision-making authority during activities, passively complying with teacher directives. This results in markedly lower engagement and attention compared to self-directed exploration. Research indicates that passive participation diminishes intrinsic motivation, gradually eroding children's interest in sensory integration activities. On the other hand, the rigid format of play is problematic: many sensory integration toys focus solely on mechanical training. For instance, a skateboard is used exclusively for straight-line gliding practice, without integrating it into scenarios like "space travel" ^[7]. This restricts children's imagination and problem-solving abilities, making it difficult to inspire sustained engagement. Furthermore, there is a lack of social

interaction and cooperative experiences: traditional sensory integration activities predominantly involve individual completion or task-oriented approaches, lacking collaborative design. Children seldom have opportunities to complete tasks or share experiences with others. This model hinders the development of cooperative awareness and social skills, making it difficult for them to integrate into group play scenarios. Finally, integration with other domains is inadequate: traditional sensory integration toys typically function solely within the motor domain, failing to incorporate elements from language, art, science, and other areas (e.g., balance beams focus solely on equilibrium without integrating counting “steps taken across the beam” or directional terms like “two steps to the left”). This prevents children from transferring sensory integration experiences to complex real-life scenarios, hindering the formation of a comprehensive cognitive framework.

3. Theoretical foundations and implications of the play perspective

3.1. The educational value of play

Play is not only inherent to childhood but also a vital pathway for learning and development. Piaget posited that play constitutes the primary form of cognitive development in children, enabling them to internalize external experiences and construct knowledge systems through symbolic play ^[8]. Vygotsky emphasized play’s role within the “zone of proximal development”, arguing that it facilitates children’s transcendence of their current developmental level to achieve higher-order psychological functioning ^[9]. Furthermore, play facilitates children’s emotional regulation, social interaction, and moral development ^[10]. Contemporary educational theory regards play as an ideal vehicle for “deep learning.” It permits children to experiment, fail, reflect, and re-attempt within a secure environment, thereby constructing complex knowledge and higher-order abilities. As advocated by Chen Heqin through “learning by doing, learning through play”, play constitutes the core method by which children actively construct their experiences ^[11].

3.2. The essence of the play perspective

The spirit of play does not merely point towards “gamification” or rely solely on altering activity formats. Its core tenets lie in respecting children’s autonomy and joyful experiences, organically embedding emotional training within natural, open, and meaningful play contexts. Its core essence can be analyzed from multiple dimensions: Firstly, the fundamental unit, which prioritizes children’s interests, needs, and developmental levels. It emphasizes educators respecting children’s agency within play, accommodating and supporting their ideas. Secondly, a process-oriented approach, valuing exploration, discovery, and firsthand experience over outcomes or skill acquisition. It permits aimless exploration and unconventional play styles. Thirdly, it involves scenario creation, where imaginative play settings (such as “Underwater Worlds” or “Space Capsules”) are employed to assign new functions and meanings to toys, enhancing immersion. Fourthly, it balances freedom with rules, establishing necessary frameworks while ensuring ample space for free exploration. This approach safeguards safety and order while encouraging collaborative rule-making. Fifthly, openness and generativity require both content and form to possess open-ended qualities, permitting young children to flexibly adapt play based on personal interests and facilitating generative curriculum implementation. Under this philosophy, play ceases to be isolated “training material” and instead becomes an active, creative practice arena for children. Its role transforms from a singular medium into an interactive connecting bond, with usage becoming increasingly diverse, dynamic, and inventive ^[12].

4. Innovative applications of sensory integration toys through a play perspective

4.1. Gamified reconstruction: Reimagining toy functionality

“Gamified reconstruction” involves altering the original function and usage of sensory integration toys through narrative scenarios, role-playing, or challenge-based tasks, integrating them into more engaging play activities.

Case Study 1: “Jungle Exploration” with multi-functional stilts

Traditionally, stilts primarily serve balance training. Under “gamified reconstruction”, educators may create a “Jungle Expedition” scenario: children embody “explorers,” with stilts becoming “logs crossing swamps”, sensory discs transforming into “mysterious stone circles”, and scooters evolving into “speeding sledges.” Children must maintain balance in “danger zones” while seeking “treasure.” This approach not only enhances balance but also stimulates imagination, language expression, and problem-solving skills. Teachers may further guide children to draw “exploration maps”, documenting routes and discoveries to achieve cross-curricular integration ^[13].

4.2. Cross-domain integration: Transcending subject and equipment boundaries

“Cross-domain integration” refers to combining sensory toys with other domains (such as language, art, science) or multiple pieces of equipment to achieve coordinated development across multiple senses and abilities.

Case Study 2: Integrated play with the “River Movement Set”

The “River Movement Set” includes equipment such as balance beams, soft mats, and rollers. Teachers may combine it with music and storytelling: Playing flowing water sounds while children role-play as “fish” navigating the “river”, requiring them to traverse the balance beam (“stone bridge”), crawl through rollers (“caves”), and jump over mats (“waves”). Rhythm games are integrated, such as walking to the tempo of drumbeats. This activity combines vestibular, proprioceptive, auditory, and rhythmic senses while developing musical perception and physical expression. Teachers may guide discussions on “river formation” and “fish behavior” to link scientific knowledge.

4.3. Role-driven: Stimulating active participation through roles

“Role-driven” refers to assigning children specific roles (e.g., firefighter, doctor, astronaut) to inspire a sense of responsibility and mission, thereby encouraging active engagement in sensory integration play.

Case Study 3: “Little Firefighters” rescue operation

Simulate a “fire scene” using equipment like slides, climbing frames, and balance beams. Children assume the role of “firefighters”, requiring them to swiftly traverse the “fire scene” (crawling mats), scale the “high-rise building” (climbing frame), and cross the “wobbly bridge” (balance beam) to execute “rescue operations.” This activity not only develops gross motor skills and sensory integration abilities but also cultivates courage, responsibility, and teamwork. Teachers may guide discussions on “safe evacuation procedures” and “fire safety knowledge” to enhance safety awareness.

5. Environment creation: Child participation in game design

“Environment creation” refers to encouraging children to participate in planning sensory integration games and arranging equipment, enabling them to become the “designers” and “creators” of the games.

Case 4: Children independently construct an “Adventure Playground”

Teachers provide various sensory integration equipment (such as soft mats, arches, ball pits, ladders) and guide children to discuss and design their own “adventure playground” in groups. Children must negotiate layouts,

establish rules, and test safety. This process not only develops spatial cognition and planning skills but also enhances cooperation, communication, and critical thinking. Teachers may document children's design plans and discussion processes as course evaluation materials.

6. Educational value of innovative usage

From a play perspective, innovative applications of sensory integration toys offer multiple educational benefits. Firstly, they significantly enhance the enjoyment and sustainability of sensory training through contextualized, role-based designs that stimulate children's motivation to participate, enabling them to continuously develop sensory skills within pleasurable experiences. Research indicates participation rates in such activities exceed traditional training methods by over 30% ^[14]. Secondly, it facilitates the holistic development of children's comprehensive abilities—transcending the limitations of single-skill training, it enables children to simultaneously develop motor skills, language expression, social interaction, emotional regulation, and other competencies during play. For instance, in firefighter role-play, children can enhance both physical coordination and problem-solving abilities while developing social role recognition. Thirdly, it fully respects individual differences and autonomy—permitting children to select play methods based on personal interests, catering to the unique needs of different developmental stages. In the “Architect” game, for instance, children independently decide the theme and approach of their constructions, thereby unleashing creativity. Fourthly, it effectively enhances teacher-child interaction and peer collaboration. Sensory integration toys serve as “play companions”, fostering positive connections between educators and children, as well as among children themselves, thereby cultivating relationships built on equality and mutual trust. For instance, in the “Traffic Engineer” game, teachers and pupils jointly explore play methods, deepening the collaborative atmosphere. Fifthly, it enables natural curriculum integration—incorporating sensory integration training into thematic activities or courses (e.g., the “Parachute Drop” game) makes sensory sessions an organic component of the curriculum rather than isolated activities, promoting systematic and life-oriented teaching content ^[15].

7. Implementation recommendations and challenge management

The implementation pathway for sensory integration toy adaptation must prioritize the deep integration of “gamification” with sensory training, driven by multi-dimensional measures: Firstly, transforming teacher guidance, shifting the teacher's role from director to observer and facilitator. Support children's autonomous exploration by providing challenging game scenarios (e.g., adding obstacles) rather than direct intervention; Secondly, optimizing environments and materials by creating rich, open, and modular sensory integration spaces equipped with multifunctional resources (e.g., balance beams adaptable for walking, role-play, and varied training). Dedicated play structures should permit children to freely combine materials for activities. Thirdly, implementing safety protocols by conducting regular hazard assessments of venues and equipment with safety as the baseline. Children should be permitted to learn through trial and error (e.g., attempting balance exercises of varying difficulty). Safety boundaries should be communicated to parents via meetings to secure understanding and cooperation. Fourthly, professional development frameworks should be established through tiered teacher training covering sensory integration theory, play design (including scenario creation and difficulty progression), and assessment methodologies. This enhances the team's capacity for gamified teaching, with reform effectiveness evaluated through observation logs and portfolio analysis. Fifthly, advancing home-school collaboration. Break the

limitations of solitary play by regularly organizing parent-child sensory integration game days, involving parents in children's learning processes to foster family recognition and support for gamified education. Only through multidimensional collaborative efforts can the deep integration of gamification and sensory integration training be achieved, enabling young children to naturally develop sensory integration abilities through joyful play^[16–18].

8. Conclusion

Sensory integration toys should transcend mere “training tools” to become “magical instruments” that ignite children's spirit of play and creative potential. Approaching sensory integration toys from a play-based perspective and innovating their usage represents a vital pathway to prioritizing children's needs and realizing education's fundamental purpose. Through models such as gamified reconstruction, cross-domain integration, role-driven engagement, and environmental creation, sensory integration education can transcend the limitations of mechanical training, moving towards a future imbued with greater vitality, imagination, and humanistic care. It is hoped that more kindergartens and educators will boldly explore these approaches, enabling every child to achieve harmonious physical and mental development through joyful play. Future research may further investigate the long-term effects of gamified sensory integration education, its applicability across diverse cultural contexts, and innovative applications of digital sensory toys, thereby providing sustained momentum for high-quality development in early childhood education^[19].

Disclosure statement

The author declares no conflict of interest.

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Research on the Impact of the Contents of Goods Reviews on Consumers' Purchasing Intention

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Abstract: This paper tries to explore the impact of online goods reviews on consumers' purchasing intentions. Based on the text word frequency statistics method, the study proposed a research hypothesis and evaluated the impacts of the primary and secondary attributes of goods involved in online reviews on the purchase intention of consumers. Reviews on the cost performance, brand, logistics service, quality, and appearance of goods will have an impact on consumers' purchase intention, with the largest impact on appearance, the second largest on quality and cost performance, and the smallest on brand and logistics service. The results of this research can provide management enlightenment for e-commerce enterprises on how to improve the market recognition of their products by virtue of Internet reputation.

Keywords: Word frequency count; Goods attributes; Purchase intention

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1. Introduction

To obtain more real reviews about the products and avoid risks, most online shoppers usually refer to relevant online product reviews before making a transaction (including: the pros and cons of the product, quality, cost-effectiveness, satisfaction, etc.)^[1]. Product online reviews reflect consumers' intuitive feelings about products, and have also become one of the references for e-commerce companies to improve products and formulate marketing strategies. To leverage the power of reviews, merchants should focus on improving overall review quality to gain consumer trust and increase purchase willingness^[2].

Numerous studies have examined the influence of online reviews on purchase intention^[1-6]. These studies examine the format, quantity, and channel of online reviews, the credibility of reviewers, consumer behavior, and online reputation. These studies primarily analyze factors influencing purchase intention from the consumer perspective, while fewer studies empirically analyze factors influencing purchase intention based on fine-grained product attributes from the merchant perspective. However, with the proliferation of online reviews, e-commerce companies struggle to truly understand consumer needs from this vast pool of feedback. For example, when consumers browse product reviews, which aspects of the product attributes are most influential in their purchase

intention? Which dimension of product descriptions in online reviews is most influential in consumers' purchase desire? Exploring these questions will help merchants identify useful reviews, thereby improving product design, developing review-driven mechanisms, and implementing targeted marketing strategies to boost consumer purchase intention.

This paper will obtain review texts based on web crawlers, extract evaluation objects (i.e., product attributes) from the texts, and then determine the potential factors that may affect consumers' purchasing intentions, propose research hypotheses, and verify the hypotheses using structural equation models.

2. Literature review

Online product reviews, as an important form of online word-of-mouth, significantly influence consumers' purchase decisions and product sales on e-commerce websites, and have always attracted the attention of the majority of researchers^[7]. A higher quantity of reviews can lead to increased consumer confidence, while the quality of these reviews is crucial for effective persuasion^[8]. Positive reviews enhance purchase intention, with valence showing a strong correlation to consumer decisions^[9].

The current research status will be elaborated from two aspects: product reviews and the influence of product reviews on consumers' purchase intentions.

Research on the content of product reviews can generally be summarized into the following aspects: the credibility of review content, the usefulness of review content, the quality of review content, and the emotional tendency of review content. Generally, the dimensions of credibility evaluation include the relevance, timeliness, accuracy, and sufficiency of reviews^[10]. In the study of review usefulness, academia has no unified view on the factors that affect the utility of online product reviews. Some studies suggest that the subjectivity of opinions in the content helps predict the utility of reviews, while others indicate that consumers' perception of review usefulness is influenced by the relevance, objectivity, and timeliness of the review information^[11–12]. The quality of review information is generally composed of dimensions such as timeliness, relevance, completeness, added value, accuracy, and understandability^[13]. In the aspect of emotional analysis of review content, a literature closely related to this study also explores attribute features in reviews and uses them as dimensions for evaluating user satisfaction^[14]. By calculating the weight values of each dimension, it finds that the key factors affecting user satisfaction are: product, price, interaction, service, and logistics. However, unlike this study, it did not investigate consumer purchase intention.

Purchase intention is the tendency of consumers to make purchase decisions and a reflection of actual purchase behavior^[1]. A large number of scholars have conducted research on how product reviews influence consumers' purchase intention. Research suggests that the quality attributes of online reviews, the platform, and user characteristics all affect consumers' purchase intention. Consumers' perceptions of the ease of use and usefulness of online reviews promote their willingness to use them, ultimately enhancing their purchase intention^[15]. Research proposes that the length, quantity, and emotional tendencies of online reviews affect consumers' perceived usefulness, meaning consumers judge whether online reviews influence their purchase decisions based on whether there are enough reviews, whether they are objective, and whether there are more positive reviews^[16]. Research conducted empirical research on the impact of review quality and reviewer status on consumers' purchase intention^[17]. Research studied the influence of online review contradiction on consumers' contradictory attitudes and purchase intention, using the product attributes mentioned in the review content and the source of the reviewer as two dimensions to categorize contradictory online reviews into four types^[18]. From an attribution theory perspective,

they explored the differences in the impact of these four types of contradictory online reviews on consumers' contradictory attitudes and purchase intention.

Through previous related research findings: the research on the influencing factors of consumer purchase intention based on product review content is mostly concentrated on the characteristics of the review text, such as text length, quantity, and sentiment tendency, these relatively broad influencing factors are discussed, and has not further refined the characteristics of the product itself into more specific factors for discussion; at the same time, most studies consider the usefulness of reviews from the perspective of consumers, fewer based on merchants from the perspective of product and service improvement to carry out research on the influencing factors of purchase intention.

Based on this, this paper intends to further refine the influencing factors of review content on purchase intention in combination with previous research into more specific and consistent with actual review content, and helpful for merchants to improve product design and service influencing factors for research.

3. Methodology

This paper captures review data from the two major Chinese online shopping platforms, Taobao and JD.com, to statistically analyze the frequency of review language in different types of products, thereby identifying fine-grained attribute features of products as influencing factors. Additionally, referring to previous research findings by other scholars, it proposes corresponding research hypotheses.

3.1. Product attribute identification

This paper uses web crawling technology to collect review data for major categories of goods, including clothing, daily necessities, mobile phones, skincare products, electrical appliances, and food, and obtains the word frequency statistics shown in **Table 1** through Chinese word segmentation.

Table 1. Product review frequency chart

Category	Review content	Frequency	Category	Review content	Frequency	Category	Review content	Frequency
Clothing	Good quality	10635	Daily Goods	Good service attitude	1852	Phones	Strong performance	4587
	Comfortable to wear	5731		Decent quality	1299		Nice phone	4452
	Looks good on	4139		Fast delivery	690		Fast shipping	1995
	Great color	3672		Matches description	211		Stylish design	1621
	Nice style	3339		Great cost-effective	98		Great cost-effective	1185
Category	Review content	Frequency	Category	Review content	Frequency	Category	Review content	Frequency
Skincare	Fast logistics	15587	Electronics	Very cheap	1055	Food	Affordable	1560
	Good packaging	10005		Good quality	880		Fast logistics	1434
	Moisturizing	8111		Fast logistics	440		Excellent quality	1119
	Good quality	4770		Good service	210		Tastes good	618
	Pleasant scent	3519		Average quality	91		Expensive	378

Through further in-depth analysis, it has been found that the review data of various products all involved cost-effectiveness, quality, brand, logistics services, and appearance, and their frequency of appearance was relatively high. Therefore, these dimensions were selected as the main attributes (quality, appearance, brand) and secondary attributes (cost-effectiveness, logistics services) of the products.

3.2. Hypotheses

As product review data grows, merchants find it increasingly difficult to derive useful insights to improve products or understand consumer behavior. Identifying how fine-grained attributes affect purchase intention can help businesses quickly identify strengths and weaknesses and develop targeted strategies. This study examines five attributes—cost-effectiveness, quality, brand, logistics, and appearance—as independent variables influencing purchase intention.

Frequently reviewed attributes indicate consumer concern, but widespread review manipulation undermines trust. When many reviews mention certain features, consumers may either perceive them as objective or suspect fraud. Decisions ultimately depend on personal judgment. From a business perspective, it remains unclear which attributes truly affect purchasing. Thus, the following hypotheses are proposed:

H1: The more reviews related to cost-effectiveness, the more they influence consumers' purchasing intention.

H2: The more reviews related to a brand, the more they influence consumers' purchasing intention.

H3: The more comments are related to logistics service content, the more they affect consumers' purchasing intention.

H4: The more comments are related to quality content, the more they affect consumers' purchasing intention.

H5: The more comments are related to appearance content, the more they affect consumers' purchasing intention.

4. Experimental design

4.1. Method

Before conducting large-scale questionnaire distribution and collection, a pre-test is first conducted to examine whether the designed questionnaire meets the reliability and validity requirements for the experiment. This paper first employs the AMOS model for confirmatory factor analysis of the data. If the measurement model's fit is acceptable, path analysis will be used to explore the relationships among the independent variables affecting consumer purchase intention and their impact on the dependent variable, identify key influencing factors, verify the model, and provide data support for this study.

The experimental work of this study is divided into three parts: 1) Designing a five-point Likert measurement scale. This scale consists of a set of statements, each with five response options: "Completely believe," "Somewhat believe", "Uncertain", "Somewhat disbelieve", and "Completely disbelieve", respectively recorded as 1, 2, 3, 4, and 5. The total attitude score of each respondent is the sum of their scores for each statement, which can indicate the strength of the respondent's attitude ^[19]. Randomly select 30 consumers with online shopping experience for pre-testing to verify the rationality and feasibility of the designed scale; 2) Select and determine the research subjects, mainly distributing and collecting questionnaires among a broad consumer group with online shopping experience, and screening out valid data; 3) Use SPSS tools to analyze the valid data to test whether it can be used for the subsequent modeling stage.

4.2. Experimental preparation

4.2.1. Measurement indicator design

The measurement indicators in the research scale designed in this paper refer to the previous research results of relevant scholars and are further modified and refined based on them (Table 2)^[20–25].

Table 2. Measurement indicators

Variable	Issue indicator	Indicator details	Source
Price-effective	P1	Most reviews state that the product offers good value for money	Wu X, 2016
	P2	Most consumers give positive feedback on the product's cost-effectiveness	
	P3	Most reviews mention that the product is attractively priced and comes with small free gifts	
	P4	Most reviews believe the product is more cost-effective than most competing products	
Brand	B1	Most reviews feel the brand's culture aligns with their own values	Wang J, 2016
	B2	Most reviews indicate the brand enjoys a certain level of public awareness	
	B3	Most reviewers have a strong sense of identity and loyalty toward the brand	
	B4	Most reviews regard the brand as highly credible or reputable making it a worry-free purchase	
Logistics service	L1	Most reviews mention information about the merchant's logistics service	Wang X, 2017
	L2	Most consumers praise the delivery personnel's service attitude	
	L3	Most consumers give positive feedback on the merchant's logistics speed (dispatch and delivery)	
	L4	Most reviews believe the product's return & exchange service is good	
Quality	Q1	Most reviews mention the product's quality	Song M et al., 2019
	Q2	Most consumers believe the product's durability meets their purchase expectations	
	Q3	Most reviews state the product's quality closely matches expectations	
	Q4	Most reviews praise the product's workmanship and material quality	
Appearance	A1	Most reviews provide concrete product-appearance descriptions and photo displays	Moon S et al., 2016
	A2	Most consumers express high satisfaction with the product's appearance	
	A3	Most reviews state the product style is novel and the description matches the actual item	
	A4	Most reviews report no color difference in the product	
Willingness to purchase	W1	I would generally be willing to buy this product	Onwezen et al., 2017
	W2	If possible, I will continue to purchase this product	
	W3	I would consider recommending this product to my classmates and friends	
	W4	When buying similar products in the future, I will prioritize this one	

4.2.2. Select research subjects

Students, as the main consumers of online shopping, play an increasingly important role in online shopping. Additionally, most students tend to browse product reviews before making a purchase, and are also more willing to

share their online shopping experiences and psychological feelings on social platforms. Therefore, this study will mainly distribute questionnaires and collect data from young students aged 18–30 to obtain the data samples for this experiment.

4.2.3. Pre-test

Pre-testing is conducted to ensure that each question indicator corresponding to each variable in the designed questionnaire meets the requirements of the experiment. Initially, a small random sample of 30 research subjects was selected and surveyed, and the sample characteristics were analyzed, and the reliability of the indicators was tested. Any indicators that did not meet the experimental requirements were repeatedly modified until the reliability analysis of the questionnaire met the experimental requirements.

Approximately 87% of the research subjects selected for the pre-test have a monthly consumption level of over 1000, indicating a certain purchasing power and making them a likely group for online shopping, which enhances the representativeness of the experimental results. Additionally, the majority of the research subjects have a college education or higher. 83.33% of them have a rich history of online shopping, and 76.67% have made more than five online purchases within the past six months, suggesting that the selected subjects are more familiar with online shopping and have a stronger voice in opinions about product reviews. This demonstrates that the selected survey subjects are targeted. It indicates that the survey subjects selected for this experiment are representative and scientifically sound, which is a crucial guarantee for making the experimental results more convincing.

To analyze the consistency of responses to various question formats regarding the same influencing factor among the research subjects, this paper uses the Cronbach Alpha coefficient from SPSS statistical analysis software to measure the reliability of the questionnaire, with the results shown in **Table 2**. The data in the table indicate that the overall reliability coefficient of the questionnaire is 0.858, which is greater than the standard value of 0.8, indicating that the designed questionnaire has high reliability^[26]. The Cronbach Alpha coefficient for each item corresponding to each question indicator after deletion is all smaller than its Cronbach's Alpha value, suggesting that all items should be retained^[27]. The overall correlation coefficient CITC for each question indicator corresponding to each variable is all greater than 0.3, indicating a strong correlation between the various question indicators^[28]. In summary, it can be demonstrated that the reliability of the questionnaire designed in this study meets the requirements of the experiment (**Table 3**).

Table 3. Pre-test statistics for each indicator

Dependent variable	Issue indicator	Scale mean if item deleted	Variance of scale if item deleted	Corrected item-total correlation	Item deleted Cronbach's alpha	Cronbach's alpha
Price-effectiveness	P1	84.13	86.878	.552	.824	0.849
	P2	84.10	85.197	.663	.748	
	P3	84.07	82.961	.510	.832	
	P4	84.20	90.303	.716	.763	
Brand	B1	84.00	87.103	.631	.800	0.818
	B2	84.17	89.937	.670	.758	
	B3	83.97	84.516	.649	.796	
	B4	83.83	86.557	.591	.811	

Table 3 (Continued)

Dependent variable	Issue indicator	Scale mean if item deleted	Variance of scale if item deleted	Corrected item-total correlation	Item deleted Cronbach's alpha	Cronbach's alpha
Logistics Service	L1	84.00	85.655	.599	.853	0.942
	L2	83.87	85.637	.648	.851	
	L3	83.90	83.817	.533	.848	
	L4	83.93	87.444	.560	.854	
Quality	Q1	84.03	87.137	.623	.811	0.829
	Q2	84.00	86.483	.524	.820	
	Q3	84.00	88.621	.513	.755	
	Q4	83.90	85.472	.612	.809	
Appearance	A1	83.77	85.633	.517	.804	0.812
	A2	83.97	86.930	.453	.791	
	A3	84.07	84.961	.546	.848	
	A4	84.20	87.476	.416	.783	
Willingness to purchase	W1	83.90	85.266	.676	.846	0.887
	W2	83.97	85.689	.424	.852	
	W3	84.43	87.220	.741	.860	
	W4	84.70	81.252	.523	.855	
Sum						0.858

5. Data analysis and discussion

5.1. Formal investigation sample statistical analysis

This survey was created on the Wenjuanxing platform. If a survey has more than 15% of its questions unanswered or marked as “uncertain”, it can be considered invalid. Additionally, surveys with identical question options and those with excessively short completion times were excluded. The survey distribution process lasted over a month, and a total of 227 valid surveys were eventually collected. The statistical profile of the research subjects is as follows:

1. The gender ratio in the total sample is largely consistent with the gender ratio in the pre-test and is relatively balanced, without bias toward any particular gender, ensuring the scientific validity of the experimental results. This indicates that the selection of male and female subjects for this experiment is reasonable.

2. The distribution of education levels in the total sample data is largely consistent with the distribution in the pre-test. Approximately 95.6% of the respondents have a college education or higher. This suggests that the subjects have a higher level of education, making them more likely to use the internet for online shopping and to pay attention to online product reviews. Therefore, the subjects selected for this experiment are more representative and targeted, strengthening the scientific validity of the conclusions.

3. The distribution of monthly consumption levels in the total sample data is largely consistent with the

distribution in the pre-test data. Over 85% of the subjects spend more than 1,000 yuan per person on average, indicating that the subjects have greater purchasing power and are more likely to engage in online shopping.

4. The distribution of online shopping history in the total sample data is basically consistent with the pre-test distribution, and the proportion of people with more than 3 years of online shopping history is as high as 85%, indicating that the survey subjects have rich online shopping experience and are more likely to post or view product reviews.

5. The distribution of online shopping frequency in the total sample data is basically consistent with the distribution of online shopping frequency in the pre-test data, and the proportion of people with more than 3 online shopping sessions within half a year is as high as 96%, indicating that the selected survey subjects have more say in product reviews.

5.2. Structural validity analysis

Structural validity is to test whether the questions in the questionnaire design are effective and reasonable. Structural validity is often tested by factor analysis to find the potential factors that affect the dependent variable, and rotation techniques can be used to explain these factors. When the cumulative variance contribution rate in the factor analysis is greater than 50% and the factor loading is above 0.5, it indicates that the designed scale has good structural validity.

This paper intends to use exploratory factor analysis for validity analysis. However, whether a questionnaire can be used for exploratory factor analysis depends on its KMO value and Bartlett's sphericity test. Only when certain conditions are met can researchers determine whether the designed questionnaire can be used for exploratory factor analysis to test its structural validity. The judgment criteria are:

1. KMO value judgment criteria^[29]: A KMO value above 0.9 indicates that it is very suitable for factor analysis; a KMO value between 0.8-0.9 indicates that it is very suitable for factor analysis; a KMO value between 0.7-0.8 indicates that it is suitable for factor analysis; a KMO value between 0.6-0.7 indicates that it is not very suitable for factor analysis; a KMO value between 0.5-0.6 indicates that it is difficult to perform factor analysis; a KMO value below 0.5 indicates that it is not suitable for factor analysis.

2. Bartlett's sphericity test judgment criteria^[30]: When the significance probability of the Bartlett value is less than 0.01, it is suitable for factor analysis.

This paper will use SPSS to conduct factor analysis on independent variables and dependent variables, respectively.

5.2.1. Factor analysis of independent variables

KMO test and Bartlett's test: The test results of the independent variables are shown in **Table 4**, where it is found that the KMO value is 0.823, greater than 0.8, and the significance probability of Bartlett's sphericity test is less than 0.01, indicating that it is suitable for factor analysis.

Table 4. KMO and Bartlett's test for the independent variable

KMO measurement of a sufficient sample size		0.823
Bartlett's sphericity test	Approximate chi-square	2494.724
	df	190
	sig.	.000

Factor extraction: The results of factor analysis are shown in **Figure 1**. Starting from the sixth factor, the size of its eigenvalue gradually becomes flat, which verifies that it is reasonable to extract five factors in this experiment.

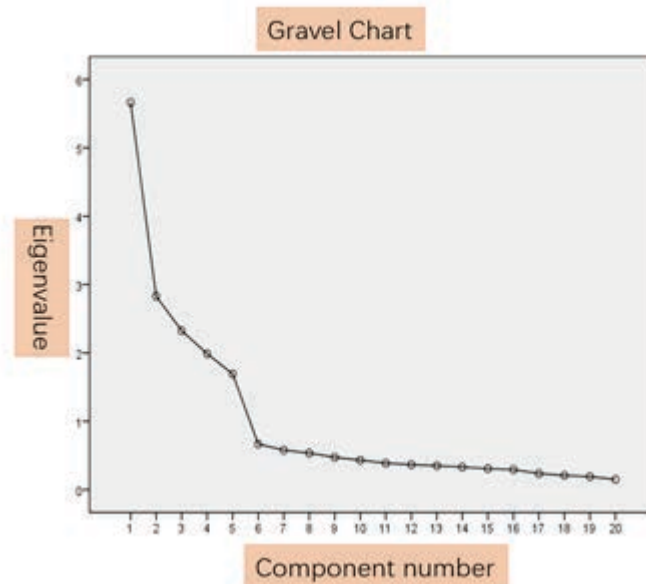


Figure 1. Gravel chart

Test results: **Table 5** is mainly used to observe which variables can be included in which factors: The variable with the highest factor loading in Column 1 is cost-performance; the variable with the highest value in Column 2 is the quality indicator; the variable with the highest value in Column 3 is the logistics service indicator; the variable with the highest value in Column 4 is the brand indicator; the variable with the highest value in Column 5 is the appearance indicator. The maximum value for each column's factor is all greater than 0.5, and the cumulative variance contribution rate of the total sample is 72.471%, which is greater than 50%, indicating that the self-variable problem items in this experimental design have good structural validity.

5.2.2. Factor analysis of the dependent variable

KMO test and Bartlett's test: The test results of the dependent variable are shown in **Table 6**, where it was found that the KMO value is 0.848, greater than 0.8, and the significance probability of Bartlett's sphericity test is less than 0.01, indicating suitability for factor analysis.

Test results: As shown in **Table 7**, the factor loadings of each measurement item for purchase behavior intention are 0.889, 0.886, 0.881, and 0.854, all of which are greater than the benchmark value of 0.5, and the cumulative explained variance contribution rate is 77.42%, which is also greater than the benchmark value of 50%. Based on the factor loadings and cumulative explained variance, the dependent variable items designed in this study demonstrate good structural validity.

Table 5 Factor analysis of measurement items for each dimension of product reviews

Dimension	Item	Factor loadings					Rotation Square Sum loading		
		F1	F2	F3	F4	F5	Eigenvalue	Explain variance%	Cumulative explained variance
Price-effectiveness	P1	.888	.104	.093	.213	.095	5.661	28.305	28.305
	P2	.866	.117	.032	.118	.044			
	P3	.821	.079	.145	.160	.043			
	P4	.859	.132	.061	.108	.114			
Brand	B1	.009	.810	.135	.084	.129	2.829	14.145	42.450
	B2	.149	.835	.154	.062	.043			
	B3	.114	.837	.187	.070	.007			
	B4	.163	.809	.078	.186	.110			
Logistics service	L1	.141	.208	.806	.028	.097	2.325	11.623	54.073
	L2	.096	.028	.874	-.018	.057			
	L3	.071	.095	.880	.031	.032			
	L4	.008	.218	.730	.037	-.004			
Quality	Q1	.114	.132	-.003	.809	.127	1.988	9.938	64.011
	Q2	.070	.139	-.035	.766	.047			
	Q3	.170	.134	.009	.824	.144			
	Q4	.236	-.035	.124	.796	.125			
Appearance	A1	.043	.071	.130	.112	.724	1.692	8.460	72.471
	A2	.021	.062	.081	.169	.846			
	A3	.087	.121	-.014	.099	.845			
	A4	.112	.014	-.029	.036	.820			

Note: Bold values are the maximum items for each column factor

Table 6. Factor analysis of the dependent variable

KMO measurement of sufficient sample size			0.848
Approximate chi-square			560.077
Bartlett's sphericity test			df
			6
			sig.
			.000

Table 7. Factor analysis of willingness to purchase measurement items

Dimension	Item	Factor loadings		Rotating sum of squares and loading	
		Factor 1	Eigenvalue	Explain variance %	Cumulative explained variance %
Willingness to Purchase	W1	0.889	3.097	77.420%	77.420%
	W2	0.886			
	W3	0.881			
	W4	0.854			

5.3. Structural equation modeling path analysis

Structural equation modeling is primarily used to verify the structural relationships of research hypotheses and generally includes steps such as model construction, model fitting, model evaluation, and model modification (Figure 2).

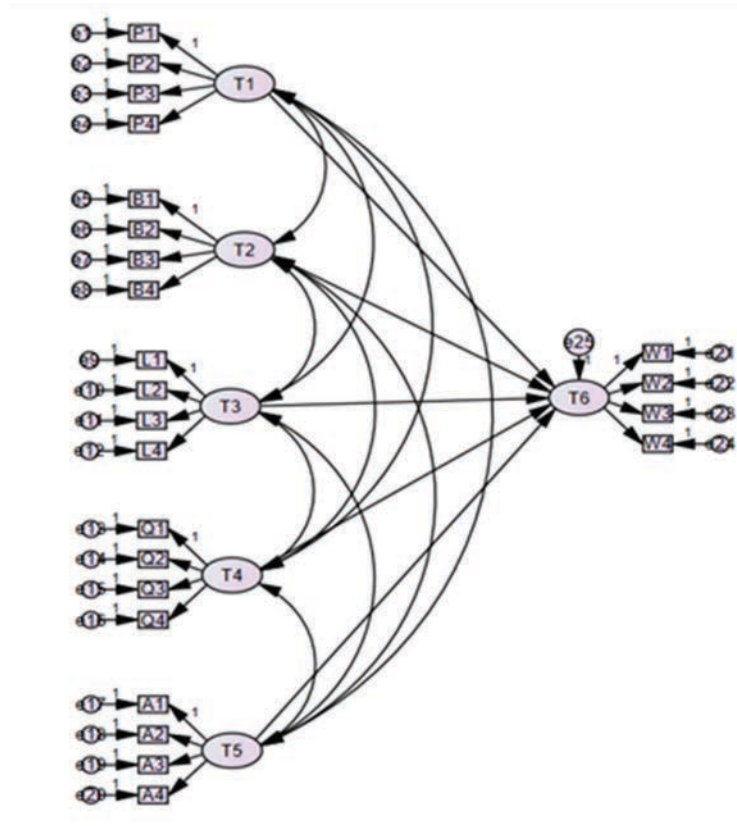


Figure 2. Initial structural equation model diagram

5.3.1. Model construction

This study uses AMOS software to conduct path analysis on structural equation models, as shown in Figure 2.

5.3.2. Model fitting

Goodness of fit analysis is used to test the constructed model and compare whether the predicted results are consistent with the actual situation and the degree of consistency. Whether a model has a good fit depends on the specific conditions of each goodness-of-fit indicator. The judgment criteria are shown in Table 8 below^[31].

Table 8. Criteria for judging the fitting indicators of SEM models

Item		Absolute fit indices			Incremental fit indices			Parsimonious fit indices	
Class	χ^2/df	GFI	RMR	RNSEA	NFI	TLI	CFI	PGFI	PNFI
Stand	<3	>0.9	<0.08	<0.08	>0.9	>0.9	>0.9	>0.5	>0.5

After importing the questionnaire data and running the model, the indicators of fitting are shown in Table 9.

Table 9. Results of the SEM equation model fitting

Item	Absolute fit indices				Incremental fit indices			Parsimonious fit indices	
Class	χ^2/df	GFI	RMR	RNSEA	NFI	TLI	CFI	PGFI	PNFI
Standard	<3	>0.9	<0.08	<0.08	>0.9	>0.9	>0.9	>0.5	>0.5
Result	1.411	0.894	0.023	0.043	0.898	0.962	0.968	0.706	0.771
Evaluation		Good				Good			Good

1. The chi-square degrees of freedom for the absolute fitting indicators are less than 3, GFI is very close to 0.9, and both RMR and RNSEA indices are less than 0.08, indicating that the absolute fitting indicators of this model fit well.

2. Among the incremental fitting indicators, the NFI index is very close to 0.9, and both TLI and CFI indices are greater than 0.9, indicating that the incremental fitting indicators of this model fit well.

3. For the parsimonious fitting indicators, both PGFI and PNFI indices are greater than 0.5, indicating that the parsimonious fitting indicators fit well.

In summary, the structural equation model constructed in this paper has a good fit.

5.3.3. Model evaluation

Model evaluation involves testing each hypothesized path in a structural equation model to determine if there is a relationship, which allows judgment of whether the independent variable has an effect on the dependent variable. The evaluation criteria are as follows: CR values greater than 1.96 with $P < 0.05$, CR values greater than 2.58 with $P < 0.01$, and CR values greater than 3.29 with $P < 0.001$. Meeting any one of these criteria allows for the conclusion that the hypothesis is accepted, indicating that the hypothesized path is valid. The path coefficient results after model execution are shown in **Table 10**.

Table 10. Initial model path coefficients and significance levels

Hypothesis	Path relationship	Estimated value	S.E.	C.R.	<i>P</i>
H1	P→W	0.216	0.076	2.527	0.027
H2	B→W	0.148	0.067	2.216	0.041
H3	L→W	0.135	0.062	2.181	0.029
H4	Q→W	0.248	0.065	2.736	0.008
H5	A→W	0.350	0.117	2.999	0.003

As shown in **Table 10**, according to the above judgment criteria, each path in the hypothesis can be established, meaning that the cost-effectiveness, brand, logistics service, quality, and appearance involved in product reviews all significantly affect consumers' purchase intention. The magnitude of the estimated values indicates the extent of the impact of each path, where the impact of appearance on purchase intention is 0.350, the impact of quality on purchase intention is 0.248, the direct impact of cost-performance on purchase intention is 0.216, and the direct impacts of brand and logistics service on purchase intention are 0.148 and 0.135, respectively. This indicates that the impact of appearance is the greatest, followed by quality and cost-performance, and the impact of brand and logistics service is the smallest. Since all the hypothesized paths in the structural equation

model are valid, this model does not require modification.

5.4. Discussion of results

Based on the research and investigation mentioned above, the analysis conclusions of this paper are as follows:

1. Among the factors influencing consumers' purchase intentions, product reviews related to appearance hold the highest impact, indicating that consumers pay particular attention to the design of product appearance. Firstly, merchants should not only focus on appearance design but also provide as detailed information as possible about the product appearance on e-commerce platforms. Moreover, when reviewers comment on the high alignment between expected and actual styles, color differences, etc., in product appearance, it will be beneficial to promote consumers' purchase intentions. At the same time, merchants can encourage and guide purchased consumers to give positive reviews on appearance.

2. In product reviews, information related to quality and cost-effectiveness has a slightly weaker impact on consumers' purchase intentions compared to appearance. This suggests that young consumer groups prioritize visual effects over product quality and price. Merchants should continuously develop innovative appearance designs to attract consumers' attention, thereby promoting purchase intentions. At the same time, they should set appropriate prices based on the product's performance to enhance cost-effectiveness and further boost consumers' purchase intentions.

3. Product reviews containing brand information have an impact on consumers' purchase intentions, but it is less significant than the impact of quality. This indicates that when consumers browse product reviews, they may already be familiar with the brand and thus do not pay much attention to brand information mentioned in the reviews. Only some consumers who are relatively unfamiliar with the product's brand may focus on such review information. Merchants should cultivate their brand's cultural value, enhance consumers' brand identity and loyalty, and build a positive brand image among the public to shape a good reputation, which will be beneficial to promoting consumers' purchase intentions.

4. Logistics services mentioned in product review content have an influence on consumers' purchasing intentions, but compared to other features, their influence is the smallest. The reason may be that logistics services are affected by multiple factors (region, weather, delivery personnel, etc.), and consumers, to some extent understand the merchants. However, merchants must choose trusted logistics partners for cooperation, ensuring timely tracking of services after orders are placed, and strive to deliver the products to consumers as quickly as possible.

6. Conclusion

The findings reveal that all five selected factors influence consumer purchase intentions, with appearance having the greatest impact, followed by quality and cost-effectiveness, and brand and logistics services having the least impact. This study will help merchants improve product design, develop mechanisms to guide reviews, and implement targeted marketing strategies, thereby enhancing consumer purchase intentions.

The research subjects in this study are all young people, and the representativeness of the conclusions for the entire user group is still limited. Additionally, this study focuses on binary variables, without incorporating more factors to explore how the content of product reviews influences consumer purchase intentions. It only investigates which aspects of reviews consumers pay more attention to, thereby assisting merchants in developing relevant

review guidance mechanisms. Future research should comprehensively consider a broader range of user groups and include more mediating variables in the research model to further study the factors influencing consumer purchase intentions related to the fine-grained attribute features of product review content.

Disclosure statement

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AI-Driven Corporate Social Responsibility Communication: Practical Applications, Ethical Considerations, and Development Pathways

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Abstract: The deployment of artificial intelligence in corporate philanthropy communication confers distinct advantages: algorithmic analytics afford a granular diagnosis of social needs, while generative models facilitate the orchestration of imaginative intervention scenarios. By open-sourcing AI assets and fostering co-creation among heterogeneous actors, firms can automatically produce multimodal philanthropic content, thereby catalyzing a paradigmatic shift away from legacy charitable formats. Yet this technologization simultaneously surfaces salient ethical tensions. Restrictive interpretations of corporate social responsibility, precarious protection of user privacy and rights, and technological over-dependence that erodes user autonomy exemplify the emergent dilemmas. To countervail these risks, corporations must integrate AI-based social initiatives into strategic master plans, intensify comprehensive technological application and iterative innovation, and bolster internal governance mechanisms while refining external philanthropic legitimacy. Moreover, cross-sector alliances with diverse non-profit organizations should be cultivated to constitute an interstitial “philanthropic ecosystem” that aggregates multi-actor resources, jointly addresses complex social problems, and accelerates societal advancement and sustainable development.

Keywords: Artificial intelligence; Corporation social responsibility communication; Ethical consideration; Development path

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1. Introduction

As the pivotal engine of global digital transformation, artificial intelligence (AI) is precipitating a new cycle of scientific-technological revolution and industrial reconfiguration. Since 2015, the Chinese state has promulgated a succession of policy instruments to accelerate AI innovation and diffusion; most notably, the 2017 New Generation Artificial Intelligence Development Plan elevated AI to the status of a national strategic priority. With society’s transition from the conventional “Internet Plus” era to an emergent “Intelligence Plus” epoch, domestic enterprises are vigorously expanding R&D investment in AI and embedding algorithmic systems across

production, circulation, and consumption circuits to enhance productive efficiency and innovative capacity. While pursuing technological advances, firms are simultaneously fulfilling social obligations by channeling resources into philanthropic initiatives. The maturation of AI and big-data architectures has markedly augmented corporate capabilities in prosocial communication. The 14th Five-Year Plan for the Development of the Advertising Industry foregrounds the primacy of social value and mandates technological innovation to catalyze digital upgrades of public-service advertising products and services. By harnessing AI to energize philanthropic messaging, corporations unlock novel opportunities for reputational construction; this reciprocal empowerment enables the realization of simultaneous rent-seeking and social value creation, yielding a Pareto-optimal equilibrium between economic returns and public welfare.

The notion of “philanthropic communication” (*gongyi chuanbo*) was first explicitly theorized in the Chinese context by Ma Xiaoli and Zhang Jiankang, who delineated it as a non-profit constellation of communicative practices—encompassing public-service advertising, news reportage, websites, campaigns, projects and donations—whose telos is the advancement of the collective good and the catalysis of cultural development and social progress ^[1]. Xia Jiaxin and Yang Weifang subsequently expanded the conceptual perimeter, foregrounding the polycentric agency characteristic of the digital ecology and the imperative of dialogic engagement with individuated publics embedded in algorithmic networks ^[2]. As the technological repertoire evolves, so too does the praxis of philanthropic communication: scholars interrogate not only the efficacy of persuasive strategies but also the structural impediments that constrain them, proffering corresponding remedial protocols. Lü Wenkai and Chen Weijian, for instance, argue that short-form video—by virtue of its interactivity, persuasive potency, granular targeting capacity, and synergistic articulation of user-generated content with celebrity capital—opens a new affordance space for prosocial messaging ^[3]. Lai Zheli, turning to the intelligent-media epoch, explicates how big-data analytics, augmented reality, blockchain infrastructures, and location-based services reconfigure the pathways through which philanthropic discourse is produced, circulated, and monetized ^[4]. Yet, within China’s internet polity, philanthropic communication remains fraught with challenges pertaining to legal-policy articulation, content quality assurance, and transactional transparency—deficits that necessitate coordinated governance by state organs, platform operators, corporations, and networked citizenries alike.

The philanthropic-communication arena is intrinsically polyphonic; the corporation constitutes merely one node within a heterogeneous constellation of actors. As early as 2009, Wang Yanlong et al. situated philanthropic communication within an emergent civil society, theorizing it as a multidimensional value system co-produced through the recursive interaction and discursive hybridization of disparate communicative agents ^[5]. These scholars taxonomize four primary modalities: media-led philanthropic dissemination, corporate philanthropic marketing, state philanthropic governance, and civic philanthropic participation. Chen Xiaodong legitimizes the instrumentalization of philanthropic communication, contending that no brand engages social issues without strategic calculi of reputational return ^[6]. Shu Yongping and Gu Yu, conversely, argue that corporate philanthropic communication transcends the marketing frame, its axiological nucleus being the centering of public interest within the firm’s operative rationality ^[7]. Contemporary scholarship predominantly privileges corporate-centric analyses, foregrounding instrumental efficacy and tactical explication. Yang Linya posits that philanthropic marketing yields brand-image appreciation, profit accretion, and public legitimation, while Bian Wei prescribes, for the digital-media epoch, granular attunement to everyday life-worlds, dialogic interactivity, strategic temporalization, platform polyvalence, and thematic sustainability ^[8–9]. Notwithstanding these contributions, theorization of philanthropic communication under the epistemic conditions of the algorithmic age remains

conspicuously underdeveloped.

1.1. AI helps corporate public welfare: The application and advantages of intelligent technology in the field of communication

1.1.1. Penetrating social demand and architecting arenas for philanthropic participation

Philanthropic praxis is oriented toward the advancement of collective welfare, prioritizing constituencies confronting structural disadvantage and ameliorating entrenched social predicaments. Corporations must therefore cultivate acute socio-diagnostic acuity prior to orchestrating philanthropic communication. Artificial intelligence (AI), via its algorithmic data-mining and machine-learning capacities, exfiltrates latent patterns and correlations from multi-stratal social datasets, enabling granular identification of heterogeneous group-specific needs and the consequent calibration of contextually appropriate philanthropic scenarios, thereby intensifying the precision of prosocial messaging. In recent years, leading internet enterprises have operationalized AI to intervene in salient social problems. In 2020, Alibaba Group and Unilever co-launched the “Plastic Free” sustainable-development initiative, co-engineering an AI-empowered closed-loop plastics-recycling system whose intelligent recovery apparatuses have been instantiated across multiple empirical contexts. In 2021, Baidu introduced the “Five Blessings AI for the Elderly” program, integrating functionalities from Baidu Brain 7.0 to address senior citizens’ requirements in social interaction, quotidian life-services, and health-care support, thereby facilitating dignified ageing. In 2022, the Ministry of Science and Technology, in concert with five ministerial counterparts, promulgated the Guiding Opinions on Accelerating Scenario-Based Innovation to Foster High-Quality Economic Development via High-Level AI Application, mandating the consolidation of corporate hegemony in AI scenario innovation and enjoining sectoral leaders to fabricate inventive scenarios targeted at national strategic imperatives and critical livelihood issues.

1.1.2. AI technology commons: Architecting an ecology of participatory innovation

Historically, philanthropic initiatives were orchestrated under the aegis of state organs. The diffusion of Internet infrastructures subsequently pluralized the agentic landscape of philanthropic communication; nevertheless, the “AI + philanthropy” paradigm has yet to permeate the civic stratum. Algorithmic capabilities remain largely sequestered within research institutes and large-scale enterprises, while the public’s AI literacy and affordances for praxis remain underdeveloped. To enroll heterogeneous actors in prosocial propagation, apex Internet and AI corporations have converted proprietary technological capital into a commons by releasing AI assets, thereby catalyzing mass-participatory innovation. The Tencent Charitable Foundation’s “Light Tech for Social Good Incubator”, in collaboration with Tencent Youtu Lab, open-sources standardized AI APIs and vertical solutions, incentivizing civic communities to redeploy Tencent Cloud’s algorithmic stack to address salient social issues. Since its inception, the incubator has mobilized more than 3,600 teams and 18,000 developers. Baidu’s “Stellar Initiative” (a CSR technology-enablement platform) discloses not only AI models but also traffic, infrastructural and financial resources, convening developers, content creators and ecosystem partners to co-produce algorithmic remedies for social problems. iFlytek likewise democratizes its service portfolio, granting philanthropic projects cost-free access to its AI platform and end-to-end technical support. Through the commodification of AI as a public good, corporations extend the semiotic reach of philanthropic communication, excavate latent innovative trajectories and emergent thematic foci, and sustain socio-algorithmic support for populations in need.

1.2. Ethical considerations: The challenge of corporate public welfare communication in the intelligent era

Obstacles to AI-enabled philanthropy: Deficient corporate sense-making. Although the last decade has witnessed a monotonic rise in corporate engagement with social causes and philanthropic communication has become a privileged vehicle for signaling CSR commitment, empirical observation reveals that a considerable proportion of firms remain cognitively entrenched in superficial interpretations of social responsibility. Despite near-consensus in both scholarly and practitioner communities that CSR is a tetradic construct encompassing economic, legal, ethical, and philanthropic accountabilities, many enterprises continue to conflate regulatory compliance with exhaustive CSR fulfilment. This reductive equation betrays a residual profit-centric episteme that impedes deeper apprehension of the normative and civic dimensions of corporate accountability, thereby constraining the imaginative and moral bandwidth necessary for algorithmically mediated philanthropic innovation.

2. Build a lasting impact: The development blueprint of the intelligent era of corporate public welfare communication

When interrogating the nexus between technology and social responsibility, Emmanuel G. Mesthene's *Technological Change: Its Impact on Man and Society* furnishes this study with a cardinal heuristic: technological artefacts are morally indeterminate—neither intrinsically benevolent nor malign; their societal valence is wholly contingent upon the modes of human appropriation. This axiom exhorts corporations to transcend inherited cognitive schemata and cultivate inventive trajectories in mobilizing technology for philanthropic communication and CSR praxis. Guided by this maxim, firms can architect and deploy AI systems to parse heterogeneous social datasets, thereby calibrating hyper-specific philanthropic interventions. Algorithmic analytics render visible previously occluded vulnerable constituencies and emergent social deficits, permitting the formulation of targeted remedial strategies. Moreover, AI-enabled feedback loops can be embedded throughout project implementation and evaluation cycles, ensuring dynamic resource optimization and continuous process refinement.

3. Discussion

In the emergent epoch of artificial intelligence, corporations are ethically enjoined to assume proactive custodianship of social responsibility by sustaining an unwavering commitment to philanthropic communication. While algorithmic architectures inaugurate unprecedented affordances for prosocial messaging, firms must simultaneously institutionalize reflexive vigilance, iteratively surfacing and redressing the ethical externalities that co-evolve with AI deployment. Through strategic deepening, intensified techno-governance, and continuous algorithmic recursivity, enterprises must enshrine human centrality and praxis-oriented rationality as axiomatic constraints, thereby steering AI trajectories toward socially generative teloi and co-optimizing corporate growth with societal flourishing. In so doing, corporations not only harmonize technological innovation with fiduciary responsibility but also ensure that the development and diffusion of AI remain subordinated to the commonweal, propelling the polity toward a more equitable and sustainable futurity.

4. Conclusion

In the era of artificial intelligence (AI), enterprises should be more proactive in fulfilling their social responsibilities while continuously paying attention to and practicing public welfare communication. However,

while recognizing the numerous benefits and opportunities that AI brings to public welfare communication, enterprises need to constantly reflect on and make every effort to mitigate or address the ethical issues inherent in AI applications. By means of strategic upgrading, technological supervision and advancement, as well as upholding the subjectivity and practicality of human beings, enterprises should continuously guide the “ethical application of AI” (AI for good), thereby achieving a win-win situation for both their own development and social progress.

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