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Research on the Hydrophilic Modification Mechanism and Application of Polypropylene Fibers Based on Silane Coupling Agents and Acrylic Resin Composite Systems

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Abstract: Polypropylene (PP) fiber plays a significant role in civil engineering, textile engineering, and filtration/separation due to its excellent mechanical properties, chemical resistance, and low cost. However, its molecular chain, composed entirely of carbon and hydrogen, lacks polar functional groups, resulting in very low surface energy and poor hydrophilicity. This inherent defect severely limits its application effectiveness in scenarios requiring good interfacial adhesion or hydrophilic/moisture-absorbing properties. For instance, in concrete, the weak interfacial bond between the fiber and the cement matrix leads to low stress transfer efficiency; in textiles, its poor moisture-wicking property significantly affects wearing comfort.

This study aims to develop and systematically investigate a composite crosslinking agent, with silane coupling agent and waterborne acrylic resin as core components, for efficient and durable hydrophilic surface modification of PP fibers. The paper begins with an in-depth literature review, analyzing the surface characteristics and modification needs of PP fibers, and systematically summarizing the principles and limitations of existing hydrophilic modification techniques. Based on this, an innovative synergistic modification mechanism of "Silane Coupling Agent Bridging - Acrylic Resin Film Formation" is proposed: The hydrolyzed silanol groups of the silane coupling agent (e.g., KH-550) anchor onto the PP fiber surface, while the organic functional group (e.g., amino group) at the other end reacts chemically with the carboxyl groups on the molecular chains of the waterborne acrylic resin. Subsequently, through the resin's own crosslinking and curing, a robust, continuous, and hydrophilic group-rich three-dimensional network coating is constructed on the fiber surface.

Based on this mechanism, this paper designs a complete and feasible experimental research plan. The scheme details the entire process from the preparation of the composite crosslinking agent, the pre-treatment of PP fibers and the dip-dry modification process, to systematic characterization and performance evaluation. Characterization methods include Fourier Transform Infrared Spectroscopy (FTIR) for analyzing changes in surface chemical structure, Scanning Electron Microscopy (SEM) for observing surface morphology evolution, contact angle measurement and water absorption tests for quantifying the improvement in hydrophilic performance, and cement mortar flexural strength tests to verify the practical enhancement effect of the modified fibers in composite materials.

Through in-depth discussion and analysis of the anticipated results, this study theoretically demonstrates the feasibility and effectiveness of this composite crosslinking agent system. The expected results indicate that polar functional groups will be successfully introduced, and a dense coating will be formed on the surface of the modified PP fibers. The water contact angle can be significantly reduced to the hydrophilic range, and the water absorption rate will be greatly improved. Furthermore, the interfacial bonding with the cement matrix will be fundamentally improved, thereby significantly enhancing the flexural strength of cement mortar. This research not only provides a novel, environmentally friendly, and highly promising technical pathway for the hydrophilic modification of PP fibers but also offers theoretical reference for deeply understanding the construction mechanism of

organic-inorganic hybrid coatings on fiber surfaces, holding significant theoretical and practical importance for promoting the development and application of high-performance PP fiber composites.

Keywords: Polypropylene fiber; Hydrophilic modification; Silane coupling agent; Acrylic resin; Concrete reinforcement

1. Introduction

1.1 Research Background and Significance

Synthetic fibers are indispensable materials in modern industry and daily life. Among them, Polypropylene (PP) fiber has experienced rapid global development since its inception, owing to its outstanding advantages such as low density (only 0.91 g/cm^3), high specific strength, strong resistance to acid and alkali corrosion, good processability, abundant raw material sources, and low cost. Its production volume ranks among the top of synthetic fibers. Currently, PP fibers are widely used in various fields: in the civil engineering and construction industry, as secondary reinforcement in concrete, they effectively inhibit plastic shrinkage cracks and improve the impermeability and durability of the material; in the textile field, for producing carpets, upholstery fabrics, safety rope nets, and various non-woven fabrics; in environmental protection, for making filter cloths, oil sorbent booms, etc. [1]

However, just as a coin has two sides, the PP fiber molecular chain consists of pure carbon-carbon backbone and methyl groups. This highly symmetric non-polar structure, while granting it excellent chemical stability, also results in its intrinsic characteristics of very low surface energy (about 30 mN/m) and large water contact angle (often greater than 90°).

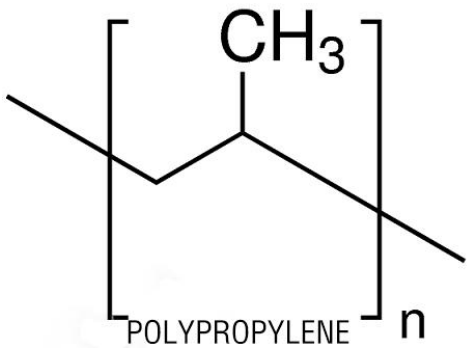

Figure 1 Polypropylene molecular structural formula

This strong hydrophobicity has become the "Achilles' Heel" restricting the further enhancement of its performance and the expansion of its application scope. In cement concrete, the hydrophobic fiber surface has poor compatibility with the strongly polar cement hydration products, leading to weak interfacial bonding force and the formation of a distinct "weak interfacial zone." This not only reduces the frictional force required to pull out the fiber from the matrix, limiting the full play of its bridging and crack-blocking effects, but may also allow the interface to become a channel for moisture and aggressive ions ingress during long-term service, potentially adversely affecting durability. [2]In the textile field, PP fibers cannot absorb human sweat, causing stuffiness and static accumulation when worn, resulting in comfort far inferior to natural fibers like cotton. This limits their application in high-end apparel, medical protection, and hygiene materials.

1.2. Necessity of Hydrophilic Modification of Polypropylene Fibers

Therefore, performing surface hydrophilic modification on PP fibers to fundamentally improve their wettability and adhesion with polar substances (such as water, cement paste) has become a key scientific and technological issue urgently needing resolution in both academia and industry. Through modification, the following goals are expected to be achieved: (1) Significantly reduce the fiber-water contact angle and improve its wetting speed and

water absorption capacity; (2) Establish strong interfacial bonding between the fiber and the matrix (e.g., concrete, resin), thereby efficiently transferring stress and fully utilizing the fiber's reinforcement and toughening effects; (3) Endow the fiber with new functionalities, such as antistatic properties, dyeability, etc., broadening its application fields. [3]A successful modification method requires not only significant effects but also a durable modification layer, with simple, controllable, and industrially scalable processes.

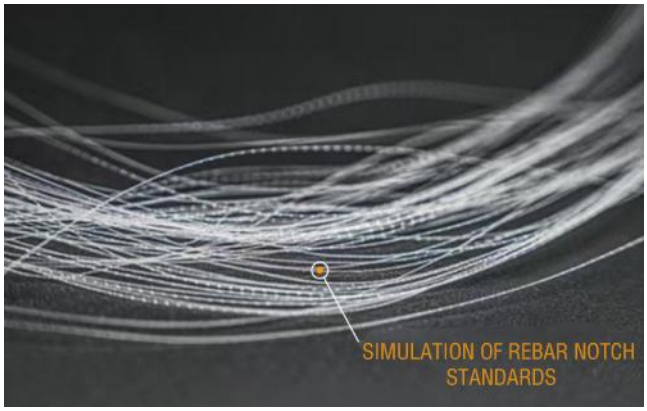

Figure 2 Simulation of Rebar Notch Standards

1.3. Main Content, Approach, and Innovation of This Research

Based on the above background, this study proposes a new strategy for surface hydrophilic modification of PP fibers using a composite crosslinking agent based on silane coupling agent and waterborne acrylic resin.

The main contents include:

Systematically reviewing the domestic and international research status of PP fiber hydrophilic modification to provide a theoretical basis for positioning this research.

Elaborating on the mechanism of synergistic modification of PP fibers by silane coupling agent and acrylic resin.

Designing a detailed experimental plan, including the preparation of the composite crosslinking agent, the modification process flow for PP fibers, and systematic and comprehensive performance characterization methods.

Theoretically analyzing and discussing the anticipated experimental results to demonstrate the feasibility and superiority of this method.

Summarizing the research findings and outlining future improvement directions and application prospects.

Research Approach: The core idea of this research is to construct a "trinity" synergistic modification system. Firstly, the silane coupling agent acts as a "molecular bridge," with its silanol end anchoring onto the PP fiber surface through physical adsorption and possible weak chemical interactions. Secondly, its organic functional group end (e.g., amino group) reacts chemically with active groups (e.g., carboxyl groups) in the waterborne acrylic resin, forming covalent bonds. Finally, the acrylic resin further crosslinks and cures during heat treatment, forming a tough, continuous, and hydrophilic functional group-rich three-dimensional network film on the fiber surface. [4]This film is firmly "locked" onto the fiber surface through chemical bonds and physical entanglement, thereby providing durable and stable hydrophilic performance.

Innovations of this research are mainly reflected in:

Creatively compounding acrylic resin, widely used in coatings and adhesives, with classic silane coupling agents to address PP fiber surface modification, providing a new technical perspective.

Moving beyond mere "physical coating" and emphasizing the "chemical bridging" between the acrylic resin and the fiber surface via the silane coupling agent, theoretically expecting more durable and robust modification effects. [5]

The research plan design encompasses a full-chain verification from molecular-level structural characterization

(FTIR) to macroscopic application performance evaluation (mortar flexural strength), aiming to comprehensively and systematically evaluate the overall effect of this modification method.

2. Literature Review and Theoretical Basis

2.1. Structure, Properties, and Application Bottlenecks of Polypropylene Fibers

Polypropylene is a typical semi-crystalline polymer with high molecular chain regularity, making it easy to crystallize. PP fibers are usually produced by melt spinning, during which the molecular chains are highly oriented along the fiber axis, resulting in high strength and modulus. However, it is precisely this regular non-polar alkane structure that causes the surface to lack polar sites capable of forming hydrogen bonds with water molecules, resulting in extreme hydrophobicity. Measurements show that the contact angle of unmodified PP fibers can exceed 104°. Furthermore, literature indicates that the "water-repellency" of PP fibers is the main obstacle faced in many applications. This hydrophobicity directly leads to two core problems: firstly, poor interfacial adhesion, making it a weak point in composites; secondly, poor moisture absorption, leading to poor comfort in textiles. [6]

2.2. Research Progress in Hydrophilic Modification Techniques for PP Fibers

To overcome the above bottlenecks, researchers have developed various hydrophilic modification techniques, which can be mainly divided into the following categories.

2.2.1. Physical Modification Methods

Mainly include corona treatment, plasma treatment, UV irradiation, and flame treatment. These methods use energetic particles or rays to act on the fiber surface, causing molecular chain scission, generating free radicals, and introducing oxygen-containing polar groups (such as carbonyl, carboxyl, hydroxyl), thereby improving hydrophilicity. Studies have used plasma treatment on PP melt-blown nonwovens, showing clear improvement in hydrophilicity after treatment. [7]The advantages of this method are fast processing speed, noticeable effects, and being a dry process; the disadvantages are that the modification effect usually decays over time (i.e., "aging effect"), and the equipment cost is high, making it difficult to treat thick parts or complex-shaped fiber assemblies.

2.2.2. Chemical Modification Methods

Mainly include surface graft copolymerization and chemical vapor deposition. Surface graft copolymerization is one of the most effective methods. It generates free radicals on the PP fiber surface via initiators or high-energy radiation, which then undergo graft copolymerization with hydrophilic vinyl monomers (e.g., acrylic acid, acrylamide), "growing" hydrophilic polymer chains on the fiber surface. The modification effect of this method is durable and stable because chemical bonding is introduced. [8]However, the process is usually complex, involving the use of monomers, initiators, and subsequent purification, and may affect the bulk mechanical properties of the fiber to some extent.

2.2.3. Surface Coating Modification Method

This method involves coating the fiber surface with a hydrophilic polymer solution or emulsion via dipping, padding, spraying, etc., followed by drying and curing to form a hydrophilic film. This is a relatively simple, mild, and industrially feasible method. Studies have used a hydrophilic finishing agent for padding treatment of PP fibers, successfully reducing their contact angle. The key to this method lies in the selection of coating materials. [9]The ideal coating material needs to combine good hydrophilicity, strong adhesion to the PP substrate, and mechanical strength and durability of the coating itself. If the coating does not adhere firmly to the fiber, the hydrophilic performance may not withstand washing and friction.

2.3. Types, Hydrolysis Mechanism, and Application of Silane Coupling Agents

Silane coupling agents are a class of organosilicon compounds with the general formula $Y\text{-}R\text{-}SiX_3$, where X is a hydrolyzable group (e.g., methoxy, ethoxy), and Y is an organic functional group (e.g., amino, epoxy, vinyl, methacryloxy). [10] Their mechanism of action is generally considered to involve the following steps: 1) Hydrolysis of X

groups in a water-alcohol solution to generate reactive silanols (-SiOH); 2) Condensation between silanols to form low-molecular-weight siloxanes; 3) These silanols and oligomers form hydrogen bonds with hydroxyl groups (-OH) on the inorganic substrate surface; 4) Further condensation during drying or curing forms strong -Si-O-M- (M being the inorganic substrate) covalent bonds. Simultaneously, the Y functional group reacts chemically or physically entangles with the organic polymer.

Silane coupling agents are powerful in improving interfacial properties. Studies using silane coupling agents to treat glass microspheres in cement-based drilling sealing materials showed that the interfacial bonding force between the glass microspheres and the cement stone was significantly enhanced after silane treatment, thereby improving the mechanical properties of the sealing material. This provides direct theoretical and practical support for this study's use of silane coupling agents to "bridge" PP fibers (as the organic phase) and the subsequent acrylic resin coating (as the organic phase, but containing polar groups). Another study went further, directly using a silane coupling agent (KH-570) to modify nano-TiO_2, then compounding it with polyacrylic resin to successfully prepare a high-performance composite tanning agent. This fully demonstrates the effectiveness of silane coupling agents in promoting the compounding of acrylic resin with inorganic nanoparticles, and its approach provides important reference for this study. [11]

2.4. Characteristics, Classification, and Hydrophilic Mechanism of Acrylic Resins

Acrylic resins are an important class of polymer polymers formed by the copolymerization of acrylate and methacrylate monomers. Their main chain consists of carbon-carbon bonds, and the side chains are carboxylic ester groups, which give them good film-forming properties, transparency, weather resistance, and mechanical properties. Depending on the dispersion medium, they can be classified into solvent-based, water-soluble, and waterborne emulsion types. Among them, waterborne acrylic resin emulsions use water as the dispersion medium, are non-toxic, non-flammable, and environmentally friendly, representing the mainstream development in the coatings and adhesives field today.

Figure 3 Chemical structural formula of acrylic resin

The hydrophilicity of acrylic resins mainly comes from the polar ester groups (-COOR) on their molecular chains and, typically, functional monomers containing carboxyl (-COOH) or hydroxyl (-OH) groups introduced during synthesis. These hydrophilic groups can form strong hydrogen bonds with water molecules, thereby endowing the material with good wettability and water absorption capacity. This provides the possibility for its use as a PP fiber surface coating material. [12]

2.5. Application of Silane/Acrylic Resin Composite Systems in Material Modification

Combining silane coupling agents with acrylic resins can achieve complementary and synergistic performance enhancement. Research modified the surface of TiO_2 with a silane coupling agent, improving its dispersion and interfacial bonding in the polyacrylic resin matrix; the final composite material performed excellently in leather retanning. This suggests that silane coupling agents can similarly be used to treat PP fiber surfaces. Although the PP surface has very few hydroxyl groups, the hydrolyzed silane can still achieve initial anchoring through physical

adsorption and van der Waals forces, creating interfacial conditions for its organic functional groups to react with the acrylic resin.

2.6. Theoretical Basis and Feasibility Analysis of This Research

Based on literature analysis, the proposed scheme of "modifying PP fibers with a silane coupling agent/acrylic resin composite system" has a solid theoretical basis and high feasibility.

Theoretical Basis:

Interfacial Anchoring Theory: The silanols generated after hydrolysis of the silane coupling agent, although difficult to form strong covalent bonds with PP, can achieve initial, stable attachment through intermolecular forces, hydrogen bonding (If pretreatment generates a small amount of oxygen-containing groups on PP), and the "anchor hook effect" by penetrating into fiber micro-voids.

Interfacial Chemical Reaction Theory: The terminal $-NH_2$ group of the selected aminosilane (KH-550) can undergo amidation condensation reaction with the -COOH groups in the acrylic resin under heating conditions ($-NH_2 + -COOH \rightarrow -NHCO- + H_2O$), forming strong covalent bonds. This is the chemical guarantee connecting the silane layer and the resin layer. [13]

Polymer Film Formation and Crosslinking Theory: During water evaporation and heat treatment, the latex particles in the waterborne acrylic resin emulsion deform and coalesce, forming a continuous and dense film. If the resin itself is designed with crosslinkable groups or external crosslinkers are added, a three-dimensional crosslinked network can be formed, greatly enhancing the coating's mechanical strength, durability, and protective ability for the core material.

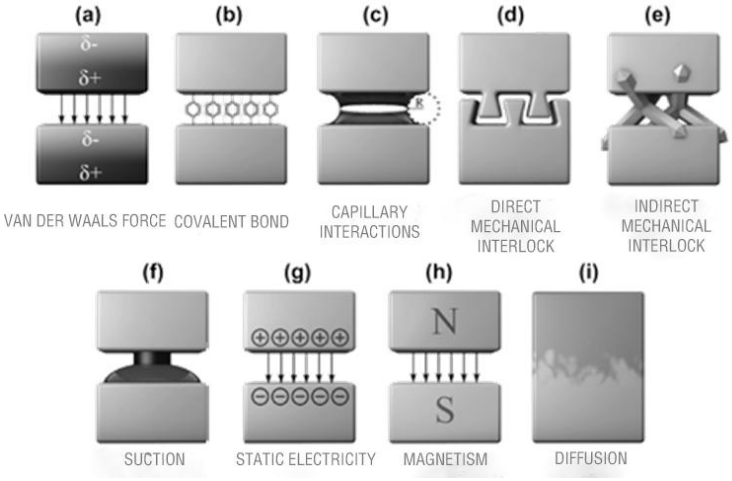

Figure 4(a) van der Waals forces; (b) Covalent bond; (c) Capillary interactions; (d) Direct mechanical interlock; (e) Indirect mechanical interlock;(f) Suction; (g) Static electrostatic; (h) Magnetic; (i) Diffusion

Feasibility Analysis:

Material Feasibility: The selected silane coupling agent and waterborne acrylic resin are commonly available commercial chemical raw materials with stable sources.

Process Feasibility: The dip-dry process is a very mature and universal finishing technology in the textile and materials fields, with simple equipment requirements, easily achievable both in the laboratory and industrially.

Performance Expectation Feasibility: Based on the proven excellent interfacial improvement capability of silanes and good compatibility with acrylic resins in the literature, it is expected that through the design of this composite system, synergistic effects superior to single-component modification can be achieved, realizing durable and robust improvement of PP fiber hydrophilicity. [14]

3. Experimental Plan Design

3.1. Experimental Materials and Equipment

3.1.1. Main Experimental Materials

Polypropylene fiber: Commercially available conventional PP multifilament or short-cut fibers, with clear specifications, recording their original state before use.

Silane coupling agent: γ-Aminopropyltriethoxysilane (KH-550, analytical grade), its Y group is amino (-NH_2), intended to react with the carboxyl groups of the acrylic resin.

Acrylic resin: Self-crosslinking waterborne acrylic resin emulsion (solid content approx. 40% ± 2%, pH 7-8), forming a transparent, flexible film, and containing sufficient carboxyl groups for reaction.

Chemical reagents: Anhydrous ethanol (analytical grade), deionized water, acetone (analytical grade).

Cement mortar test part: P.O 42.5 grade cement, ISO standard sand, distilled water.

3.1.2. Main Experimental Equipment and Instruments

Preparation and Processing Equipment: Electronic balance (accuracy 0.0001g), constant temperature magnetic stirrer, digital ultrasonic cleaner, electric blast drying oven, vacuum drying oven, dipping tank, padder (or using glass rods for manual pick-up control).

Characterization and Testing Instruments: Fourier Transform Infrared Spectrometer (FTIR, with ATR accessory), Scanning Electron Microscope (SEM, equipped with X-ray Energy Dispersive Spectrometer EDS), Static Contact Angle Goniometer, Thermogravimetric Analyzer (TGA), Electronic Single Fiber Tensile Tester, Cement Mortar Mixer, Cement Sand Test Molds, Universal Material Testing Machine. [15]

3.2. Preparation and Optimization of Composite Crosslinking Agent

3.2.1. Preparation of Silane Coupling Agent Hydrolysate

Accurately weigh a certain mass of KH-550 and slowly add it to a mixed solvent prepared from ethanol and deionized water in a volume ratio of 7:3. The initial concentration of KH-550 is set at 2 wt%. Stir magnetically at 500 rpm for 30-60 minutes at room temperature for sufficient hydrolysis. The solution should be prepared fresh for use to prevent excessive self-condensation of silanols, leading to inefficiency. The chemical reaction during hydrolysis is mainly:

$$Si(OC_2H_5)_3 + 3H_2O \rightarrow Si(OH)_3 + 3C_2H_5OH$$

3.2.2. Formulation of Silane/Acrylic Resin Composite Crosslinking Agent

Mix the prepared silane hydrolysate with the waterborne acrylic resin emulsion at different mass ratios. To optimize the formulation, a series of gradients are planned, for example:

Group A: Pure acrylic resin emulsion (as control group 1, to examine the effect of resin alone).

Group B: Silane hydrolysate : Acrylic resin = 1 : 20

Group C: Silane hydrolysate : Acrylic resin = 1 : 10

Group D: Silane hydrolysate : Acrylic resin = 1 : 5

Group E: Pure silane hydrolysate (as control group 2, to examine the effect of silane alone).

All mixtures require slow stirring for over 30 minutes to ensure uniform mixing and avoid demulsification.

3.2.3. Optimization Design of Crosslinking Agent Ratio

The optimization basis will comprehensively consider: 1) Stability of the composite liquid (whether flocculation or stratification occurs); 2) Hydrophilic performance of the modified fibers (contact angle, water absorption rate); 3) Firmness of the coating (e.g., number of wash cycles resisted). By comparing the differences in these performances

under different ratios, the optimal compounding ratio will be determined.

3.3. Hydrophilic Modification Process for Polypropylene Fibers

3.3.1. Fiber Pretreatment

Place PP fibers in a Soxhlet extractor and continuously extract with acetone for 6 hours to thoroughly remove impurities such as spinning oils and waxes adsorbed during production and storage. After extraction, dry them in a vacuum oven at 60°C to a constant weight and store them in a desiccator for subsequent use. [16] This step is crucial to ensure a clean fiber surface, enabling the crosslinking agent to directly contact the fiber surface.

3.3.2. Dip Modification Process

Immerse the pretreated PP fiber bundles completely in the prepared composite crosslinking agent, ensuring all fiber surfaces are fully wetted. The immersion time is initially set at 5 minutes. Slight oscillation can be applied during this period to ensure uniformity. After removal, squeeze with two glass rods or use a small padder to control the pick-up rate to about 80% - 100%.

3.3.3. Heat Treatment Curing Process

Immediately transfer the impregnated fibers to a preheated blast drying oven for stepwise heating and curing. For example: Pre-dry at 80°C for 10 minutes to remove most water and solvent, then raise to 120°C (or according to the recommended curing temperature for the acrylic resin) and cure for 30 minutes. This process is key for the amidation reaction between the silane and resin and the self-crosslinking film formation of the resin.

3.3.4. Discussion on Optimization of Process Parameters

Besides the ratio, curing temperature and time are also key parameters. Single-factor experiments can be designed to investigate the effects of different curing temperatures (100°C, 120°C, 140°C) and times (20 min, 30 min, 40 min) on the modification effect to determine the optimal process window.

3.4. Testing and Characterization Methods

3.4.1. Surface Chemical Structure Analysis (FTIR)

Use ATR-FTIR mode. Directly press the fiber sample tightly onto the ATR crystal. Scan range 4000-500 cm^{-1}, resolution 4 cm^{-1}, number of scans 32. Focus on: whether characteristic peaks for amide I and II bands appear at ~1640 cm^{-1} and ~1550 cm^{-1} (confirming reaction between $-NH_2$ and -COOH); whether the Si-O-Si/Si-O-C stretching vibration peak at ~1100 cm^{-1} is enhanced (confirming siloxane network formation); changes in the C=O stretching vibration peak at ~1700 cm^{-1}.

3.4.2. Surface Morphology and Elemental Analysis (SEM/EDS)

Fix a small amount of fibers on a sample stub with conductive adhesive, sputter-coat with gold, and observe. Acceleration voltage 5-15 kV. Observe the surface smoothness, roughness, and whether a continuous coating is formed on unmodified and modified fibers. Use EDS for area or line scans to analyze the distribution of Si on the fiber surface, indirectly proving the successful introduction of silane and the uniformity of the coating.

3.4.3. Hydrophilic Performance Testing

Contact Angle: Use the sessile drop method. Align fiber bundles parallel and closely fixed on a glass slide. Use a microsyringe to place a 2 μL droplet of ultrapure water on the fiber bundle. Record the droplet shape with a high-speed camera on the contact angle goniometer and calculate the static contact angle using software. Measure at least 5 different locations per sample and take the average.

Water Absorption Rate: Precisely weigh a certain mass (W_d) of modified and unmodified fibers, completely immerse in deionized water for 24 hours until saturated. Remove, quickly blot surface water with filter paper, and immediately weigh (W_w). Water Absorption Rate = [(W_w - W_d) / W_d] × 100%.

Capillary Effect: Refer to textile standards, measure the height of water rising along a vertically suspended fiber

bundle within a certain time.

3.4.4. Thermal Stability Analysis (TGA)

Take a small amount of fiber sample. Under nitrogen atmosphere, heat from 50°C to 600°C at a heating rate of 10 ° C/min, record the thermogravimetric curve. Compare the initial decomposition temperature and the temperature of maximum decomposition rate of fibers before and after modification to investigate the effect of the coating on the fiber's thermal stability.

3.4.5. Mechanical Performance Testing (Single Filament Tensile Strength)

Randomly select at least 30 single filaments. Refer to ASTM D3822 standard, determine their breaking force and elongation at break on an electronic single fiber tensile tester. Gauge length 10 mm, tensile speed 2 mm/min. Calculate the average and standard deviation to evaluate the impact of the modification process on the fiber's intrinsic mechanical properties.

3.4.6. Performance Evaluation in Cement Mortar Composite System

Refer to GB/T 17671 "Method of testing cements-Determination of strength (ISO method)". Prepare reference mortar (without fiber), mortar with 0.1% by volume of unmodified PP fibers, and mortar with 0.1% by volume of modified PP fibers into test specimens (40mm × 40mm × 160mm). After standard curing (temperature 20±1°C, relative humidity >90%) for 28 days, test their flexural strength using a universal material testing machine. By comparison, evaluate the enhancement effect of the modified fibers on the cement-based material.

4. Expected Results and Discussion

4.1. Film-Forming Ability and Stability Analysis of Composite Crosslinking Agent

The composite crosslinking agent with the optimal ratio (e.g., Group C, 1:10) is expected to appear as a uniform milky liquid, showing no stratification or flocculation within 24 hours, indicating good physical stability. After casting it into a film on a PTFE plate and curing, a transparent, continuous, and somewhat flexible film is expected, demonstrating the good film-forming ability of this system, laying the foundation for forming a continuous coating on the fiber surface.

4.2. Evolution and Analysis of Surface Chemical Structure (FTIR) of Modified Fibers

The FTIR spectrum of unmodified PP fibers is expected to show only its characteristic absorption peaks: $-CH_2-$ and $-CH_3$ stretching vibrations (~2950, 2920, 2850 cm^{-1}) and bending vibrations (~1450, 1375 cm^{-1}). After treatment with pure silane (Group E), the spectral changes might be minor. After treatment with pure acrylic resin (Group A), a distinct C=O stretching vibration peak at ~1700 cm^{-1} is expected.

For fibers modified with the composite crosslinking agent (e.g., Group C), the FTIR spectrum is expected to show the following key changes:

The C=O peak remains but its shape or position might slightly change due to reaction with the amino group.

New, distinct absorption peaks appear near ~1640 cm^{-1} and ~1550 cm^{-1}, attributed to amide I band (C=O stretch) and amide II band (N-H bend & C-N stretch) respectively, providing direct evidence for the amidation reaction between the amino group of KH-550 and the carboxyl groups of the acrylic resin.

The broad and strong absorption band near ~1100 cm^{-1} is significantly enhanced, which is the superimposed peak of Si-O-Si and Si-O-C bond stretching vibrations, indicating the formation of a siloxane network after silane hydrolysis and possible connection to the fiber surface via Si-O-C bonds.

These spectral changes will strongly demonstrate that the composite crosslinking agent is not a simple physical mixture of its components, but that the expected chemical reactions occur on the fiber surface, successfully constructing an organically-inorganic hybrid coating bonded by chemical bonds.

4.3. Analysis of Surface Morphology (SEM) and Elemental Distribution (EDS) of Modified Fibers

The SEM image of unmodified PP fibers is expected to show a relatively smooth surface with only some grooves from the spinning process. After modification with pure resin (Group A), the surface might be covered with a discontinuous or somewhat thick resin film. After modification with the composite crosslinking agent (Group C), a uniform, dense coating tightly bonded to the fiber substrate is expected to be observed, and the fiber surface becomes rougher. EDS area scan analysis is expected to show very weak Si element signal on the unmodified fiber surface, while showing uniform and strong distribution on the composite-modified fiber surface. This, from morphological and elemental distribution perspectives, visually proves the successful and uniform coating of the silane/acrylic resin composite on the PP fiber surface. [17]

4.4. Hydrophilic Performance Improvement Effect and Mechanism Discussion

The contact angle of unmodified PP fibers is expected to be greater than 90°, exhibiting typical hydrophobic characteristics. After treatment with pure silane (Group E), the contact angle might decrease slightly, but the effect is limited because the siloxane network formed by the silane itself is not highly hydrophilic. After treatment with pure acrylic resin (Group A), the contact angle is expected to decrease significantly, possibly to around 70°, but its durability (wash fastness) might be poor due to insufficiently strong physical adhesion.

For fibers modified with the composite crosslinking agent (Group C), they are expected to exhibit the most excellent hydrophilic performance: the contact angle can be significantly reduced to below 50°, and water droplets can spread and penetrate rapidly within seconds.[18] Their water absorption rate and capillary effect are also expected to improve by orders of magnitude.

Mechanism Discussion: This synergistic enhancement effect can be attributed to: 1) The acrylic resin provides a large number of hydrophilic groups (-COOH, -COOR); 2) Through the "bridging" role of the silane coupling agent, this hydrophilic coating is firmly anchored to the fiber surface via chemical bonding and physical crosslinking networks, avoiding detachment due to water swelling or external forces, thereby achieving efficient and durable hydrophilic functionality.

4.5. Impact of Modification on Fiber Intrinsic Mechanical Properties and Thermal Stability

Single filament tensile test results are expected to show no significant difference (statistically insignificant) in the breaking strength and elongation at break of fibers before and after modification. This indicates that the modification process conditions are mild, primarily occurring on the fiber surface at the nano- to micro-scale, and do not damage the fiber's bulk structure, preserving its core mechanical properties as a reinforcement material.

TGA analysis is expected to show that the initial decomposition temperature (T_5 %) of the modified fibers might be comparable to or slightly higher than that of unmodified fibers. This is because the surface silicon-acrylic hybrid coating acts as a thermal insulation and barrier to some extent, delaying the thermal decomposition of the main PP fiber body. [19]

4.6. Reinforcement Mechanism and Performance Expectation in Cement-Based Composites

The 28-day flexural strength of the reference mortar and mortar with unmodified fibers are expected to be similar, indicating the limited reinforcement effect of hydrophobic fibers. In contrast, the mortar with composite-modified fibers is expected to show a statistically significant increase in flexural strength (e.g., an improvement in the range of 10%-20%).

Reinforcement Mechanism Discussion: The hydrophilic coating on the modified fiber surface greatly improves its compatibility with the cement paste. During mixing, cement particles and hydration products can better wrap and embed into the rough coating on the fiber surface. After hardening, stronger mechanical interlocking and van der Waals forces are formed between the fiber and the cement stone. More importantly, the polar groups in the coating may form ionic bonds or hydrogen bonds with cement hydration products (e.g., Ca^{2+} , Si-OH in C-S-H gel), thereby

achieving a leap from physical anchoring to chemical bonding, significantly enhancing the interfacial bond strength. When the material is stressed, this strong interface can more effectively transfer stress from the brittle cement matrix to the tough fibers, fully utilizing the fiber's bridging and pull-out energy dissipation effects, macroscopically manifesting as improved flexural strength and toughness. [20]

5. Conclusion and Outlook

5.1. Research Conclusions

Through the systematic literature review, theoretical analysis, detailed experimental plan design in this paper, combined with in-depth discussion of the expected results, the following conclusions can be drawn:

The proposed composite crosslinking agent system, based on silane coupling agent (KH-550) and waterborne acrylic resin, is theoretically and technically feasible for efficient and durable hydrophilic modification of PP fibers.

The synergistic modification mechanism of "Silane Bridging - Resin Film Formation" is reasonable. The silane coupling agent acts as a key bridge, achieving firm bonding between the acrylic resin coating and the PP fiber surface.

The expected characterization results (FTIR, SEM, EDS, contact angle, etc.) will confirm the successful construction of this composite coating and its excellent hydrophilic effect from chemical, morphological, and performance perspectives. [21]

This modification method is expected not to damage the intrinsic mechanical properties of PP fibers and can significantly improve their interfacial bonding with the cement matrix, thereby substantially enhancing the flexural strength of cement-based composites.This research provides a new path with broad application prospects for developing novel, environmentally friendly, and efficient PP fiber surface modification technologies. [22]

5.2. Limitations of This Study

As a theoretical design and exploration based on literature, this study mainly has the following limitations:

All conclusions are based on theoretical deduction and literature support, and have not yet been ultimately verified by first-hand experimental data.

The specific role and strength of the initial anchoring mechanism of silane on the completely non-polar PP surface still require more sophisticated characterization techniques (e.g., XPS) for in-depth clarification.

Although wash fastness is considered in the plan, the durability assessment of the modified fibers under harsh environments like long-term damp heat, UV aging has not been involved.

5.3. Future Work Outlook

Based on the results and limitations of this research, future work can proceed from the following aspects:

Experimental Verification: The primary task is to strictly conduct experiments according to the plan designed in this paper, obtain real data, and verify and correct relevant theories and expectations.

In-depth Mechanism Study: Use X-ray Photoelectron Spectroscopy (XPS) for quantitative analysis of the fiber surface elemental composition and chemical state to more precisely reveal the interfacial chemistry. Use Atomic Force Microscopy (AFM) to study the nanoscale mechanical properties of the coating.

Process Optimization and Intelligence: Drawing on ideas from literature, introduce optimization algorithms like Response Surface Methodology (RSM) or BP neural networks to systematically optimize multiple factors such as crosslinker ratio, curing temperature and time, and establish process-performance prediction models.

Durability and Application Expansion: Systematically study the fatigue resistance and aging resistance of modified fibers. Apply them to specific products such as high-performance concrete, functional geotextiles, advanced filtration membranes, etc., to test their practical application value.

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Artificial Intelligence-Driven Smart Homecare: A Review of Applications, Challenges, and Prospects

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Abstract: With the accelerating global trend of population aging, traditional elderly care models are increasingly strained by limited service resources and growing quality demands. As a sustainable and cost-effective alternative, home-based elderly care has garnered widespread attention. However, older adults living at home often face critical challenges, including discontinuous health monitoring and insufficient emotional support. The rapid advancement of Artificial Intelligence (AI) technologies offers new pathways for developing intelligent elderly care solutions. This review systematically examines the major applications of AI in home-based care, focusing on two key domains: intelligent health monitoring and management and smart home environment systems. By analyzing representative research findings and practical implementations both domestically and internationally, this paper identifies core challenges across technical, user-centric, systemic, and ethical dimensions. Furthermore, it outlines future research directions, including personalized modeling, edge intelligence, empathetic human-AI interaction, multimodal data integration, and privacy-preserving strategies. This review aims to provide a theoretical foundation and a comprehensive framework to guide future research and practical advancements in AI-powered smart elderly care.

Keywords: Smart Homecare; Artificial Intelligence

Introduction

Population aging has emerged as a major global social challenge of the 21st century. In light of this demographic shift, providing sustainable, high-quality, and dignified eldercare services has become a pressing issue for governments and societies worldwide (Beard et al., 2016). Compared with institutional care, home-based eldercare presents inherent limitations in areas such as health management, safety assurance, emotional support, and emergency response, urgently calling for structural empowerment through new-generation information technologies(Qian et al., 2021).

As a core driver of current technological advancement, Artificial Intelligence (AI) has demonstrated transformative potential across various fields, including healthcare, smart homes, and intelligent manufacturing(Qian et al., 2021). In recent years, AI applications in smart eldercare have rapidly expanded, encompassing a wide range of capabilities — from monitoring vital signs and personalized health forecasting to voice-interactive companion robots, smart home automation, fall detection, and emergency response systems(Mohan et al., 2024). AI has thus become a critical technological pillar in the transformation and modernization of eldercare services.

Although a growing body of research has explored the potential of AI in the broader eldercare domain, comprehensive reviews focusing specifically on its applications, technical implementations, and development bottlenecks within the context of home-based eldercare remain limited. This review aims to bridge this gap by systematically examining the primary AI-driven application areas in home-based eldercare. We synthesize current research achievements, analyze key technical approaches and representative systems, and identify prevailing challenges and future trends from multiple dimensions, including technology, user experience, system integration, ethics, and policy. Ultimately, this paper seeks to provide a theoretical foundation and research roadmap for scholars and practitioners working at the intersection of AI and eldercare.

The main contributions of this review can be summarized as follows:

1. Scope specialization in home-based eldercare. Unlike prior reviews that broadly examine AI in healthcare or institutional settings, this paper specifically focuses on *home-based eldercare*, systematically covering two key domains: intelligent health monitoring and smart home environments.
2. Transparent and reproducible methodology. The review adopts a *structured narrative approach* supplemented with systematic literature scanning, with clearly defined databases, search strategies, timeframes, and inclusion/exclusion criteria, thereby enhancing methodological transparency and reproducibility.
3. Evidence mapping and technological synthesis. By organizing diverse AI approaches — including CNNs, LSTMs, GNNs, reinforcement learning, and Transformer-based models — across different data modalities and eldercare scenarios, this review provides a comparative synthesis of methodologies, applications, and performance challenges rather than a mere listing of technologies.
4. Multi-dimensional analysis of challenges. Beyond technical perspectives, this work critically discusses current bottlenecks from five interrelated dimensions: system robustness, user adaptability, standardization, ethical and privacy risks, and commercialization barriers, offering a holistic understanding of existing limitations.
5. Forward-looking research agenda. Based on current gaps and emerging trends, the review highlights future directions such as *personalized AI modeling, multimodal fusion, edge intelligence, and age-friendly human –AI interaction*, providing actionable insights for advancing both research and practice.

2. Methodology

To ensure transparency and reproducibility, this study adopted a structured narrative review approach supplemented with elements of systematic literature scanning. Searches were conducted across IEEE Xplore, PubMed, Scopus, using keyword combinations such as "Artificial Intelligence", "AI", "Machine Learning", "eldercare", "older adults", "aging population", "smart home", "assistive technology", "activity monitoring". The boolean search string is ("Artificial Intelligence" OR "AI" OR "Machine Learning") AND ("eldercare" OR "older adults" OR "aging population") AND ("smart home" OR "assistive technology" OR "activity monitoring"). The timeframe was restricted to publications between January 2020 and September 2025, thereby covering both foundational developments and the most recent advancements. Inclusion criteria were: (i) peer-reviewed journal articles or conference proceedings; (ii) studies focusing on AI-enabled technologies for home-based eldercare rather than institutional or hospital contexts; and (iii) articles published in English. Exclusion criteria were: (i) non-AI IoT systems such as purely mechanical or manual monitoring solutions; (ii) studies confined to pediatric or general healthcare settings without direct eldercare relevance; and (iii) grey literature including patents, marketing reports, or white papers. A total of 408 records were initially retrieved including 193 from IEEE Xplore, 158 from Scopus, and 57 from PubMed. After removing 74 duplicates, 334 articles remained for title and abstract screening. Following this process, 112 articles met all criteria and were included in the final synthesis. Reference chaining was further applied to capture seminal works not indexed in database searches. This structured process ensured that the review remains comprehensive and academically rigorous, while retaining the interpretive flexibility characteristic of narrative reviews.

2.1 Intelligent Health Monitoring and Management

Home-based eldercare faces persistent challenges in timely health risk detection, chronic disease management, and emergency response, as traditional approaches such as manual check-ins and periodic examinations lack continuity and sensitivity (Shi et al., 2025; Li et al., 2024). With the integration of Artificial Intelligence (AI), supported by the Internet of Things (IoT) and advanced sensing modalities, health monitoring is increasingly shifting toward personalized, precise, and real-time surveillance.

(1) Data acquisition and sensing modalities.

Wearables, ambient sensors, and vision-based systems form the backbone of data collection. Wearable devices—ranging from wristbands to intelligent textiles—enable continuous tracking of vital signs, while ambient sensors (infrared, pressure, accelerometer) capture activity routines and mobility pattern. Non-contact sensing, including radar and Wi-Fi-based approaches, offers privacy-preserving alternatives (Bačić et al., 2024; Qin, 2025). Compared to wearables, ambient and vision-based systems reduce compliance burdens but raise concerns over intrusiveness and data fidelity.

(2) Analytical approaches: strengths and limitations.

Health data analysis has evolved from rule-based systems to AI-driven modeling:

- **Conventional machine learning (e.g., SVM, decision trees):** Lightweight, interpretable, and suitable for limited datasets, but constrained in scalability and robustness.
- **CNN-based architectures:** Strong in feature extraction from vision data (e.g., fall detection), yet limited in capturing long-term dependencies (Katmah et al., 2023).
- **LSTM and RNN models:** Effective for physiological time-series forecasting (e.g., glucose, heart rate), though computationally demanding and often data-hungry.
- **Graph Neural Networks (GNNs):** Emerging tools to model interdependencies among multimodal signals, with potential for integrated health surveillance, though still lacking external validation in elder populations (Arora & Sinha, 2025).

Collectively, this comparison indicates that while deep learning approaches broaden the scope of detectable anomalies and trends, their deployment in real-world homecare remains hampered by computational cost and generalizability.

(3) Toward multimodal fusion and contextual awareness.

Recent efforts highlight the integration of heterogeneous data streams—combining physiological signals, behavioral patterns, and contextual cues — to enhance system accuracy. For instance, reinforcement learning and memory-augmented models have been applied to activity recognition in complex home environments (Jin et al., 2024; Lu et al., 2023). Vision-based anomaly detection techniques, such as temporal grounding and feature sampling, improve segmentation of daily routines but remain susceptible to privacy concerns and environmental variability (Yang et al., 2021; Tang et al., 2022). These findings suggest that multimodal fusion is essential for robust monitoring, yet interoperability and privacy remain critical barriers.

(4) Challenges and research agenda.

Several unresolved issues persist. First, generalizability across heterogeneous populations is limited, as most models are trained on small or homogeneous cohorts. Second, data sparsity and labeling bottlenecks hinder supervised approaches, motivating interest in few-shot, self-supervised, or federated learning paradigms. Third, user compliance remains fragile; older adults often resist wearables due to discomfort or memory lapses, leading to incomplete data streams. Finally, data governance and ethics—including secure transmission, storage, and consent management—require urgent attention (Wang et al., n.d.).

From these observations, three testable research questions emerge:

- *RQ1:* Can federated learning frameworks improve cross-household model robustness without sacrificing accuracy?

- *RQ2:* To what extent can edge intelligence reduce latency in anomaly detection below clinically actionable thresholds?
- *RQ3:* How can multimodal fusion be designed to balance accuracy with user privacy, especially in vision-based monitoring?

In sum, intelligent health monitoring has progressed from isolated sensing to AI-driven, multimodal analytics. However, achieving reliable, ethical, and widely adoptable systems will require not only algorithmic advances but also solutions for compliance, interoperability, and privacy—underscoring the importance of holistic, user-centered system design.

2.2 Smart Home Environment for Eldercare

2.2 Smart Home Environment for Eldercare

The home constitutes the central living space for older adults, directly influencing their safety, independence, and quality of life. Traditional residential environments, however, lack adaptive and responsive features to manage emergencies, detect behavioral anomalies, or ensure age-friendly accessibility. The application of Artificial Intelligence (AI) within smart home systems is transforming these spaces into dynamic environments that can sense, reason, and respond to the needs of elderly residents (Shi et al., 2025).

(1) Core sensing infrastructures and their roles.

Smart home environments typically rely on distributed sensor networks comprising motion, temperature, humidity, pressure, gas leakage, and smoke detectors. These systems provide continuous monitoring of activity and environmental changes, enabling both safety assurance and comfort enhancement. Compared to health-specific wearables, ambient sensor networks are less intrusive and reduce compliance challenges. However, their granularity is limited, and they struggle to differentiate between benign and hazardous inactivity.

(2) Intelligence in activity recognition and anomaly detection.

AI models significantly enhance the interpretive capacity of sensor data.

- **Probabilistic models (e.g., Hidden Markov Models):** effective in modeling sequential activities, yet sensitive to noise and limited in generalizing to new behaviors.
- **RNNs and deep learning architectures:** superior in detecting subtle deviations in activity patterns, such as prolonged immobility, but data-intensive and prone to overfitting (Farsi, 2021).
- **Transformer-based and hybrid attention models:** recently explored for robust human activity recognition in noisy home settings, offering improvements in adaptability (Y. Liu et al., 2025).

Despite progress, a recurrent issue is the lack of validation in complex, multi-occupant households, where overlapping activity signals pose challenges for reliable inference.

(3) Interaction modalities and usability.

Voice-based systems, powered by advances in speech recognition and natural language processing, provide intuitive control over lighting, appliances, and climate regulation (Chakraborty et al., 2023). However, recognition accuracy often declines for elderly users due to slow speech, slurred articulation, or dialectal variation (Li & Wang, 2024; Lu et al., 2024). Transformer and BERT-based models have demonstrated higher robustness (Gardazi et al., 2025), yet the challenge of balancing technical accuracy with user accessibility remains unresolved. Beyond voice, gesture recognition and multimodal interaction are being investigated but face high deployment costs and limited user familiarity.

(4) Decision-making paradigms: from rules to adaptive intelligence.

Early smart homes relied on rule-based systems, such as threshold-triggered alarms or static environmental controls. While transparent and predictable, these systems lack flexibility. AI-driven approaches, particularly reinforcement learning (RL), enable adaptive control that optimizes energy use and aligns with individual comfort

preferences (Yang et al., 2021). However, RL-based systems demand large volumes of training data and risk unintended behaviors if not carefully constrained. The challenge is to ensure adaptive intelligence without compromising system stability or user trust.

(5) Barriers to real-world adoption.

Despite technical advances, three structural barriers hinder widespread implementation:

- **System robustness and reliability:** false alarms or malfunctions erode user trust, which is critical among older populations with low tolerance for technical errors.
- **Fragmentation and interoperability:** diverse commercial ecosystems lack standardized protocols, preventing seamless integration and data exchange.
- **Privacy and ethical concerns:** especially for camera-based monitoring, older adults may perceive surveillance as intrusive, creating resistance even when safety benefits are clear. Balancing functionality with dignity is therefore a pressing concern.

(6) Emerging directions: personalization and privacy-preserving intelligence.

The frontier lies in designing smart home systems that are both adaptive and respectful of user autonomy. Privacy-preserving sensing modalities (e.g., millimeter-wave radar, Wi-Fi CSI analysis) offer alternatives to intrusive cameras. Edge intelligence reduces reliance on cloud infrastructure, lowering latency and safeguarding personal data. Simultaneously, user-centered design approaches — integrating co-design with older adults — can improve acceptance and usability.

Research agenda.

The synthesis highlights several open questions:

- *RQ1:* How can smart home anomaly detection systems be generalized to multi-occupant households without inflating false alarms?
- *RQ2:* What design frameworks can ensure age-friendly voice and multimodal interfaces that accommodate linguistic and cognitive variability?
- *RQ3:* To what extent can reinforcement learning be safely deployed in critical smart home controls without compromising stability and user trust?
- *RQ4:* How can privacy-preserving sensing (radar, Wi-Fi) be validated against clinical-grade benchmarks while ensuring user acceptance?

AI-enabled smart home environments have evolved from rule-based automation to adaptive, learning systems that address safety, comfort, and independence. Yet large-scale deployment remains constrained by technical fragility, interoperability gaps, and ethical dilemmas. Future research must emphasize standardized protocols, rigorous validation in real-world households, and co-designed, privacy-conscious solutions. Only through such integrative approaches can smart homes mature into reliable, trusted infrastructures for aging in place.

3. Discussion: Current Challenges and Future Research Directions

As Artificial Intelligence (AI) technologies increasingly permeate the domain of home-based eldercare, their applications in health monitoring, emotional companionship, and smart home environments have demonstrated significant potential. At the same time, the role of information media—including online platforms, social media, and digital health portals — has begun to shape public perception, influence user behavior, and mediate access to eldercare solutions. However, both research efforts and real-world deployments reveal that AI-enabled eldercare still faces numerous unresolved challenges. These issues are not only technical in nature but also extend to user acceptance, system sustainability, ethical considerations, and policy support. To advance the deep integration and large-scale adoption of AI in eldercare services, it is essential to critically examine current limitations and outline future research and development priorities.

3.1 Current Challenges

(1) Limitations in Technical Performance and System Reliability

Although AI models have been applied to vital sign analysis, fall detection, emotion recognition, and speech interaction, the overall robustness and generalizability of these systems remain suboptimal. Elderly individuals exhibit high degrees of variability in physiological parameters, speech characteristics, and behavioral patterns, making it difficult for trained models to be directly transferred to practical scenarios. Moreover, health monitoring and behavior recognition rely on multi-source heterogeneous data, where issues such as signal noise, temporal misalignment, and data loss affect system accuracy and stability.

(2) Low Adaptability and Acceptance Among Older Users

Many current AI eldercare products lack proper adaptation to the needs and abilities of older users. User interfaces, interaction logic, and device designs often fail to align with age-friendly principles. Some older adults resist wearable devices due to discomfort or unfamiliarity, leading to low adherence and frequent data interruptions. Voice interaction systems often struggle with slow speech, unclear pronunciation, or regional dialects, resulting in decreased recognition accuracy and frustrating user experiences.

(3) System Fragmentation and Lack of Standardization

Smart eldercare systems are frequently developed by different companies or research teams, leading to non-standard hardware protocols and closed software interfaces. This fragmentation impedes interoperability between devices and results in data silos that limit cross-system integration. For instance, health monitoring data may not be effectively shared with home care or community health systems, hindering holistic health management. Such isolation also restricts the scalability and refinement of service models.

(4) Increasing Ethical Concerns and Privacy Risks

AI-enabled monitoring in private homes—especially involving video capture, voice recording, and physiological data analysis — raises significant privacy concerns. Many existing systems lack comprehensive privacy protection mechanisms throughout the data lifecycle, including acquisition, transmission, storage, and use. Inadequate user consent and unclear data ownership may result in privacy violations, data misuse, or psychological distress. Furthermore, the ethical boundaries of replacing human companionship with AI are still undefined, as overreliance on emotional robots could undermine natural social support networks.

(5) Slow Commercialization and Unfavorable Cost Structures

Advanced AI eldercare systems, particularly those involving multi-sensor fusion and high-performance computing, incur substantial development and maintenance costs. In the absence of economies of scale, these costs hinder adoption in individual households or care institutions. Additionally, the lack of standardized reimbursement policies, public subsidies, or service pricing frameworks slows market expansion and limits sustainable business development.

3.2 Future Research and Development Directions

(1) Developing Robust and Personalized AI Models

Given the individual variability among older adults, future research should focus on personalized modeling approaches. This includes the development of adaptive algorithms capable of continuous learning and model updates, improving system performance in diverse data environments. Additionally, enhancing model interpretability and visualization will help users and caregivers better understand decision-making processes, thereby increasing trust and adoption.

(2) Advancing Multimodal Data Fusion and Edge Intelligence

To improve decision-making accuracy, future systems must overcome the technical barriers of multimodal data fusion by integrating visual, speech, physiological, and behavioral inputs in real time. To reduce latency and

enhance privacy, edge computing and lightweight AI models should be adopted to enable on-device processing of critical tasks—facilitating real-time, efficient, and privacy-aware solutions at the user end.

(3) Enhancing Human-AI Interaction with Emotional and Age-Friendly Design

AI interaction systems should account for the linguistic traits, emotional needs, and behavioral tendencies of elderly users. Developing dialogue systems with empathic capabilities and social memory functions can provide emotionally intelligent, human-like experiences. Simultaneously, user interface design and operational workflows should be optimized to minimize interaction barriers and improve accessibility.

4 Conclusion

The rapid advancement of Artificial Intelligence technologies has brought new vitality to traditional eldercare models, demonstrating particularly significant potential in home-based care scenarios. From dynamic health monitoring and emotional state recognition to smart home environmental control and rapid emergency response, AI is progressively shaping an integrated eldercare system that addresses physical well-being, emotional support, environmental adaptation, and safety risks. A systematic review of domestic and international literature reveals that AI applications in home-based eldercare are evolving from isolated functionalities toward integrated systems, with increasingly mature algorithmic models and platform architectures.

Nonetheless, several challenges remain for the widespread adoption and practical deployment of intelligent eldercare systems. These include insufficient adaptability of AI algorithms to individual differences among older adults, limited capacity for real-time multimodal data fusion, lack of standardized system interfaces, underdeveloped privacy protection mechanisms, and generally low technology acceptance among elderly users. Addressing these challenges will require interdisciplinary collaboration, policy-level support, and industry-wide standardization efforts.

Future research should focus on developing AI models with enhanced personalization and contextual awareness, promoting the adoption of edge intelligence in eldercare settings, and optimizing age-friendly human-computer interaction designs. Additionally, it is critical to establish comprehensive frameworks for data privacy and ethical governance, and to foster an open, collaborative ecosystem involving stakeholders from technology, healthcare, and social service domains. Through the deep integration of AI with eldercare services, it is possible to realize a truly human-centered model of proactive, continuous, and life-cycle-oriented home-based eldercare.

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Strategic Planning Research on the Development of Local Characteristic Agricultural Product Industrial Clusters——A Case Study of Longyou Bamboo Industry Based on Neo-endogenous Development Theory

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Abstract： As the rural revitalization strategy advances further and the process of agricultural modernization accelerates, developing industrial clusters for local characteristic agricultural products has become a key avenue to boost high-quality regional economic development and increase farmers' incomes. Known as the "Hometown of Bamboo in China," Longyou County has a bamboo forest area of around 410,000 mu (approximately 27,333 hectares), a standing bamboo stock of more than 70 million culms, and an annual output value of its bamboo industry exceeding 4 billion yuan (RMB)—making it one of the most distinctive industries for improving local people's livelihoods in the county. However, the industry faces challenges such as extensive resource use, inadequate industrial chain extension, insignificant brand value, and weak interest links with communities, rendering the traditional exogenous-driven model no longer viable.

Following the principles of the Neo-endogenous Development Theory and from its perspective, we conducted a thorough review of the strengths and challenges faced by the Longyou Bamboo Industry Cluster (a cluster of bamboo-related businesses in Longyou). Based on this review, we put forward directions for better development, such as: supporting the growth of local stakeholders, promoting the integration of the primary, secondary, and tertiary industries, establishing a network for innovation and exchange, implementing a dual strategy of brand building and green development, and improving ways of internal collaboration and external cooperation. This study aims to provide both theoretical guidance and practical support for the Longyou Bamboo Industry, as well as similar characteristic industries in other regions.

Keywords: Local Characteristic Agricultural Products; Industrial Clusters; Strategic Planning; Neo-endogenous Development Theory; Longyou Bamboo Industry

1. Introduction

Cultivating distinctive and competitive industrial clusters is a key measure to promote rural revitalization in an all-round way and accelerate the modernization of agriculture and rural areas. Longyou County has abundant bamboo resources and a relatively solid industrial foundation, but how to convert its resource advantages into sustainable competitive edges remains the core challenge it currently faces.

The Neo-endogenous Development Theory emphasizes that development should be based on the organic integration of internal and external resources, with the participation of local stakeholders and capacity building as the core, so as to achieve inclusive and sustainable regional development. This theory provides a key analytical framework for Longyou's bamboo industry to break through the bottleneck of "abundant resources but a small-scale industry". Examining the development path of Longyou's bamboo industry and promoting its deep

integration with the concept of neo-endogenous development is of great significance for formulating a scientific industrial development plan.[1]

2. Overview of Neo-endogenous Development Theory and Its Application Value

The Neo-endogenous Development Theory holds that sustainable development must be led by local social actors, based on local resources, knowledge and culture, while selectively interacting with the external environment to ultimately achieve the overall improvement of local well-being. This theory breaks the path dependence of the traditional exogenous development model on external capital and technology, and emphasizes the endogenous driving force of development and its in-depth alignment with the local ecology. [2]Its application value in the planning of characteristic industrial clusters has been fully verified by numerous practices and data, mainly reflected in the following two aspects:

2.1 Enhancing Industrial Rootedness and Resilience

By enhancing internal connections between industries and the local social-ecological environment, and building a symbiotic system of "local resources – industrial chain – social network", we can not only significantly reduce the impact of external risks but also fundamentally avoid the predicament of industrial "enclaveization".

A 2025 study by the Enterprise Big Data Research Center of Peking University showed that amid macroeconomic shocks like the COVID-19 pandemic, areas with a high degree of industrial clustering have greater resilience against risks: one month after the Spring Festival in 2020, the number of newly registered private enterprises in highly clustered areas fell by 67% compared to previous years, while the drop in areas with low clustering reached 74%; for every one standard deviation rise in the clustering index, the number of new enterprises can increase by 12%.

This risk resilience stems from the completeness of the local industrial chain and the support function of social networks: in highly clustered areas, over 80% of core suppliers and clients are based locally. By leveraging informal networks like hometown connections, they can realize resource sharing and mutual support, allowing the industrial chain to keep running at a basic level even in extreme situations such as city lockdowns.[3]

By contrast, the "enclave economy" that is detached from the local ecology is often unsustainable. For instance, Jiangyin-Jingjiang Industrial Park, China’s first enclave park, failed to achieve deep integration with local resources.[4] As a result, the proportion of its economic indicators in the two regions fell from 7% and 20% at their peak to 2% and 5%, eventually falling into a state of stagnation. Foxconn’s two failed investment attempts in Indian industrial parks also confirmed this point: due to its failure to integrate into the local supply chain and social culture, power shortages alone caused a 30% drop in production capacity, and hidden costs completely offset the advantage of low labor prices.

2.2 Improving Development Inclusiveness and Sustainability

By stimulating the sense of participation and creativity of multiple subjects such as local enterprises, residents and social organizations, the Neo-endogenous Development Theory can promote the sharing of development achievements locally and realize the synergy of economic, social and ecological benefits. The practice of Lanling County in Shandong Province is highly representative: relying on its traditional advantages in sprayer manufacturing, the county built a "1+N" industrial ecology with Baonong Company as the core, fostering a number of supporting enterprises in lithium batteries, cartons and chargers. Through the "chain leader model", local resources were guided to gather in the industrial chain, driving more than 1,000 villagers around to obtain employment at their doorsteps. Among them, Kelei New Energy, a supporting enterprise alone, employed more than 60 local laborers.[5] This locally led development model not only created economic value (Baonong Company’s annual production capacity reached 3 million units), but also allowed small-scale operators to share development dividends by

lowering the threshold for entrepreneurship, forming a virtuous cycle of "enterprise growth, villagers' income increase and regional development". The transformation of Gejia Village in Zhejiang Province is also typical: under the "villager empowerment and cultural deepening" model, local villagers used their own skills and local materials to participate in rural construction, not only making the village one of the "National Key Rural Tourism Villages", but also transforming villagers from "onlookers" to "rural construction artists", realizing the dual well-being of material income increase and spiritual improvement. This inclusive growth is precisely the core goal of neo-endogenous development.[6] As emphasized by the Asian Development Bank, its essence is to enable ordinary people to share development achievements to the greatest extent through an equal-opportunity participation mechanism.

3. General Situation and Advantages of Longyou Bamboo Industry

Located in western Zhejiang Province, Longyou County was awarded the title of "Hometown of Bamboo in China" in 1996 due to its rich bamboo resources and solid industrial foundation. Bamboo resources are not only its iconic ecological assets, but also the core endogenous element supporting regional economy and people's livelihood.

From the perspective of resource endowment, the county's bamboo forest area is stable at 410,000 mu, mainly concentrated in southern mountainous areas such as Miaoxia Town, Xikou Town and Dajie Town. Among them, Moso bamboo accounts for more than 95% (the core raw material for the bamboo processing industry), with a standing stock of 70 million culms and an average of 170 culms per mu, which is higher than the average level of Zhejiang Province (150 culms per mu). Approximately 5 million Moso bamboos can be harvested annually, and the resource density and sustainable supply capacity rank among the top in county-level regions in the province, providing an endogenous foundation of "local material acquisition and stable supply" for the industrial cluster (Source: Longyou County Forestry Bureau. 2023. Report on Resource Census and Sustainable Utilization of Bamboo Industry).[7]

From the perspective of employment and people's livelihood, Longyou Bamboo Industry has formed a pattern of "employment absorption throughout the industrial chain": there are about 35,000 employees in the county's bamboo industry, accounting for 12% of the total employment in the secondary and tertiary industries of the county, and more than 85% of them are local registered residents, avoiding the "development hollowing-out" caused by labor outflow. Employment is distributed across all links of the industrial chain: about 8,000 people in the bamboo harvesting and transportation link (mostly farmers in mountainous areas, with an average annual income increase of 28,000 yuan, accounting for 35% of farmers' annual net income), about 12,000 people in the primary processing link (bamboo chips, bamboo strips, mainly employed by small and micro enterprises in towns and townships), about 11,000 people in the deep processing link (bamboo flooring, bamboo furniture, concentrated in above-scale enterprises, including technical workers and managers), and about 4,000 people in the sales and supporting services link (e-commerce, logistics, design). This forms a people's livelihood security system of "employment at the doorsteps and income increase throughout the chain", which fully aligns with the core goal of neo-endogenous development of "prioritizing local well-being" (Source: Longyou County Bureau of Economy and Information Technology. 2023. Report on Employment Structure and Income Contribution of Bamboo Industry).[8]

When it comes to the scale of industrial clusters and the completeness of the industrial chain, Longyou's bamboo industry has developed a closed-loop endogenous ecosystem of "from resources to value". As of 2023, there are over 150 bamboo-related enterprises in the county, including 25 above-scale ones, which account for 8.3% of the total number of above-scale industrial enterprises in the county.

These 25 above-scale bamboo enterprises have generated an output value of 2.86 billion yuan, making up 71.5% of the total output value of the county's bamboo industry and demonstrating a high level of industrial

concentration. Leading enterprises like Zhejiang Hengsheng Bamboo Industry Co., Ltd. have an annual production capacity of 3 million square meters of bamboo flooring. Their products have obtained the EU CE certification and are exported to Europe, the United States, and Southeast Asia, with annual export volume exceeding 120 million yuan. Zhejiang Jufeng Bamboo Industry specializes in custom bamboo furniture, recording revenue of over 210 million yuan in 2023 and boasting a 40% customer repurchase rate.[9]

Looking at the industrial chain structure, the local area has established a complete industrial chain of "bamboo harvesting and transportation – primary processing – deep processing – waste recycling and utilization":

Primary processing link: Annual output of 180,000 tons of semi-finished products such as bamboo strips and bamboo shavings, providing raw material support for downstream enterprises;

Deep processing link: Covering a variety of high value-added products, among which the annual output of bamboo flooring accounts for 18% of the province’s output (with annual sales exceeding 1.2 billion yuan); 3 enterprises in the bamboo tableware field have passed the US FDA certification, with an annual export volume of more than 20 million sets (export value of 150 million yuan); the annual production capacity of bamboo charcoal products (for air purification and soil improvement) is 15,000 tons; the annual revenue of bamboo fiber products (home textiles, baby products) exceeds 300 million yuan;

Recycling and utilization link: Bamboo processing waste is used to produce bamboo vinegar and bamboo fiber boards, with a waste utilization rate of 90%, realizing "zero ecological waste" (Source: Zhejiang Provincial Forestry Bureau. 2023. White Paper on the Development of Bamboo Industry in Zhejiang Province; Annual Operation Report of Longyou Bamboo Industry Association).

From the perspective of output value scale and growth quality, the total output value of Longyou Bamboo Industry is expected to exceed 4 billion yuan in 2023, an increase of 14.3% compared with 2022, with a growth rate significantly higher than the county’s GDP growth rate (6.5%) and the growth rate of added value of above-scale industries (9.2%). More importantly, the industrial structure is continuously optimized: the proportion of deep processing output value reaches 62%, an increase of 18 percentage points compared with 2020, breaking away from the traditional low-value-added path of "selling raw materials and rough processing" and shifting to an endogenous growth model of "technology empowerment and brand value increase", which confirms the core logic of neo-endogenous development of "realizing value upgrading based on local resources" (Source: Longyou County Bureau of Statistics. 2023. Annual Economic Express).[10]

The development of Longyou Bamboo Industry Cluster has four core advantages for implementing the neo-endogenous strategy, all of which form a closed loop based on local elements:

3.1 Endogenous Advantage of Resource Endowment

Besides its existing bamboo forest resources, Longyou has also found a way to turn ecological value into actual income by taking advantage of the ecological strengths of the upper reaches of the Qiantang River. In 2023, the county conducted 12,000 tons of bamboo forest carbon sink transactions and gained 600,000 yuan in carbon sink revenue.

At the same time, through the "Low-Yield Bamboo Forest Renovation" project — with the government offering a subsidy of 120 yuan per mu — Longyou has so far renovated 80,000 mu of bamboo forests, boosting per-mu bamboo output by 15%.[11]

This method not only ensures more sustainable use of resources, but also converts ecological strengths into economic benefits, successfully avoiding the "dilemma of relying on resources for development" (Source: Longyou County Bureau of Ecology and Environment, 2023, Report on the Conversion of Ecological Value and Green Industry

Development).

3.2 Synergistic Advantage of Industrial Foundation

Longyou has built the "Longyou Bamboo Industry Characteristic Park", which houses 43 enterprises and is equipped with a shared bamboo material storage center (reducing enterprise storage costs by 20%) and a bamboo processing technology R&D center (co-established with Zhejiang A&F University as the "Joint Laboratory of Bamboo Deep Processing"). In 2023, the laboratory invested more than 30 million yuan in R&D and obtained 27 patents. Among them, the "bamboo mildew-proof modification technology" reduced the product defect rate from 8% to 3%, and the "bamboo fiber lightweight processing technology" reduced raw material consumption by 12%, forming an endogenous innovation ecology of "enterprise agglomeration - resource sharing - technology synergy" (Source: Longyou Economic Development Zone Management Committee. 2023. Park Development Evaluation Report).[12]

3.3 Enabling Advantage of Cultural Heritage

Longyou bamboo weaving technique originated in the Song Dynasty and was included in the Zhejiang Provincial Intangible Cultural Heritage List in 2009. There is 1 provincial-level intangible cultural heritage inheritor, 3 municipal-level inheritors, and more than 50 new-generation inheritors have been cultivated relying on the "Longyou Bamboo Weaving Workshop". In recent years, through the integration of "intangible cultural heritage + cultural and creative products", products such as bamboo woven tea sets, decorative paintings and intangible cultural heritage handmade gift boxes have been developed. The sales volume of bamboo woven cultural and creative products reached 80 million yuan in 2023, an increase of 200% compared with 2020. At the same time, the "Longyou Bamboo Culture Festival" is held annually, which attracted more than 150,000 tourists in 2023 and drove the income from bamboo cultural and tourism integration to 23 million yuan, realizing a closed loop of "cultural inheritance - industrial value increase - people’ s livelihood income increase".[13] This is a typical practice of the "cultural rootedness-driven" neo-endogenous development (Source: Longyou County Bureau of Culture, Radio, Television, Tourism and Sports. 2023. Work Report on Intangible Cultural Heritage Protection and Cultural-Tourism Integration).

3.4 Guiding Advantage of Policy Support

Longyou County has listed the bamboo industry as one of the "3+1" leading industries (high-end equipment, special paper, bamboo industry + digital economy). A total of 180 million yuan of special support funds for the bamboo industry have been invested from 2021 to 2023, with policies focusing on "endogenous capacity cultivation": first, technological transformation subsidies (enterprises can receive a 30% subsidy for purchasing intelligent bamboo processing equipment, with a maximum subsidy of 5 million yuan per enterprise, driving 120 million yuan of enterprise technological transformation investment in 2023); second, brand cultivation (rewards of 200,000 to 500,000 yuan for bamboo enterprises that obtain "Zhejiang Made" and "Green Product" certifications, and 8 bamboo enterprises have obtained such certifications so far); third, talent guarantee (launching the "Bamboo Industry Talent Special Plan", introducing 23 bamboo processing technology talents and 35 e-commerce operation talents, and distributing more than 5 million yuan in talent subsidies). The policies do not rely on external "blood transfusion", but activate the endogenous driving force of the local industry through "subsidies + guidance" (Source: Longyou County Government.[14] 2023. Evaluation Report on the Implementation Effect of Bamboo Industry Development Policies).

4. Main Challenges and Bottlenecks

Although Longyou Bamboo Industry has formed scale advantages, the Neo-endogenous Development Theory emphasizes "local subject leadership, in-depth resource integration and endogenous value increase". In contrast,

the industry still faces three core bottlenecks, restricting its transformation from "scale expansion" to "quality improvement".

4.1 Fragmented Resources and Loose Interest Linkages Restrict Endogenous Driving Force

The core of neo-endogenous development is to activate the participation and initiative of local subjects (especially bamboo farmers), but the pattern of "dominance of individual farmers and weak linkages" in Longyou Bamboo Industry has led to a serious lack of this endogenous driving force. From the perspective of resource management model, among the 35,000 employees in the county's bamboo industry, 83% of the bamboo forests are managed independently by individual farmers (with a single household management area of 5-15 mu), and only 12% of individual farmers have joined bamboo professional cooperatives. The level of large-scale and intensive management is far lower than that of benchmark regions in the province (e.g., the coverage rate of bamboo forest cooperatives in Anji County reaches 45%). This fragmented management directly leads to two problems:First, the income of bamboo farmers is low, and their willingness to participate is weak. According to the Longyou County Forestry Bureau's 2023 Report on Bamboo Forest Management Models and Income Analysis, the average annual bamboo sales income per mu of bamboo forests managed by individual farmers is about 3,200 yuan, which is 33.3% lower than that of bamboo forests managed uniformly by cooperatives (4,800 yuan per mu). Moreover, individual farmers can only obtain income by "selling raw materials" and cannot share the value increase in the downstream processing link. Taking bamboo flooring as an example, bamboo raw materials account for 25% of the cost of end products, but individual farmers can only obtain 80% of this 25% (i.e., 20% of the terminal value), while cooperatives can enable their members to obtain 35% of the terminal value through "unified purchasing and order processing".[15] The imbalance in income distribution leads to insufficient enthusiasm of bamboo farmers to participate in industrial upgrading: a 2023 survey by the Longyou County Bureau of Economy and Information Technology showed that only 28% of bamboo farmers are willing to invest funds (such as 200 yuan per mu for bamboo forest improvement) to improve bamboo quality, and only 15% of bamboo farmers try to participate in primary processing (such as bamboo chip cutting). Most of them still rely on the traditional model of "cutting and selling bamboo", and the "sense of ownership" of local subjects has not been activated.

Second, the interest connection mechanism is fragmented, and there is insufficient coordination in the industrial chain. Currently, the relationship between bamboo farmers and processing enterprises in Longyou is mainly based on "spot transactions" – the contract signing rate for long-term stable orders is less than 15%, and only 5% of bamboo farmers can link their interests with enterprises through methods such as "shareholding dividends" and "minimum purchase price + profit rebate".

Take Zhejiang Hengsheng Bamboo Industry, a leading enterprise, for example. In 2023, it procured 12,000 tons of bamboo, but only signed long-term agreements with 300 bamboo farmers (representing 18% of its raw material suppliers), with the rest being temporary purchases. By comparison, "Yongyu Bamboo Industry", a leading enterprise in Anji County, has adopted a "cooperative + enterprise" model with 2,000 bamboo farmers, and the average annual dividend for each bamboo farmer exceeds 8,000 yuan.

This loose connection makes it hard for enterprises to secure stable and high-quality raw materials, while bamboo farmers fail to share the benefits of industrial upgrading. This creates a gap in endogenous momentum where "enterprises want to upgrade but bamboo farmers are unwilling to take action".[16]

4.2 Short Industrial Chain and Insufficient Innovation Capacity Limit Value Enhancement

Neo-endogenous development requires "realizing a value closed loop based on local resources", but the current situation of "low-end lock-in and weak innovation" in Longyou Bamboo Industry has led to the insufficient release of industrial chain value. From the perspective of industrial structure, among the more than 150 bamboo enterprises in

the county, 80% are concentrated in the primary processing and mid-to-low-end manufacturing links, with a low proportion of high value-added end products. According to the Zhejiang Provincial Forestry Bureau's 2023 White Paper on the Development of Bamboo Industry in Zhejiang Province, the output value structure of Longyou Bamboo Industry presents an "inverted pyramid" characteristic: the output value of primary processed products (bamboo chips, bamboo strips, roughly processed bamboo materials) accounts for 38%, mid-to-low-end products (ordinary bamboo flooring, basic bamboo tableware, bamboo charcoal) account for 32%, while end consumer products (such as high-end bamboo fiber home textiles, customized bamboo furniture, intangible cultural heritage bamboo woven cultural and creative products, functional bamboo materials) account for only 27%, which is much lower than that of Anji County (51% for end consumer products) and Lin'an District (42%).[17] More importantly, 80% of the end products are concentrated in the domestic mid-to-low-end market, and the average price of exported products is only 45% of that of similar bamboo home products of German brands and 38% of that of Japanese TOTO bamboo fiber bathroom products, lacking high value-added competitiveness of "technology + design".

Lack of innovation capability is the core issue hindering the extension of the industrial chain. In 2023, the average R&D investment ratio of above-scale enterprises in Longyou's bamboo industry was only 0.6% — this not only falls below the average level of Zhejiang's bamboo and wood industry (1.8%), but also below that of advanced manufacturing enterprises in the Yangtze River Delta (2.5%).

In terms of innovation output, enterprises within the cluster file an average of only 1.2 invention patent applications per enterprise each year. Seventy percent of these enterprises have no independent R&D teams, and their reliance on external parties for core technologies — such as mildew-resistant modification of bamboo, efficient bamboo fiber extraction, and bamboo-based composite material production — reaches 65%. For instance, bamboo mildew resistance is a core technology for high-end bamboo furniture. Currently, only 3 enterprises in Longyou have mastered this technology, and all of them acquired the patents from Zhejiang A&F University (paying over 2 million yuan annually in patent fees).

By contrast, "Yongyu Bamboo Industry" in Anji County independently developed a "nano-level bamboo mildew inhibitor," with a patent technology conversion rate of 80%. This not only reduced the product defect rate from 8% to 2%, but also cut costs by 15%. Additionally, there is insufficient industry-university-research collaboration: Longyou's bamboo enterprises have only 8 long-term cooperative projects with universities and research institutions, which is merely 22.8% of Anji County's total (35 projects). Currently, there is a lack of cross-sector innovation such as "bamboo industry + new materials" and "bamboo industry + smart home," leaving the industry stuck in the "processing and manufacturing" stage and making it hard to move toward high-value-added stages like "R&D and design" and "brand services."[18]

4.3 Insufficient Brand Premium and Lack of Ecological Value Conversion Affect Sustainable Development

Neo-endogenous development emphasizes "synergy of internal and external resources and sustainable value creation", but the shortcomings of Longyou Bamboo Industry in the two fields of "brand empowerment" and "ecological monetization" have limited its long-term development space.

From the perspective of brand building, the "Longyou Bamboo" regional public brand has notably insufficient market reach and premium power. According to the 2023 Report on Regional Public Brand Competitiveness Evaluation by the Quzhou Municipal Market Supervision Bureau, the market recognition rate of "Longyou Bamboo" is only 32% — far lower than that of "Anji Bamboo" (78%) and "Deqing Bamboo" (55%).

In terms of pricing, "Longyou Bamboo" bamboo flooring has an average price of around 180 yuan per square meter. This is 30.8% cheaper than "Anji Bamboo" (260 yuan per square meter) and 52% cheaper than international brands (such as IKEA's bamboo storage series). There are also gaps in brand management: currently, only 18

bamboo enterprises have obtained authorization for the "Longyou Bamboo" public brand, accounting for less than 12% of the total number of bamboo enterprises in the county. Some authorized enterprises even engage in substituting inferior products for quality ones (2023 sampling by market supervision departments showed the product pass rate of authorized enterprises was 85%, lower than Anji County's 98%), which further undermines the brand's credibility.

By contrast, Anji County has implemented "unified standards, unified authorization, and unified marketing." A total of 210 enterprises have obtained authorization to use "Anji Bamboo," and the annual sales volume of branded products exceeds 8 billion yuan — accounting for 60% of the total output value of the county's bamboo industry — with a prominent brand premium effect.

From the perspective of ecological value conversion, Longyou's abundant bamboo forest carbon sink resources have not yet formed a stable market-based monetization pathway. According to the Study on Bamboo Forest Carbon Sink Potential and Monetization Pathways by the Longyou County Bureau of Ecology and Environment, the annual carbon fixation potential of the county's 410,000 mu of bamboo forests reaches 1.26 million tons — which is equivalent to cutting the annual carbon emissions of 630,000 family cars. However, only 12,000 tons of carbon sink transactions were actually completed in 2023, with a transaction volume of 600,000 yuan, accounting for just 0.95% of the total potential.

Compared with Anji County (which completed 120,000 tons of bamboo forest carbon sink transactions in 2023 with a transaction volume of 6 million yuan, and also introduced "carbon sink pledge loans" enabling 15 bamboo enterprises to secure over 50 million yuan in loans), Longyou's carbon sink market mechanism is clearly lagging. It has not yet established integrated models such as "carbon sink + finance" and "carbon sink + cultural tourism." For example, Anji County has developed "bamboo forest carbon sink study tours," receiving over 500,000 tourists annually and driving 320 million yuan in ecological tourism revenue. In contrast, similar projects in Longyou are still in the pilot phase: its bamboo cultural tourism revenue in 2023 was only 23 million yuan, less than 7.2% of Anji's.

Additionally, mechanisms for collaborative innovation between internal and external resources are inadequate. In 2023, Longyou's bamboo enterprises had only 8 cross-sector collaborative projects with external enterprises and research institutions (such as "bamboo product live-streaming sessions" in cooperation with e-commerce platforms) — far fewer than Anji County's 35 (covering fields like "bamboo industry + digital economy" and "bamboo industry + big health").[19] Currently, there is a lack of effective ways to unlock the value of local ecological resources through external resources. This prevents the industry's "ecological advantages" from being converted into "economic advantages," resulting in insufficient momentum for sustainable development.

5. Strategic Optimization Paths of Longyou Bamboo Industry Cluster Based on Neo-endogenous Development Theory

5.1 Strengthen Subject Cultivation and Interest Linkages to Activate Endogenous Driving Force

At present, 83% of bamboo forests are all managed by smallholder farmers. Under such circumstances, the key lies in innovating organizational models and profit distribution models.

Efforts should be made to fully promote the "enterprise + cooperative + base + bamboo farmer" joint-stock cooperative model, supporting bamboo farmers in converting resources such as bamboo forest management rights into shares to invest. Meanwhile, a pilot program should be launched to establish a "Bamboo Industry Common Prosperity Alliance," ensuring that bamboo farmers and community representatives can genuinely participate in decision-making regarding industrial planning and profit distribution — helping them transition from mere "resource providers" to "shareholders and participants in industrial development," and fundamentally stimulating

the enthusiasm and creativity of local entities.[20]

5.2 Promote In-depth Integration of Industrial Chain and Innovation Chain to Improve Value Level

Efforts need to be made to adjust the industrial structure where the proportion of end consumer goods is less than 30%. Vertically speaking, prioritize tackling the R&D and industrialization of high-value-added products such as bamboo-based new materials and bamboo fiber eco-friendly products; horizontally, further advance the integration of "bamboo industry +", diversify the experience formats of projects like "Xikou Bamboo Culture Theme Town", and develop bamboo forest wellness and nature education.

Clear targets should also be defined: within the next five years, raise the proportion of end consumer goods to over 50%, double the revenue from bamboo cultural tourism and bamboo wellness, and create a diversified way to realize value.

5.3 Implement Brand Leadership and Ecological Value Conversion to Expand Development Space

We need to systematically develop and manage the "Longyou Bamboo Living" regional public brand, set strict access requirements and quality control standards, and enhance the brand's premium potential. Meanwhile, speed up the market-oriented development of ecological value, prioritize advancing the development and trading of VCS/CCER and other carbon sink projects (Note: VCS/CCER are mainstream international and domestic carbon sink project types) covering 410,000 mu of bamboo forests, and turn the ecological edge of millions of tons of annual carbon sequestration into real economic gains.

Using this as a starting point, drive the green transition of the industry and achieve the effective conversion of "lucid waters and lush mountains" into "gold and silver mountains".

6. Conclusion

To develop Longyou’ s bamboo industry in the future, it must shake off the path dependence on resource scale and processing capacity, and take a new strategic path guided by the Neo-endogenous Development Theory. The core of this path lies in stimulating the internal driving force with bamboo farmers, craftsmen, and local enterprises as the core — digging deeply into the diverse ecological and cultural values of bamboo resources, and then converting external resources into positive forces that serve the local area’ s long-term goals through effective governance mechanisms.

By carrying out the above-mentioned optimization paths, Longyou’ s bamboo industry is expected to build into a modern industrial cluster featuring strong rootedness, vibrant innovation, diverse values, and shared benefits. This will offer a replicable "Longyou Experience" for reviving characteristic resource-based industries in hilly and mountainous areas across the country.

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Challenges and Coping Strategies for Foreign Trade Enterprises in Yinzhou District in the Trump 2.0 Era

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Abstract: The "Trump 2.0" policy, involving tariff adjustments, reforms to trade preference systems, and measures to enhance supply chain security, introduces changes in the global trade environment. As a leading region in Ningbo's foreign trade, Yinzhou District faces a new external environment and structural adjustments under these evolving trade policies. Factors such as tariff modifications, updated compliance requirements, and shifting market structures influence the operations of the district's foreign trade enterprises, particularly in areas of cost management, risk control, and market deployment. Based on the development of Yinzhou's foreign trade, this paper examines the key components of the policy, identifies the challenges faced by enterprises, and provides strategic recommendations for addressing them.

Keywords: Trump 2.0 policy; tariffs; foreign trade enterprises

1. Introduction

In recent years, Yinzhou District has maintained a steady upward trajectory in foreign trade, with notable achievements in market diversification. While sustaining stable growth with traditional trading partners, the district has also expanded its engagement with emerging markets. In 2024, the total import and export volume of Yinzhou District reached RMB 257.29 billion, a year-on-year increase of 12.5%, significantly higher than the Ningbo city average. Exports were particularly strong, totaling RMB 204.17 billion—up 17.5%, 3.4 percentage points above the city average. In terms of export structure, exports to emerging markets amounted to RMB 86.23 billion, growing by 16%; exports to the EU and the United States reached RMB 41.80 billion and RMB 45.00 billion, rising by 18.8% and 17.3% respectively; exports to 64 countries along the Belt and Road totaled RMB 59.92 billion, an increase of 16.3%. However, with Donald Trump's return to the U.S. presidency, the global political and economic landscape is undergoing profound transformation. The advent of the Trump 2.0 era marks major shifts in U.S. foreign trade policy, posing substantial challenges for Yinzhou's foreign trade enterprises—especially those deeply embedded in global value chains and reliant on traditional European and American markets. Against this backdrop, how can Yinzhou's foreign trade enterprises confront these challenges and seize emerging opportunities? How can local governments provide effective support to help enterprises weather this new round of international economic turbulence? These questions are central to the current discussion and warrant in-depth examination.

2. Core Components of the Trump 2.0 Policy

2.1. Adjustment of the Tariff Structure

After taking office on January 20, 2025, President Trump initiated a phased adjustment of U.S. tariff policies. Beginning February 1, a 10% baseline tariff was imposed on Chinese exports to the United States, followed by an additional 10% increase on March 4, bringing the cumulative rate to 20%. On April 2, the United States implemented a universal 10% tariff increase on all imported goods, while imposing additional tariffs on products from China, the European Union, Vietnam, Japan, and other regions. On April 9, a "reciprocal tariff" mechanism was introduced for selected Chinese goods, raising rates to 125%. The White House clarified on April 10 that the overall effective tariff rate on Chinese imports averaged around 145%. Subsequently, on April 15, tariffs on certain Chinese exports to the U.S. were raised to 245%. On May 12, China and the United States signed the "Geneva Joint Statement," under which the U.S. agreed to remove approximately 91% of tariffs on Chinese goods and suspend 24% of tariff measures for 90 days. Overall, the Trump administration adopted a phased, rapid-response approach to tariff policy adjustment within a relatively short timeframe.

2.2. Restructuring of Global Industrial Chains

Within the framework of industrial chain security, recent U.S. policy has introduced an expanded tariff system and complementary measures aimed at influencing global industrial chain configurations, with stated objectives including the promotion of domestic manufacturing and diversification of supply chain dependencies [1]. Specifically, a "baseline-plus-differentiated" tariff structure has been implemented, which includes a 10% baseline tariff applicable to all trading partners, along with additional surcharges on certain Asian economies. This structure is intended to incentivize multinational enterprises to adjust their production and supply chain layouts. Beginning on April 15, U.S. Customs required importers to provide three-tier supply chain traceability documentation, a measure that increased compliance requirements and extended customs clearance times for exporters. These adjustments may influence production relocation decisions by global firms, including companies such as Samsung and Volkswagen, toward regions including Southeast Asia and Mexico. On July 4, the U.S. administration enacted an extension of the Tax Cuts and Jobs Act, which permanently reduced the corporate income tax rate to 21% and introduced targeted tax incentives for enterprises reshoring production. Taken together, these policy measures represent a multidimensional approach to enhancing supply chain management, adjusting industrial geography, and supporting domestic manufacturing competitiveness through coordinated trade and fiscal policy instruments.

2.3. Multi-Dimensional Development of Technology Controls

Technological capability constitutes a core component of national economic competitiveness and a key area of international technological interaction. Recently, the U.S. administration has implemented adjustments in technology policy with implications for international markets, evolving from a framework primarily focused on export restrictions to a more comprehensive regulatory system. These measures exhibit two main dimensions. First, the scope of technology export controls has been expanded. Through legislative amendments and updates to the Entity List, restrictions have been extended to the export of key technologies such as semiconductors and artificial intelligence. For instance, NVIDIA's H20 chip was recently included in the export control list, and in May 2025, the U.S. government announced restrictions on the supply of high-end AI chips to certain markets, with some measures applied globally, as part of broader objectives related to technology transfer and national security. Second, market access regulations have been adjusted. In February 2025, the U.S. Congress introduced the U.S. Artificial Intelligence Capability and Technology Management Act of 2025, which establishes requirements for the use of designated

foreign AI products by U.S. entities, with noncompliance subject to legal penalties. Additionally, the administration has pursued international coordination in technology governance, including the development of technical standards and cooperation with partner economies [2]. Collectively, these measures represent a multidimensional approach to technology regulation aimed at addressing supply chain considerations and influencing international technology flows.

3. Challenges Faced by Foreign Trade Enterprises in Yinzhou District

3.1. Escalating Dynamic Cost Pressures

The Trump 2.0 tariff policy toward China has introduced heightened volatility and uncertainty through frequent adjustments to tariff rates and implementation timelines. The average tariff level increased from 19% during the initial phase to a temporary peak of 245%, substantially elevating the cost burden on enterprises [3]. Although the Geneva Interim Agreement subsequently lowered tariffs to 30%, this figure remains considerably higher than the 10% baseline applied by major economies such as the European Union and Japan. Moreover, the 90-day policy window, combined with compliance complexities and the rise of non-tariff measures, has continued to expose firms to regulatory and cost-related risks.

As a major hub of Ningbo's foreign trade, Yinzhou District hosts 31,443 import–export enterprises as of June 2025, representing roughly one-quarter of the city's total, according to data from Aiqicha. In April 2025, China's exports to the United States fell by 21.0% year-on-year, affecting the stability of overseas orders for Yinzhou-based firms. In response to tariff fluctuations, local enterprises have adopted adaptive strategies aimed at mitigating exposure. For instance, Huacai Electric accelerated its expansion into emerging markets in Latin America and ASEAN to diversify risk; however, this transition has required additional expenditures for overseas technical deployment and workforce training. Similarly, Ningbo Berrylai International Trading Co., Ltd. adopted a "China Core + Southeast Asia Manufacturing + Global Assembly" model, establishing production bases in Vietnam and Cambodia to optimize tariff structures. Nonetheless, cross-border production adjustments have involved substantial upfront investment, increasing labor costs, and coordination challenges across supply chains. The short-term tariff window has also led to a surge in export activity, as firms expedited shipments prior to tariff adjustments. This surge in transportation demand has driven up freight rates on China–U.S. routes, further amplifying logistics expenses and operational costs for enterprises in the district.

3.2. Constraints on Technology Supply and Challenges to R&D

Recent U.S. policy adjustments under the Trump 2.0 framework have intensified export controls on advanced technologies, exerting notable effects on the technological supply chains of Yinzhou's foreign trade enterprises. The United States has expanded restrictions on critical technologies such as semiconductors and artificial intelligence, further refining the list of regulated items [4]. These measures have limited access to high-end computing components for Yinzhou's electronics manufacturers, thereby influencing the district's broader innovation ecosystem. Specifically, areas such as autonomous driving, large-scale model development, and smart city projects have encountered delays due to constraints in computing resources. U.S. restrictions on AI chips and model parameters have prompted local technology firms to explore alternative pathways, including domestic open-source models, which require additional algorithmic adaptation and extended R&D cycles. In response, many Yinzhou-based enterprises—particularly in the automotive and electronic component industries—have reallocated resources from long-term R&D to short-term risk management, including supply chain restructuring and the establishment of overseas facilities. This shift has placed additional pressure on innovation investment,

underscoring the complex trade-offs between technological resilience, cost control, and long-term competitiveness within Yinzhou's manufacturing sector.

3.3. Market Volatility and Compliance Challenges

Yinzhou's foreign trade enterprises have historically maintained a high degree of dependence on traditional markets such as the United States, with orders and profits concentrated in these regions. Under the Trump 2.0 administration's expanded tariff measures and tightened technology-related restrictions, volatility in the U.S. market has increased, introducing greater uncertainty into the order flows of Yinzhou-based firms. To sustain operations, many enterprises continue to rely on these markets while managing heightened policy and regulatory risks. For instance, Ningbo Kaiyue International Trading Co., Ltd. experienced repeated order cancellations from U.S. clients due to changing tariff policies. The firm adopted flexible negotiation strategies to mitigate contractual risks, as formal legal remedies would entail high costs and potential strain on long-term partnerships, thereby affecting its overall market position. At the same time, adjustments in trade policies among Southeast Asian economies have added further complexity. In response to evolving global tariff arrangements and compliance frameworks, several countries have strengthened rules of origin and introduced additional trade documentation requirements. Vietnam, a key destination for relocated Chinese manufacturing, reached an agreement with the United States in April 2025 to enhance verification mechanisms for product origin, increase localization thresholds, and implement supplementary trade measures such as import quotas and stricter environmental standards. These developments have indirectly increased entry barriers for re-export trade involving Chinese intermediate goods. Frequent and sometimes unpredictable policy shifts have created notable compliance challenges for enterprises. Many firms face difficulties in obtaining complete and up-to-date regulatory information, complicating cross-border compliance management. To address these challenges, Ningbo Kaiyue International Trading Co., Ltd. engaged a third-party auditing firm to conduct comprehensive traceability certification for its overseas production facilities. Each audit cost more than RMB 500,000, significantly increasing export-related expenditures and operational costs.

4. Recommendations for Supporting Yinzhou's Foreign Trade Enterprises in Coping with Challenges

4.1. Developing a Resilient Supply Chain System

As of February 2025, Yinzhou District hosted 25 national-level "Single Champion" enterprises and 83 "Specialized, Refined, Distinctive, and Innovative" (SRDI) "Little Giant" firms. Leveraging its robust manufacturing base, the district's foreign trade enterprises can strengthen supply chain resilience through global capacity allocation and digital transformation [5]. Given Yinzhou's stage of industrial development, local policymakers may capitalize on Ningbo's position within national advanced manufacturing clusters and the province's "415X Industrial Cluster Initiative." Strategic guidance could focus on promoting the orderly relocation and optimization of key industries, both domestically and internationally, while enhancing the application of digital technologies in supply chain integration [6]. Such efforts would improve the region's overall capacity to absorb external shocks. In practice, Yinzhou enterprises in sectors such as automotive components and smart appliances could utilize the incentives under the "62 New Policies for Promoting High-Quality Economic Development in Yinzhou District" to establish production bases in Southeast Asia and Mexico, forming complete industrial chains from raw materials to final assembly. Concurrently, firms could modernize their inventory management systems by adopting AI-based predictive models developed in the Yongjiang Software Industrial Park. For instance, predictive pricing systems could enable manufacturers such as Huayi Electric to identify cost-efficient procurement opportunities, thereby improving price competitiveness. Moreover, companies could apply blockchain technologies to enhance supply chain transparency—replicating the "supply chain visualization" experience of Ningbo World Trade Link—to

improve data connectivity and coordination between upstream and downstream partners.

4.2. Sustained Diversification of Export Markets

In light of demand fluctuations in traditional European and North American markets, Yinzhou’ s foreign trade enterprises are encouraged to expand further into emerging regions, including ASEAN, Latin America, the Middle East, Central Asia, and Africa. Market diversification should be supported through detailed local market research, targeted product alignment, and the strengthening of trade promotion channels. District-level and industry associations could play a facilitating role by organizing participation in international trade fairs and supply chain promotion events. For example, through platforms such as the China–CEEC Expo, leading Yinzhou manufacturers—including Ningbo Shenglong Group and Jinghua Electronics — may engage in Central and Eastern European infrastructure projects, particularly in new energy vehicle charging systems and intelligent transportation facilities. Additionally, the local government may consider targeted support measures such as subsidies for trade fair participation, logistical cost assistance, and financial incentives for overseas warehouse development. A collaborative mechanism integrating government, enterprises, and academia could further enhance international competitiveness. Partnerships with universities would help cultivate interdisciplinary talent proficient in both technological innovation and regional business practices. Through cross-border e-commerce and big data analytics, Yinzhou enterprises could more accurately identify global market demand, thereby strengthening resilience and contributing to a diversified, multi-polar pattern of foreign trade growth.

4.3. Establishing a Dual Mechanism for R&D and Compliance

The current global trade environment increasingly emphasizes technological standards as a key dimension of international competition. Non-tariff measures — such as Section 337 investigations — have raised compliance requirements for Chinese exporters, intensifying the need for risk management and regulatory preparedness [7]. To address these challenges, Yinzhou may promote the development of a dual mechanism integrating R&D innovation and compliance management. From a technological perspective, export-oriented enterprises are encouraged to expand investment in research and development to strengthen core capabilities, enhance brand competitiveness, and overcome technical entry barriers in advanced markets. The establishment of district-level innovation centers—drawing on models such as the Bowei Alloy Digital R&D Platform—could focus on frontier fields including embodied intelligence and new materials. Firms with R&D expenditures exceeding 7% of revenue might be prioritized for tax deduction incentives to sustain long-term innovation. From a compliance perspective, the district government can facilitate cooperation with consulting agencies and legal firms to provide specialized services, such as U.S. and EU patent strategy planning and trade remedy response mechanisms. For industries with higher exposure to trade disputes, including automotive parts and electronic equipment, the creation of an early-warning database for technical standards would help firms identify and mitigate potential compliance risks. This framework could reduce regulatory costs and support stable participation in international markets.

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The Current Situation and Future of Tea Culture and Regional Tourism Development under the Background of "Internet +"——A case study of Yueyang City, Hunan Province

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Abstract: Tea culture is an important part of China's excellent traditional culture. In the context of "Internet +", how to develop and inherit traditional tea culture is a problem we need to consider at present. With the rapid development of China's economy, the quality of people"s life continues to rise, and the demand for culture is constantly changing, forming a new consumption concept. At the same time, the "Internet +" culture relying on the Internet, using big data as a means, and characterized by mobility and networking has rapidly emerged and quickly penetrated into all walks of life. The tourism industry took advantage of this shareholder wind and came across the traditional tea industry which was facing an inheritance crisis, then a new idea of combining the tea industry and regional tourism was born. Tea Culture and Regional Tourism is a cultural form, based on tea as the carrier, combined with tourism, leisure, health. The integrated development of Tea Culture and Regional Tourism is a new industrial form born under the background of rapid growth of tourism, which plays a significant role in promoting national economic development, social progress and cultural prosperity. It is an important way not only for industrial optimization and upgrading, but also for regional cultural innovation and development. Taking Yueyang City, Hunan Province as an example, this paper studies current situation and prospects of Tea Culture and Regional Tourism in Yueyang City, through questionnaire survey, literature research, SWOT analysis. It aims to put forward suggestions to solve the problems in the integrated development of Yueyang"s Tea Culture and Regional Tourism, selection of tea product marketing strategy and industrial development planning, so as to provide reference for promoting the healthy and rapid development of China's Tea Culture and Regional Tourism.

Keywords: Internet+; Tea Culture and Regional Tourism; SWOT analysis

1. Introduction

The development of tea tourism culture under the background of "Internet +" is an industry that the state attaches great importance to, and the tea tourism culture industry is also a very promising industry in the future Internet situation. The research in this paper is not only conducive to the overall development of the tea tourism industry to provide reference to promote the development of tea tourism and cultural enterprises, but also conducive to improving local livelihoods, solve the employment problem, and stimulate economic development. For the research object of the project, Yueyang yellow tea, it can also create a nationally renowned tea culture tourism area, and make Yueyang special brand, in order to improve brand awareness and recognition.

At present, previous research on this topic has made some progress at home and abroad. Jin Wenbin[1], Li Lingfeng[2], Zhu Xuedong and Liu Rui[3] discussed the feasibility of the future integration of the tea tourism industry from the perspective of domestic scholars, while Sita K [4], Hartwig Bohne [5], and Sanjana Monda [6] pointed out the challenges that the industry may face while proposing the direction of the development of the tea tourism industry

from the perspective of foreign scholars.

After collecting and analysing the results of previous projects, this paper intends to start from the background of the era of Internet + to explore the future development direction of the tea tourism industry and the Internet for deep integration. And in the process of this research to solve the problem of how to improve the integration of tea tourism culture in the Internet + era, how to improve the tea tourism culture recognition in many brands, how to improve the tea tourism brand awareness in the fierce competition, how to improve the tea tourism economic synergy in the gradual development.

2. Research background

In the context of "Internet +", the development of tea tourism culture is an industry that the state attaches great importance. 29 April 2021, the twenty-eighth meeting of the Standing Committee of the thirteenth National People's Congress voted to adopt the "Law of the People's Republic of China on the Promotion of Rural Revitalisation". 18 May 2021, the Ministry of Justice issued the ""Rural Revitalisation Rule of Law Peer" Activity Programme". On May 18, 2021, the Ministry of Justice issued the ""Rural Revitalisation and Rule of Law" activity programme".2022 The results of the survey of the National People's Congress were released, and the "Rural Revitalisation" was ranked the eighth in terms of attention[7]. This paper is to respond to these two policies to promote the expansion of Yueyang yellow tea tea travel culture industry market, in order to revitalise the rural economy of Yueyang.

At the same time, the tea tourism culture industry is also a very promising industry in the future Internet situation. 2025 Central Document No. 1 proposed to vigorously promote the construction of digital countryside, strengthen scientific and technological innovation and institutional innovation. Promote the development of intelligent agriculture, and promote the integration and application of information technology and agricultural machinery and agronomy. And Yueyang is not only a famous tea key production area in Hunan Province and even the whole country, but also the main production area of yellow tea. In recent years, Yueyang tea tourism and cultural development has always adhered to the principles of ecological development and green development of the industry, combined with market demand, reconstructing the ecological civilisation of the tea industry, the transformation of the tea industry has taken new steps[8]. The arrival of the Internet + era has brought new opportunities for the development of Yueyang tea tourism culture, which is both an opportunity and a challenge for the development of Yueyang tea tourism culture.

3. Domestic and international research status and development dynamics

3.1 Domestic tea travel development research status and development dynamics

Jin Wenbin[1] by describing the basic conditions for the development of tea tourism integration in Hangzhou Xiaogucheng Village, reveals the current problems of the tea tourism industry, including the lack of awareness of ecological protection of tea farmers, the lack of promotion efforts, the lack of cultural and tourism management personnel, and puts forward countermeasures, in order to promote the development of the local economy to provide reference.

Li Lingfeng[2] and others use literature survey method, questionnaire survey method, interview method, case study method and other research methods, through the "due to geographic location, popularity and economic development level and other constraints caused by the development and use of tourism resources in the region reduced value" as the content of the phenomenon of tourism shielding, to carry out the Anhui Lu'an tea cultural tourism "shielding". Tourism "shield" factor analysis, and then from the tea travel consumer tourism motivation, combined with the experience marketing under the AISAS model, explore in the "Internet +" under the Lu'an tea representative of the Liu'an Gua Pian cultural tourism product development path and mode. In order to provide targeted advice and development for the development of tea plantations in Anhui Province and China's tourism-restricted tea areas, and at the same time to support the main tea-producing cities and counties to build tea

tourism boutique lines, tea tourism boutique parks, tea tourism characteristics of small towns, and to develop new tea tourism fusion products, such as "tea tourism + lodging", "tea tourism + learning" and so on. The development of "tea tourism + lodging", "tea tourism + study" and other tea tourism integration of new forms; and create a number of good growth, strong competitiveness, outstanding characteristics of the tea brand, consolidate and enhance the results of industrial poverty alleviation.

Zhu Xuedong and Liu Rui[3]extracted the main values of tea culture tourism experience through questionnaire survey and factor analysis. The results show that: aesthetic ornamental value, health care and health maintenance value, entertainment experience value and education and science popularisation value are the values for tourists to participate in tea culture tourism experience.

3.2 Current status of research and development of tea tourism development abroad

Sita K [4]argues that the diversity of employment avenues for people living around tea plantations that have been developed into tourism is increasing. Corporate Social Responsibility (CSR) provides further opportunities for sustainable development of tea tourism. Improving service satisfaction of tea tourists is one of the important ways to increase the willingness to revisit. Establishing partnership synergies can compensate for the lack of resources and capacity in the integrated development of tea and tourism linkages. For future practical impacts, it is important to expand the integration of tea and tourism by building partnerships that stimulate more local participation and provide more local benefits.

Hartwig Bohne [5]analysed the initial effects of tea on the regional economy, as well as the cultural and social roots associated with tea tourism, and weighted them to present the uniqueness of the world's only UNESCO-awarded tea-consuming tradition and the impact it has on tourism. As well as analysing the tools that can help to enhance authentic tea oriented destination marketing.

Sanjana Monda[6]focused on the demand and supply perspectives of tea tourism and its stakeholders and identified the main problems and challenges as the key dimensions of inadequate planning and marketing efforts, limited co-operation among stakeholders, local participation, socio-economic inequalities and consumer attitudes towards tea tourism. This study will help future researchers and scholars to expand the field of tea tourism and is of great significance for policy makers, regulatory agencies, marketers, and tour operators to grasp the socio-economic perspectives while formulating suitable marketing strategies for tea tourism to ensure the sustainable development of tea tourism.

In summary, many scholars at home and abroad for the development of tea tourism industry research are relatively objective. However, scholars from different regions and countries with different levels of development are affected by research perspectives, research methods, research funding and other factors, the research on the development of tea tourism industry is not the same, but most scholars believe that the development of the tea tourism industry should be brand strategy planning, increase the investment of scientific and technological funds, improve the value of the tea brand, enhance the brand's cultural connotations, and continue to extend the tea tourism industry chain, to promote the development of the tea tourism industry. Development. In the era of rapid development of science and technology, tea tourism wants to rapidly develop the need for deep integration with the Internet, the full and reasonable use of online and offline integration mode, to the traditional tea tourism industry to enter the fresh blood, change the traditional tea tourism industry sales channels, continue to cultivate e-commerce talent, the establishment of a sound and perfect tea tourism industry information network platform, relying on network platforms to provide information resources for tea, so that consumers can enjoy more The right to know, better for consumers to provide personalised services, closer to the distance between business and consumers, in order to achieve the transformation and upgrading of tea enterprises, and ultimately achieve the rapid development of the tea tourism industry.

4. Internet + era Yueyang tea tourism culture development of the status quo and problem analysis

4.1 Yueyang tea tourism culture development status quo

Dongting landscape show, Yueyang yellow tea fragrance. Yueyang city has a long history of tea production, known as "China's yellow tea township" reputation, but also has won the "national geographical indications trademark" and "Hunan Province, the top ten agricultural regional public brand" and so on. A number of honours. In recent years, the development of yellow tea industry in Yueyang, not only was selected as the national "100 counties - 100 tea - 100 people" list, but also among the Hunan tea rural revitalisation of the "top ten leading brands", the brand value of 2.076 billion yuan, to become the focus of the 100 billion tea industry in Hunan Province! Brand and "colourful Hunan tea" important plate.

Yueyang city tea industry development work to adhere to the implementation of General Secretary Xi Jinping "three tea" integrated development ideas, based on the new development stage, the implementation of the new development concept, build a new development pattern, and promote high-quality development requirements, around the Yueyang "three districts and a centre" strategic positioning and the "11" Yueyang tea industry. Yueyang tea industry "113" goal. 2021, the city's tea plantation area of 306,000 acres, the total tea production of 34,700 tonnes, of which 9,106 tonnes of yellow tea production, the comprehensive output value of nearly 6 billion yuan, to achieve a piece of leaf rich people's vision of a party. As of the end of 2024, Yueyang city's tea plantation area stabilised at 321,700 mu, the total output reached 34,800 tonnes, of which 10,400 tonnes of yellow tea production, the comprehensive output value of tea exceeded 8.9 billion yuan, with practical action to drive the local farmers to become rich, and to promote the development of the tea industry in Yueyang City. Yueyang City, the person in charge of the tea industry said, tea as a medium, tea will be friends, exchange and cooperation, mutual benefit and win-win situation, and make every effort to promote the integration of tea tourism development in Yueyang City, to achieve value-added tea industry to extend the chain, to benefit more people. (Data from Yueyang Yellow Tea Official Accounts)

According to the plan, by the end of 2025, Yueyang city's tea plantation area will continue to expand steadily, one, two, three industries in-depth integration of the comprehensive output value of the tea industry exceeded 10 billion yuan, and strive to "Yueyang yellow tea" into a nationally renowned brand, and to achieve the transformation from a large tea-producing city to a strong industrial city.

4.2 Yueyang tea tourism culture problem analysis

Through the questionnaire survey on Yueyang yellow tea (In which the sample of questionnaires came from local people in Yueyang, the questionnaire survey was distributed a total of 215 questionnaires, of which the data of validly completed questionnaires were 200, so the sample size of Table 1 is 200) and field research, Table 1 shows that the development of Yueyang tea tourism culture mainly exists in the following problems:

4.2.1 The brand building of Yueyang yellow tea is not strong enough and too single.

Brand building is the fundamental channel to communicate with consumers, and the expectation of market share depends on the brand influence that matches it, so the development of brand building by enterprises is the way to go. Yueyang city's yellow tea in the brand building deficiencies, so Yueyang city should dig deeper into the connotation of tea culture, finishing Yueyang yellow tea, Junshan Silver Needle and other Yueyang historical tea cultural lineage, tell the story of Yueyang Yellow Tea, prepare for the construction of the Yellow Tea Museum, give full play to the function of the Yellow Tea Museum, promote the integration of tea culture and the tourism industry, to create a unique Yueyang tea travel culture brand.

4.2.2 Tea quality and safety are not guaranteed.

Among the many problems faced by China's tea industry at present, the issue of tea quality and safety is the most urgent problem to be solved, and how to go about controlling the source of pollution is the key to solving the problem. In the process of producing tea try to avoid the application of synthetic fertilisers, pesticides, plant growth regulators, food additives and other substances[10], which should become an important direction for the development of the tea industry in the future. This is also a key to further enhance the competitiveness of Yueyang

yellow tea in the country.

4.2.3 Single way of product sales

In recent years, the rapid development of the Internet, the service industry, the integration of the retail industry and the Internet has become the mainstream, the development of online and offline sales has become the inevitable choice of many enterprises seeking development, however, at present, Yueyang yellow tea and its ancillary products sales channels are relatively single, so in this context, with the help of the power of the Internet for the long term and stable development of the tea tourism culture, it is particularly important.

4.2.4 Imperfect tourism supporting infrastructure for tea tourism integration

Yueyang City, although there are many tourist attractions, but the distance between the attractions is far away, not concentrated, in addition to the integration of tea industry and tourism is not high enough, has not yet formed a yellow tea industry circle around the Dongting Lake, therefore, in the discovery of Yueyang tea culture, should follow the "tea area scenic spots, scenic spots, tea area," the development of ideas and strategies will be the Yueyang Tower, the Qu Zi Temple, Junshan Island, the Yueyang Tower, the Qu Zi Temple, the Junshan Island, the Yueyang Tower and the Yueyang Tower. Quzi Ancestral Temple, Junshan Island, Tianjing Mountain and other tourist attractions and Yueyang City characteristics of the combination of tea culture, to create Yueyang "a building, an island, a lake, a tea, a thought" marketing concept, in order to promote the long history of the local tea culture in Yueyang, will be able to attract more domestic and foreign tourists, expanding the influence of the yellow tea in Yueyang.

4.2.5 Insufficient innovation in cultural tourism product development

At present, Yueyang City, in the local characteristics of cultural tourism product development and innovation there are some shortcomings: First, the development of the product of their target audience group positioning is too broad, not precise enough, the lack of cultural tourism product characteristics of the thinking, can not meet the personalised needs of tourists; the second is the local characteristics of cultural tourism products is not obvious enough, did not dig deep into the local characteristics of the culture of Yueyang, the integration of the long history of Yueyang folk culture, the lack of their own style of folk culture, and the lack of the local culture of Yueyang, and the lack of the local characteristics of the local culture of Yueyang. Folk culture, the lack of innovation of their own style, the core competitiveness of cultural tourism products is insufficient.

If you can combine Yueyang yellow tea with some of today's market popular film and television IP image, to create a popular IP related to Yueyang tea tourism, which attracts tourists to travel to Yueyang interest in Yueyang culture and tourism products, and effectively convey the brand concept, improve the brand's own recognition.

Table 1 Questionnaire

What problems do you think exist in the development of tea tourism culture in Yueyang?	Proportions %
Brand building is not strong enough and too single	82%
Tea safety and quality is not guaranteed	55%
Single way of product sales	63%
Incomplete tourism facilities for tea tourism integration	77%
Insufficient innovation of local speciality cultural and tourism products	42%

Note:The above percentages are based on a valid sample of 200 completions.

5. SWOT analysis and strategic choice of Yueyang tea tourism culture development in the Internet + era

5.1 Advantages (Strengths)

Rich tourism resources help to expand the market of tea tourism industry. Yueyang has a long history, including Yueyang Tower, Junshan, Xiao Qiao's Tomb, Lu Su's Tomb, Temple of Literature and many other well-known tourist attractions. In terms of natural resources, there are Dongting Lake, South Lake Scenic Spot, Danyun Mountain, Wutian Mountain and other attractions, which constitute a magnificent picture scroll, but also has a wealth of natural resources, which provides unlimited travelling fun, attracting a large number of tourists to come to hit, and providing sufficient customer resources for the development of the tea travel industry.

Convenient transport and geographical location, reducing travel obstacles for tourists. Yueyang is located in the north of Hunan, between Changsha and Wuhan, the two provincial capitals, 107 National Highway, 240 National Highway, Beijing-Hong Kong-Macao Expressway, Xu-Guangzhou Expressway, Beijing-Guangzhou Railway, Haoji Railway, Beijing-Guangzhou high-speed railway running through Yueyang from the north to the south, in addition, Yueyang is the waterway hub of Hunan, and an important highway and railway hub, with a strong comprehensive capacity of transport, which is convenient for tourists to go to from all over the country.

Tea culture has a long history. Yueyang yellow tea in the early Tang Dynasty has been one of the top quality tea, the Tang Dynasty has become a tribute in the court royal family. There are also rumours of e Huang, female Ying brought Yueyang yellow tea, Yueyang yellow tea and Princess Wencheng into Tibet and other legends, the tourists have a certain cultural attraction, but also for the development of tea tourism industry in Yueyang to create a strong atmosphere of tea culture.

Yueyang yellow tea has a good brand foundation. Produced in yueyang "junshan silver needle" is known as "yellow tea of the crown", and yellow tea famous "north port Mao Jian", yueyang is also China's yellow tea production, processing and trade of the largest concentration of industrial area. 2011, yueyang yellow tea production, processing and trade of the largest scale. In 2011, Yueyang was awarded the title of "Hometown of Yellow Tea in China", and on 9 April 2014, the former State General Administration of Quality Supervision, Inspection and Quarantine (AQSIQ) approved the implementation of Geographical Indication Product Protection for "Yueyang Yellow Tea". In 2017, it was rated as one of the top ten agricultural regional public brands in Hunan Province, and on 15 November 2019, it was selected as one of China's agricultural brand directories.

5.2 Disadvantages (Weakness)

Product quality varies. Due to the lack of standardised production models and strict market regulation, the tea market is mixed, which has a certain impact on the brand reputation.

Low comprehensive utilisation of tea resources. In the mode of traditional tea farmers, tea farmers have skills and experience, but no market acumen, only know blindly expand the planting scale. At the same time, the planting method is traditional and the production efficiency is not high.

Lack of relevant talents. Whether it is production and planting, or marketing management are inseparable from the support of professionals. Yueyang yellow tea has not yet completed the successful transformation of the industry, planting management team is still dominated by traditional tea farmers, a shortage of professionals.

Tea industry and tourism integration is not sufficient, infrastructure is not perfect, fewer leading enterprises. Visitors participate in the experience of fewer projects, industry mining is not deep enough, the tea industry and tourism integration experience is not enough, the lack of leading enterprises to lead.

Brand awareness is limited, the international market is difficult to open new horizons. Yueyang transport network connected to all parts of the country, but the connection with the rest of the world is very limited, tourists from other countries are difficult to reach, and Yueyang Yellow Tea is not prominent enough in the international market, which increases the difficulty of expanding the international market for the tea tourism industry.

5.3 Opportunities

Tea brand building is effective. Through the release of yueyang yellow tea high-speed train advertisement, create yueyang yellow tea advertisement corridor and other ways, all-round set up yellow tea brand image,

effectively enhance the exposure rate of yueyang yellow tea more than ten million times. For the follow-up tea tourism industry integration promotion work to lay a solid brand foundation.

After the epidemic era of tourism back to spring. During the epidemic, travellers' consumer demand for tourism and expectations continue to rise, now ushered in the post epidemic era, tea tourism industry has a certain market potential.

Convenient Internet provides new ideas for development. Big data, 5G and other high-tech gradually gain popularity, accelerating the speed of information dissemination, but also for the tea tourism industry online and offline resources integration to provide technical support.

Government and policy support. The development of the tea industry is highly valued. 2022 Central Document No. 1 proposes to vigorously promote the construction of digital villages, promote the development of intelligent agriculture, and promote the integration and application of information technology and agricultural machinery and agronomy [11]. In addition, the Chinese Tea Ancestor Festival Organising Committee, China Tea Circulation Association Yellow Tea Professional Committee, China Yellow Tea Industry Alliance and other units jointly issued a document, decided to host the 2022 "Nine Lion Zhai Cup" China Yellow Tea Tea Competition. Expanding the visibility of yellow tea in Yueyang, promote internal communication within the industry, and create a good environment for healthy competition.

5.4 Threats

Domestic competition in the tea industry is fierce. China's vast area, the land is vast, countless tea products, tea culture has been passed down from generation to generation, loved by the people. Tea industry across the country in order to win more markets, have to speed up the transformation and upgrading of the industry, increase investment, open up a new track of tea tourism and actively run, intensifying industrial competition. How to stand out among the many competitors is the test faced by Yueyang yellow tea.

5.5 Strategy Selection

Four strategic options can be derived from Table 2. Firstly, the internal advantages of the tea tourism industry are demonstrated through external opportunities, and a growth strategy can be launched to seamlessly integrate online and offline resources. Deeply explore the value of the tea industry, create a special IP rooted in traditional tea culture, complete brand building with a good brand foundation, and seize the opportunity to make it grow through the wind. Second, the internal disadvantage through the opportunity to achieve transformation, can be launched to reverse the strategy, in the government as well as policy support, strengthen the introduction of talent, accelerate the integration of tea tourism, increase investment in science and technology, the implementation of standardised production of tea plantations, standardised supervision, with the help of the opportunity to alleviate the disadvantage, so that the disadvantage to the advantage of the development. Third, using internal advantages to face external threats, can launch a diversification strategy, segmentation of tourism resources, increase visitor interaction projects, create a unique brand, expand the new track, so that it is in the many products to emerge. Fourth, to make up for internal disadvantages to defend against external threats, it can launch a defensive strategy, vigorously introduce professional talents, improve product quality and productivity, enhance brand awareness, and prevent it from drowning in the fiercely competitive market.

In view of the overall domestic tea travel industry is still in the initial development, has not yet appeared prominent leading enterprises, brand influence ranking has not yet formed in the minds of consumers, the threat is less than the opportunity, can give priority to the opportunity to combine with the advantages and disadvantages of the strategy. Therefore, the growth strategy and the reversal strategy is more suitable as the current Yueyang yellow tea selected strategic measures. On the one hand, Yueyang yellow tea has significant advantages and many opportunities, making full use of both can effectively empower the industry. On the other hand, the effect produced by reversing the disadvantages with the help of opportunities can also help to deal with the threats and make Yueyang Yellow Tea stand out, which is two birds with one stone.

Table 2 Swot matrix diagram

Internal capabilities External factors	Strengths	Weaknesses
	Rich in tourism resources; Convenient transport; Long history of tea culture; Good brand foundation.	Uneven product quality; Low comprehensive utilisation of tea resources; Lack of relevant talents; Inadequate integration of tea industry and tourism; Limited brand awareness.
Opportunities	SO	WO
Tea branding is effective; Tourism recovery in the post epidemic era; Convenient internet; Government as well as policy support.	Seamlessly integrate online and offline resources. Deeply explore the value of the tea industry, create a special IP rooted in traditional tea culture, and complete brand building with the help of a good brand foundation.	In the government as well as policy support, strengthen the introduction of talent, accelerate the integration of tea tourism, increase scientific and technological investment, the implementation of standardised production of tea plantations,standardised supervision.
Threats	ST	WT
Fierce competition in the domestic tea industry	Break down tourism resources, increase visitor interaction programmes, create unique brands and expand new tracks.	Vigorously introduce professional talents, improve product quality and production efficiency, and enhance brand awareness.

6. Put forward innovative countermeasures for the Internet + era Yueyang tea tourism culture development

6.1 Rely on cultural heritage, establish a unique brand image

Brand is an ideology, and a large part of the reason for consumers to choose a product comes from the added value of the product. Yueyang has famous attractions such as Yueyang Tower, Junshan Island, Temple of Literature, and the history of yellow tea has a long history. In the development of Yueyang tea tourism culture, we must give full play to the advantages of Yueyang's tourism culture and tea culture resources, develop products with depth, and create an iconic brand with Yueyang characteristics. This can not only to a certain extent to promote the local cultural flavour of Yueyang, to attract the interest of consumers, but also easier to make a distinction between their own products and other products, conducive to the establishment of a personalised brand image, expanding the influence of the brand, so that consumers are impressed. Realise Yueyang yellow tea and other cultural and tourism industries complement each other, tea tourism depth integration.

6.2 Optimise marketing strategies and firmly grasp different markets

In the consumer market of influential social media platforms such as Jitterbug, Xiaohongshu and Weibo, which focus on entertainment, the official account with high credibility is borrowed to increase advertising, promote the tea tourism industry, create brand awareness, accelerate the integration of tea tourism, and help Yueyang yellow tea to stimulate competition. Can also be linked with the net red brand such as "tea colour" to expand the consumer groups. In the focus on economic and practical consumer market, should be strengthened around the scenic area of

cultural construction, attraction construction, as well as infrastructure construction. To dig deeper into the cultural connotation of Yueyang yellow tea and Yueyang Tower, Temple of Literature and other scenic spots, to play its core role, enhance the competitiveness of scenic spots. Create Netflix hit spots and hold combined promotions of scenic spots and peripheral industries such as accommodation, travelling and cultural and tourism derivatives to attract tourists to them. Improve the infrastructure construction of the scenic spot's transport system, service industry, sewage system, etc., and arrange and distribute them in a centralised, scientific and reasonable manner to highly integrate the tea industry and tourism, promote the development of the yellow tea industry in the Dongting Lake area, and provide tourists with a high-quality experience.

6.3 Promote digital engineering and optimise intelligent service experience

Promote the digital transformation of the tea tourism industry, carry out the construction of the digital platform of the tea tourism industry, and build digital scene services. Establish a sound and complete information network platform for the tea tourism industry, relying on the network platform to provide tea information resources, and empower consumers to learn more about information. Online and offline achieve seamless connection through digitalisation, provide booking business in the context of the era of comprehensive liberalisation, and enhance the efficiency of scenic area management. On this basis, with the help of the big data platform, consumer preferences are analysed, and personalised, intelligent and convenient services are provided for them. Provide a consumer feedback platform, improve the tea quality traceability system, and according to the feedback to continuously optimise the product and improve the service level.

6.4 Focus on talent training and provide technical and theoretical support

Cooperate with a number of tea-related colleges and universities, set up relevant subject courses and professions, and achieve the integration of production, learning and research, so as to provide strong support for the promotion of high-quality development of tea tourism integration. Carry out relevant personnel training to strengthen the professionalism of the scenic area staff for the knowledge of tea tourism, and promote the comprehensive quality of staff and the improvement of service level. The introduction of regional planning talent, targeted to improve the Yueyang attractions scenic construction of scattered problems. Vigorously develop asexual tea varieties, expand the scale of tea plantation planting, improve the yield per unit area and the quality of finished products, and promote the standardisation of tea production and supervision.

7. Conclusion

The advantages brought about by the integrated development of the tea tourism industry should not be ignored. On the one hand, it can make more people understand the excellent traditional yellow tea culture, and let the culture go to the public. On the other hand, it can also promote the development of tourism in Yueyang, attract more tourists to Yueyang, thus helping the implementation of rural revitalisation strategy. Hunan Province is China's tea production province, the booming development of tourism is bound to be able to drive the prosperity of the local economy, promote the sale of tea. In this paper, "Yueyang yellow tea" as a case, the use of SWOT analysis of Yueyang yellow tea and local tourism industry combined with the advantages and disadvantages of the discussion and assessment, so as to make a reasonable development strategy, and the corresponding development strategy put forward specific ideas. Yueyang should give full play to the connotation and advantages of the local tea culture and tourism industry, follow the trend of the times, and effectively promote the development of tea tourism.

Data Availability Statement

All data comes from actual surveys and is guaranteed to be official data.

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Optimizing Employee Motivation Mechanisms in Modern Enterprises: A Theoretical and Practical Analysis

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Abstract: Employee motivation mechanisms have become increasingly crucial for maintaining competitiveness in modern enterprises. Drawing on classical motivation theories and organizational behavior research, this study analyzes the conceptual foundations, key influencing factors, and common problems in current motivation practices. The findings reveal that many enterprises still face issues such as insufficient fairness and transparency, overreliance on homogeneous incentives, weak implementation, and a lack of alignment with employees' dynamic and diverse needs. In response, this study proposes a set of targeted optimization strategies, including establishing transparent performance evaluation systems, adopting diversified and personalized incentive tools, strengthening execution and supervision, and building adaptive motivation frameworks. These recommendations aim to improve employee engagement, enhance organizational effectiveness, and provide practical guidance for enterprises seeking to refine their motivation practices in rapidly changing environments.

Keywords: Employee motivation; incentive mechanisms; organizational behavior; performance evaluation; workplace management; human resource practices

1. Conceptual Definitions and Theoretical Foundations

This chapter clarifies the fundamental concepts related to employee motivation mechanisms and reviews the major theories that support their design and application. It also provides an overview of existing research in China and abroad, forming the conceptual and theoretical basis for the subsequent analysis.

1.1. Definition of Employee Motivation Mechanisms

Employee motivation mechanisms refer to organized and systematic managerial arrangements through which enterprises guide employee behavior and stimulate individual potential in order to achieve organizational goals. These mechanisms are designed to influence employees' internal and external motivations and to align personal performance with organizational expectations.

In practice, a motivation mechanism typically involves three core elements:

- Satisfaction of multi-level needs: providing both material and non-material incentives that address employees' diverse and evolving needs.
- Behavioral alignment: directing employee efforts toward activities that support organizational strategies.
- Balance between organizational and individual goals: ensuring that employees' personal aspirations can be realized within the organizational context.

Such mechanisms generally exhibit the following characteristics:

- Psychological foundations: Motivation is rooted in individual differences in needs and values; thus, incentives must consider employees' internal drivers.
- Systematic and dynamic nature: Motivation mechanisms operate as part of a broader management system and must adapt to changes in organizational strategy, market environment, and workforce composition.
- Individualization: Different groups of employees—distinguished by roles, experience, or career stages—may require different combinations of incentives.

1.2. Major Theoretical Foundations of Motivation Mechanisms

The design of employee motivation mechanisms draws on several classical theories in organizational behavior and psychology. These theories provide insights into how employees respond to incentives and why different motivation strategies may be effective.

- Maslow's Hierarchy of Needs[1]

Maslow's theory posits that human needs form a hierarchy ranging from physiological needs to self-actualization. For enterprises, this implies that both basic job security and higher-level developmental opportunities should be considered in motivation strategies.

- Herzberg's Two-Factor Theory[2]

This theory divides influencing factors into "hygiene factors," which prevent dissatisfaction, and "motivator factors," which enhance satisfaction. Effective motivation requires attention to both types: fair compensation and policies on one hand, and recognition, responsibility, and achievement on the other.

- McClelland's Theory of Needs[3]

McClelland identifies achievement, affiliation, and power as three dominant needs that vary among individuals. This highlights the importance of differentiated motivation strategies tailored to individual preferences or job characteristics.

- ERG Theory[4]

Alderfer's ERG theory condenses needs into existence, relatedness, and growth, emphasizing that individuals may shift between different need levels. This perspective provides theoretical support for flexible and adaptive motivation systems.

Together, these theories underscore a central principle: motivation mechanisms must be grounded in employees' real needs and must integrate both material and psychological dimensions to be effective.

1.3. Overview of Domestic and International Research

Research on employee motivation has expanded significantly in recent decades. Although both domestic and international scholars emphasize the relationship between motivation and organizational performance, their research focuses often differ.

International research tends to emphasize:

- construction of dynamic or data-driven motivation models,
- quantitative analysis of the link between incentives and performance,[9]
- diversity in employee motivation and individual differences.

Such research often demonstrates strong methodological rigor and theoretical innovation.

Domestic research focuses more on:

- integrating classical motivation theories with Chinese management practices,
- summarizing practical experiences from enterprises,
- exploring institutional and policy-related motivation issues.

This research tendency reflects China’ s management context, which places greater emphasis on application and case-based analysis.

Common limitations across existing studies

Despite growing attention to employee motivation, several gaps remain:

- insufficient exploration of motivation needs among younger generations,
- limited research on digital or data-enabled motivation mechanisms,
- lack of systematic frameworks for designing personalized incentive systems.

These observations highlight the need for further research and provide direction for the present study.

2. Key Factors Influencing the Effectiveness of Employee Motivation Mechanisms

The effectiveness of employee motivation mechanisms is shaped not only by their design but also by broader organizational and individual conditions. This chapter analyzes the main factors that influence how motivation systems operate in practice, focusing on employee needs, organizational culture and management style, and the quality of incentive design and implementation. These factors form the basis for identifying issues in existing motivation mechanisms and for proposing improvement strategies in later chapters.

2.1. Multi-Level and Diverse Employee Needs

Employee needs represent the foundation of any motivation mechanism. In most organizations, the workforce is heterogeneous in terms of age, education, career stage, and personal values. As a result, employees differ significantly in what they expect from rewards, career development, work environment, and recognition.

Key observations include:

- Needs exist across multiple levels.

Employees are not only motivated by salary or benefits; they also seek respect, achievement, personal growth, and meaningful relationships at work.

- Significant individual differences.

Employees at different stages often prioritize different forms of motivation. For example:

- newly hired employees typically value learning opportunities and skill development,
- mid-career employees focus more on promotion prospects and increased responsibilities,
- senior or core employees tend to value strategic involvement and long-term incentives.
- Needs change dynamically over time.[5]

As the organizational environment evolves and employees progress through their career cycles, their motivational needs also shift. A static incentive system may therefore fail to sustain long-term motivation.

These characteristics highlight that motivation mechanisms must be both differentiated and adaptive in order to meet employees’ changing expectations.

2.2. Influence of Organizational Culture and Management Style

Organizational culture and management style create the environment in which motivation mechanisms operate. They influence employees’ interpretations of incentives and their willingness to participate actively in organizational activities.

Key aspects include:

- Organizational culture establishes the foundation for motivation.[6]

Open, inclusive, and innovation-oriented cultures encourage employees to accept diverse incentive approaches and to take initiative.

In contrast, highly hierarchical or rigid cultures may reduce employees' sense of autonomy and weaken motivation.

- Leadership and management style shape motivational perceptions.

Supportive leaders who communicate effectively tend to foster trust in the motivation system, [7]while overly controlling or task-oriented styles may lead employees to perceive incentives as pressure rather than support.

- Culture and management style interact.

A positive organizational culture reinforces effective management practices, and good management practices in turn strengthen cultural values. When the two are aligned, motivation mechanisms are more likely to achieve their intended outcomes.

2.3. Quality of Incentive Design and Implementation

Even well-designed motivation mechanisms may fail if implementation is inconsistent or unclear. The design, execution, and monitoring processes jointly determine whether employees perceive incentives as fair and motivating.

Three main dimensions affect implementation quality:

- Scientific and clear incentive design.

Motivation systems require clear goals, measurable indicators, and diversified incentive tools. Vague or overly general criteria make it difficult for employees to understand how performance is evaluated or how incentives are granted.

- Transparency and fairness during implementation.

Employees expect:

- transparent evaluation standards,
- timely communication of results,
- reward distribution aligned with individual contributions,
- consistent and unbiased execution by managers.

Any deviation — such as delayed rewards or inconsistent enforcement — can undermine trust in the entire mechanism.

- Feedback and monitoring mechanisms.

Without regular feedback channels or monitoring systems, motivation mechanisms may become procedural or symbolic. Data-driven monitoring, employee surveys, and regular performance discussions help ensure that incentive systems are continuously improved and remain relevant.

3. Major Problems in Current Employee Motivation Mechanisms

Although many enterprises recognize the importance of employee motivation and have introduced various incentive programs, significant shortcomings remain in practice. These problems reduce the effectiveness of motivation mechanisms and may even create negative perceptions among employees. This chapter analyzes four common issues that hinder the successful implementation of motivational systems: limited fairness and transparency, overly homogeneous incentive methods, weak execution, and low alignment with actual employee needs.

3.1. Insufficient Fairness and Transparency

Fairness and transparency are fundamental conditions for any motivation system[8] to function effectively. However, many enterprises still struggle to achieve consistency and openness in the evaluation and reward process.

Common issues include:

- Unclear performance criteria.

In some organizations, performance indicators lack specificity or are not fully quantifiable. This creates room for subjective judgment and makes it difficult for employees to understand how their performance is assessed.

- Disconnect between rewards and actual contributions.

Rewards may be distributed based on seniority or job position rather than measurable performance, leading to perceptions that effort and outcomes are not adequately recognized.

- Limited supervision and review.

Without open review processes, employees may suspect favoritism or hidden decision-making, which weakens trust in the system.

A lack of fairness not only affects motivation but also damages organizational cohesion and employees' willingness to contribute.

3.2. Overly Homogeneous Incentive Methods

Many enterprises continue to rely heavily on traditional material incentives, which often fail to reflect the growing diversity in employee expectations.

Key problems include:

- Excessive reliance on monetary rewards.

Bonuses, allowances, and subsidies are frequently used as primary incentives, while non-material motivators—such as recognition, career development, and empowerment—are insufficiently emphasized.

- Limited consideration of different employee groups.

Employees vary in age, career stage, and personal values. A standardized incentive approach cannot meet the needs of all groups and may leave large segments of the workforce unmoved.

- Lack of innovation in incentive design.

Modern incentive approaches — such as flexible benefits, project-based incentives, team-based rewards, or recognition platforms—are underutilized in many organizations.

These factors contribute to a mismatch between what enterprises offer and what employees value, reducing the effectiveness of motivation systems.

3.3. Weak Execution and Formalistic Tendencies

The success of a motivation mechanism depends not only on its design but also on how consistently and rigorously it is executed. Many enterprises face problems related to insufficient implementation strength.

Key issues include:

- Low managerial commitment.

Some managers regard incentives as supplementary tools rather than essential components of performance management, resulting in insufficient resource allocation or attention.

- Policies remaining at the formal level.

Motivation policies may be clearly documented, but lack concrete implementation steps, practical guidelines, or follow-through.

- Absence of regular assessment and feedback.

Without periodic evaluation or employee input, issues accumulate over time and the mechanism gradually loses relevance and credibility.

Weak execution not only limits the impact of well-designed policies but can also reinforce negative perceptions among employees.

3.4. Low Alignment Between Incentives and Actual Employee Needs

Effective motivation requires accurate identification of employee needs,[9] yet many enterprises lack mechanisms for continuous needs assessment.

Common symptoms include:

- Insufficient research into employee needs.

Many organizations do not conduct regular surveys, interviews, or data analysis to understand motivational drivers. As a result, incentive programs often take a "one-size-fits-all" approach.

- Lack of long-term and developmental incentives.

Training, career progression, and learning opportunities are often overlooked in favor of short-term rewards. This is particularly ineffective for younger employees who value growth and participation.

- Limited adjustment based on feedback.

Without mechanisms for ongoing feedback, enterprises fail to update outdated incentive practices, leading to declining engagement and "motivation fatigue."

Poor alignment between incentives and actual needs is one of the core reasons motivation mechanisms fail in practice.

4. Strategies for Optimizing Employee Motivation Mechanisms

Building on the earlier analysis of influencing factors and existing problems, this chapter proposes practical improvement strategies for enterprises aiming to enhance the effectiveness of their motivation mechanisms. The recommendations focus on four key areas: strengthening fairness and transparency, diversifying incentive tools, improving execution and supervision, and establishing a dynamic and adaptive motivation system.

4.1. Establishing a Fair and Transparent Performance Evaluation and Feedback System

Fairness is a core determinant of whether employees perceive incentives as credible and motivating. Enterprises should strengthen the transparency and objectivity of their performance evaluation processes.

Key strategies include:

- Develop clear and measurable performance indicators.

Evaluation standards should be aligned with job responsibilities and organizational goals. Employees need to understand what is being assessed and how results are interpreted.

- Adopt multi-dimensional evaluation methods.

Combining self-evaluation, peer assessments, and manager evaluations can reduce bias and increase objectivity. Review committees may also be used for key positions or critical assessments.

- Provide consistent and timely feedback.

Regular performance discussions, written records, and constructive feedback help employees understand their strengths, identify gaps, and adjust future goals. [10]Transparent communication also enhances trust in the system.

A well-structured evaluation and feedback system forms the foundation for all subsequent incentive actions and helps ensure that employees view rewards as legitimate and deserved.

4.2. Developing Diversified Incentive Tools to Match Employee Needs

Given the diversity and dynamic nature of employee needs, enterprises should adopt a broader and more flexible combination of incentive tools. Sole reliance on monetary rewards is insufficient for achieving sustained motivation.

Recommended approaches include:

- Enhancing material incentives with flexible benefits.

Options such as health benefits, transportation subsidies, housing allowances, or holiday-related support can be adjusted based on employee preferences and organizational conditions.

- Strengthening non-material incentives.

These include recognition programs, career development opportunities, training initiatives, enhanced participation in decision-making, and clear promotion pathways. Non-material incentives tend to be particularly effective for professional growth and long-term engagement.

- Designing personalized incentive plans for different employee groups.

For example:

- young employees may prioritize development opportunities,
- mid-level employees may value expanded responsibilities,
- core talent may require long-term incentives such as stock options or project-based rewards.
- Collecting employee feedback and adjusting incentives regularly.

Surveys, interviews, and informal communication help identify changing needs and refine incentive plans accordingly.

Diversified and personalized incentives not only align with employees' expectations but also enhance their organizational commitment and motivation.

4.3. Enhancing Execution and Strengthening Supervision Mechanisms

Even well-designed motivation systems may lose effectiveness if implementation is weak or inconsistent. Enterprises must ensure that incentive policies are executed accurately, fairly, and transparently.

Improvement measures include:

- Defining clear implementation procedures and accountability.

Standard operating guidelines can help ensure consistency across departments and managers. Specific responsibilities should be assigned to avoid ambiguity in policy execution.

- Increasing transparency through public disclosure of criteria and results.

Making evaluation criteria, selection processes, and incentive outcomes accessible to employees reduces information asymmetry and strengthens the perceived fairness of the system.

- Establishing multiple channels for employee feedback.

Feedback mechanisms — such as suggestion boxes, periodic meetings, or anonymous surveys — allow employees to express concerns and provide input on policy adjustments.

- Conducting regular evaluations of incentive effectiveness.

Organizations should periodically assess the impact of incentives using indicators such as employee engagement, performance trends, and turnover rates. Adjustments should be made based on these findings.

Effective execution and supervision mechanisms ensure that incentives are not merely symbolic but serve as true drivers of employee behavior and organizational performance.

4.4. Building a Dynamic and Adaptive Motivation System

In a rapidly changing environment, motivation mechanisms must remain flexible and responsive. A dynamic system ensures that incentives remain aligned with evolving organizational goals and employee expectations.

Recommended strategies include:

- Developing structured career planning systems.

Enterprises should analyze employees' skills, aspirations, and potential to design individualized development paths. Matching development plans with appropriate incentives can enhance long-term engagement.

- Implementing dynamic performance evaluation mechanisms.

In addition to annual evaluations, quarterly or monthly assessments help maintain momentum and allow managers to respond to performance changes promptly. Performance indicators should be updated as organizational strategies evolve.

- Integrating short-, medium-, and long-term incentives.

By combining immediate rewards (such as bonuses), medium-term incentives (such as promotions or role expansion), and long-term incentives (such as equity plans), organizations can address diverse motivational needs more effectively.

- Strengthening communication and employee participation.

Open communication allows employees to understand the rationale behind incentive policies. Involving employees in the design or revision of motivation mechanisms increases their acceptance and sense of ownership.

A dynamic motivation system enhances organizational adaptability and enables enterprises to maintain motivation effectiveness in the face of internal and external changes.

5. Conclusion and Future Research Directions

Based on the theoretical foundations, influencing factors, existing problems, and optimization strategies discussed in the previous chapters, this study summarizes the key findings on employee motivation mechanisms and outlines several directions for future research.

5.1. Conclusion

This study highlights the critical role that employee motivation mechanisms play in supporting organizational performance and sustainable development. A well-structured motivation system not only stimulates employees' enthusiasm and creativity but also strengthens organizational cohesion. The effective use of incentives helps align individual efforts with organizational goals, contributing to overall competitiveness.

The analysis shows that many enterprises still face notable challenges in the design and implementation of motivation mechanisms. Common issues include insufficient fairness and transparency, overly homogeneous incentive methods, weak execution, and limited alignment between incentive strategies and employees' actual needs. These problems interact and reduce the overall effectiveness of existing systems.

The findings further indicate that employees' motivational needs are multi-dimensional, differentiated, and continually evolving. Traditional one-size-fits-all approaches are no longer adequate. Organizations must adopt more diversified and personalized incentive systems that combine material rewards, developmental opportunities, recognition, and meaningful participation.

Finally, the study emphasizes that the effectiveness of motivation mechanisms depends not only on design but also on fair implementation, transparent communication, and continuous adjustment. Only by integrating these elements can enterprises establish motivation systems that are both stable and adaptable.

5.2. Future Research Directions

Although this study provides a structured analysis of employee motivation mechanisms, several areas require further exploration due to the complexity of workforce management and the dynamic nature of organizational environments.

Future research may consider the following directions:

- Industry-specific analysis.

Motivation practices differ significantly across industries due to variations in work characteristics, workforce composition, and organizational priorities. Further studies can explore how motivation strategies should be tailored to manufacturing, services, high-tech firms, and other sectors.

- Digital and data-driven motivation systems.

As digital management tools become increasingly common, future research can examine how data analytics, digital platforms, and intelligent evaluation systems can support more precise and timely motivation practices.

- Motivation needs of younger generations.

Younger employees place greater value on autonomy, development opportunities, and alignment with organizational values. Exploring these differences can help organizations design more targeted incentive models.

- Interaction between organizational culture and motivation mechanisms.

Organizational culture shapes employees' perceptions of incentives, while motivation mechanisms can influence cultural development. Future studies can analyze the bidirectional relationship between culture and motivation to provide deeper theoretical and practical insights.

Overall, employee motivation remains a dynamic and multifaceted research area. Continued exploration will contribute to more effective and adaptive motivation practices in the evolving organizational landscape.

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Research on the Impact of Smart City Construction on New Quality Productivity - A Quasi-Natural Experiment Based on the "Smart City" Strategic Pilot

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Abstract : Based on the panel data of 287 prefecture-level cities from 2011 to 2022, this article takes "smart city construction" as a quasi-natural experiment and uses the difference-in-differences model to analyze the impact of smart city construction on new quality productivity. Benchmark analysis indicates that the construction of smart cities has a significant positive impact on new quality productivity. Mechanism analysis indicates that both the level of human capital and the level of science and technology play a mediating role in the impact of smart city construction on new quality productivity. In the heterogeneity test, in terms of urban location heterogeneity, the construction of smart cities in the eastern and western regions has a significant promoting effect on new quality productivity. The significance in the western region is greater than that in the eastern region, while it is not significant in the central region. In the heterogeneity of urban scale, the influence coefficient of large cities is negative and not significant. In medium and small-sized cities, the construction of smart cities has a promoting effect on new quality productivity. The threshold effect indicates that there is a threshold effect in the upgrading of industrial structure. The stronger the level of industrial structure upgrading, the stronger the promoting effect of smart city construction on new quality productive forces. Therefore, it is proposed to promote the construction of new infrastructure related to smart cities, take human capital and scientific and technological levels as important means to enhance the quality of productivity, promote the regional coordinated construction of smart cities, and provide differentiated policy support to regions and industries at different stages of industrial structure upgrading.

Keywords: Smart city construction; New Quality productivity; The level of science and technology; Human capital level Upgrading of industrial structure

1. Introduction

New quality productivity is a new economic concept proposed by China based on the characteristics of the economic development era [1]. The Outline, released in March 2021, for the first time proposed at the national strategic level to "accelerate digital development and create new advantages in the digital economy", emphasizing the cultivation of new forms of productive forces through technological innovation and institutional reform. In December of the same year, The State Council issued the "14th Five-Year Plan for the Development of the Digital Economy", further clarifying that "data should be the key element to promote the deep integration of digital technology and the real economy", providing a policy interpretation for the connotation of new quality productive forces. In academic research, scholars such as Hong Yinxing systematically expounded the theoretical framework of new quality productivity in Economic Research Journal, pointing out that its essence is "a productivity leap that reconstructs the factor allocation and industrial collaboration model with digital technology as the core driving force" [2]. It is evident that the proposal and deepening of new quality productivity is not only an active response

from the policy level to global technological competition and domestic transformation and upgrading, but also a contemporary expansion of traditional productivity theories by the academic community.

As a practical carrier of the deep integration of digital technology and urban governance, smart cities are an important breakthrough for cultivating new quality productive forces. From 2012 to 2014, the Ministry of Housing and Urban-Rural Development established three batches of national smart city pilot projects, covering 277 regions across the country, aiming to optimize resource allocation and industrial collaboration efficiency through technological innovation. The first batch of pilot projects (in 2012) focused on infrastructure layout. Taking Wuxi City as an example, it built the country's first full-coverage Internet of Things perception network, with the access rate of the public data platform reaching 85%, and reduced the cost of digital transformation in the manufacturing industry by 22%. In the second batch of pilot projects (2013), the efficiency of public services was enhanced. Foshan City reduced the administrative approval time limit by 58% through the "one-stop" government affairs system, and the citizen satisfaction rate increased to 91%. Zhengzhou City's intelligent transportation system reduced the congestion index during peak hours by 17%. The third batch of pilot projects (in 2014) focused on the synergy between industry and ecology. Baoding City achieved a 13% reduction in energy consumption per unit of GDP and an average annual growth rate of 24% in the output value of the new energy industry by relying on the smart energy management platform. Sanya City optimized the efficiency of tourist diversion through the tourism big data center, and the carrying capacity of scenic spots increased by 28%[3]. Research shows that the construction of smart cities can reduce institutional transaction costs by 12% to 15% through the circulation of data elements and drive the average annual growth of total factor productivity by 0.3 to 0.5 percentage points [4].

Based on this, the article uses 287 prefecture-level cities across the country from 2011 to 2022 as panel data to empirically test the impact of smart city construction on new quality productivity, explore the influence mechanism of the two, and further analyze regional heterogeneity and threshold effects. The marginal contribution of this paper lies in the following: First, on the basis of improving the theory of smart city construction and new quality productivity, the differin-differences model is used to test the mediating effect between the level of science and technology and the level of human capital. Second, taking industrial structure upgrading as a threshold variable, the threshold effect between smart city construction and new quality productivity is studied. Thirdly, from the perspectives of regional heterogeneity and urban scale heterogeneity, study the effects of smart city construction on new quality productivity in different regions.

2. Literature Review

(1) Literature Review on the Concept of Smart City Construction

The construction of smart cities is the product of the deep integration of informatization and urbanization. Its core feature lies in relying on new-generation information technologies such as the Internet of Things, big data, cloud computing and artificial intelligence to promote the intelligent reconstruction of urban infrastructure, public services and industrial systems [5]. From a theoretical perspective, smart cities optimize the efficiency of urban resource allocation by building data-driven perception networks and intelligent decision-making systems, effectively promoting technological upgrading of traditional industries and the cultivation of knowledge-intensive emerging industries, and thereby forming a new type of economic growth momentum with technological innovation and the improvement of total factor productivity as its core [6]. At the practical level, this concept emphasizes inclusive social development, enhancing people's well-being through public services such as smart healthcare and education, and promoting sustainable urban development through the application of green technologies [7]. However, it should be noted that there is significant regional heterogeneity in the policy effect: the eastern region is more likely to achieve industrial upgrading by relying on its technological accumulation and resource endowment advantages, while the central and western regions are faced with the dual constraints of lagging technological penetration and insufficient matching of production factors [8].

Foreign scholars' research on smart cities presents a diverse perspective. Caprotti and Cowley(2019)[9]

conducted a study on various cities in the UK and found that there are three ideas for smart city construction: The first one holds that the objects of smart city construction are special departments; The second view holds that the construction of smart cities is the organic integration of modern information technology and eco-cities. The third view holds that the construction of smart cities is the application of modern information technology to cities. Some scholars have also attempted to analyze the construction of smart cities from the perspectives of smart cities and human capital, urban management and public services. Giffinger et al. (2018) [10] hold that the core of smart city construction lies in integrating urban endowments with human capital: that is, providing citizens with the information the city possesses for them to make judgments and decisions, thereby exerting significant influences on urban economic growth, human capital, public services, and quality of life.

A comprehensive review of domestic and international research shows that a smart city is not merely a physical space transformation project empowered by technology, but also a systematic urban development model that integrates technological innovation, institutional innovation and governance innovation. The ultimate goal lies in achieving a balanced development of economic efficiency optimization, social equity improvement and ecological benefit enhancement through multi-dimensional collaborative innovation.

(2) Literature Review on New Quality Productivity

It is an advanced productive force state led by scientific and technological innovation, integrating features such as high technology, high efficiency and high quality. It emphasizes promoting industrial transformation and upgrading through innovation-driven development, getting rid of the traditional extensive development mode, and achieving sustainable and high-quality economic development. Although this concept was proposed relatively recently, it has already drawn extensive attention and discussion from the academic community. Gao Fan (2023) [11] holds that new quality productivity, as a transitional form of the integration of industrialization and informatization, reconstructs the productivity system through the integration of data elements, the improvement of total factor productivity, the cultivation of strategic emerging industries, and the government-market collaborative mechanism. Zhou Wen and Xu Lingyun (2023) [12] focused on the core position of disruptive technological breakthroughs, pointing out that they are driven by cutting-edge technologies such as artificial intelligence and rely on intellectual labor, high-precision and advanced equipment, and new production relations to achieve generational changes in productivity. Both reveal that the essence of new quality productive forces is the systematic upgrading of factors - technology - industry - system under the leadership of scientific and technological innovation.

In terms of the construction of the indicator system for new quality productive forces, the existing literature mainly conducts multi-dimensional indicator exploration based on the theoretical framework of the three elements of productive forces in Marxism. For instance, Lu Jiang et al. (2024) [13] constructed a comprehensive evaluation system integrating science and technology, green, and digital productivity, and adopted the improved entropy weight-TOPSIS method to reveal regional heterogeneity; Han Wenlong et al. (2024) [14] introduced a dual dimension of physical and penetrating elements, covering multiple indicators such as new types of workers, intelligent labor tools, and data elements, and verified its spatial spillover effect through the spatial Durbin model. Wang Jue (2024) [15] proposed the "1-2-3-4" theoretical framework, emphasizing the core position of scientific and technological innovation and the optimization of human capital structure. Its indicator system highlights the proportion of strategic emerging industries and the level of digitalization. Methodologically, entropy method, Dagum Gini coefficient and spatial convergence model have become mainstream tools. Sun Liwei et al. (2024) [16] further identified the transformation of technology and the upgrading of industrial structure as key constraints through the obstacle factor model. At present, existing research shows two major trends: one is the differentiated construction of indicators from a single economic field to multiple industries, and the other is the strengthening of spatial measurement methods to capture the regional linkage characteristics of new quality productivity. This provides a methodological basis for the spatial analysis of the impact effects of smart cities.

(3) Literature Review on the Impact of Smart City Construction on New Quality Productivity

In recent years, scholars at home and abroad have been conducting an increasing number of studies on smart city construction and new quality productivity. However, no research has been found so far to explore the correlation between smart city construction and new quality productivity. As the new quality productivity emphasizes the core features of "greenness, digitalization and innovation-driven", the construction of smart cities can be explored in these three aspects.

At the level of green development, the construction of smart cities has significantly promoted the low-carbon transformation of cities through the innovation of environmental governance models and the spillover effects of green technologies. Wei Lin and Ma Mengru (2022) [17] conducted an empirical study based on listed manufacturing companies, which demonstrated that smart city pilot projects have significantly increased the quantity and quality of green invention patents by optimizing the quality of internal control within enterprises and alleviating financing constraints. The mechanism of action is reflected in the enhanced environmental supervision efficiency and the optimal allocation of green innovation resources empowered by digital technology. Song Deyong et al. (2021) [18] further verified from the urban level the "simultaneous increase in quantity and quality" effect of smart city pilot projects on green technological innovation, and found that the information support effect and scale agglomeration effect were the main transmission paths, especially in the fields of alternative energy and transportation emission reduction, the incentive effect of technological innovation was significant.

In terms of digital transformation, the construction of smart cities has reshaped the economic operation paradigm of cities by building digital infrastructure and governance platforms. Xie Xiaoqin and Ren Shihui (2022) [19], taking the construction of a smart city in Chengdu as an example, revealed the integration efficiency of data elements under the "platform as government" model, and pointed out that digital scene applications such as e-government platforms and smart transportation systems have formed a new governance ecosystem of "overall intelligent governance" by enhancing governance perception and response speed. Hui Xianbo's (2023) [20] research further expanded the economic and social benefits of digital transformation. It was found that smart cities promote the digital reorganization of production factors by stimulating entrepreneurial activity. The new business forms such as e-commerce platforms and the sharing economy they give rise to have significantly improved the efficiency of resource allocation and provided digital impetus for the realization of the goal of common prosperity.

In the dimension of innovation-driven development, the construction of smart cities, through the reconstruction of the technological innovation ecosystem, has become the core engine for cultivating new quality productive forces. Wang Jie et al. (2024) [21] further revealed the dual mechanism of the effect of technological innovation: on the one hand, the industry-university-research collaboration platform for smart city construction has accelerated the integrated innovation of cutting-edge technologies such as artificial intelligence and blockchain; On the other hand, the environmental intelligent monitoring system compels enterprises to carry out green process innovation and promotes the evolution of technological innovation towards low-carbonization

3.Theoretical Analysis

(1) Direct impact

The core element of new quality productive forces is the organic unity of laborers, objects of labor and means of labor, and it has a strong driving force for development. First, the role of smart city construction in enhancing the quality of workers. The development of smart city construction has raised society's demands for digital skills talents and professionals in related industries, promoting the training and development of education and skills. Workers can learn the modular course system through the cloud architecture platform [22] to achieve personalized ability expansion. This lifelong learning mechanism has enhanced the digital application capabilities of workers and promoted the transformation of their skill systems towards a composite ability structure that meets the demands of the intelligent era [23]. When workers are seeking positions, this enhances the value they can exert and makes them more worthy of being hired. Second, the role of smart city construction in the intelligent upgrading of labor resources. The Internet of Things (iot) technology enables industrial equipment to have environmental perception

and autonomous decision-making capabilities, and realizes digital collaboration throughout the entire production process through M2M communication [24]. This intelligent transformation not only enhances the operational efficiency of equipment but also reduces downtime losses through predictive maintenance. The intelligent dispatching system in the logistics field optimizes the transportation network based on real-time traffic data and combines blockchain technology to achieve full traceability of the supply chain [25], thus building an efficient circulation system for production factors. The application of intelligent warehouse robots and automated sorting systems has increased the labor efficiency in the logistics process by more than 30% [26], providing material guarantees for the development of new quality productivity. Third, the multi-dimensional improvement effect of smart city construction on the labor force. The big data generated by urban operation is transformed into decision support for urban governance and element resources for industrial innovation through cleaning, modeling and visualization processing. The development and utilization of this new type of labor object have given rise to emerging business forms such as smart transportation and precision medicine. Meanwhile, the engineering application of new materials such as nanomaterials and smart composite materials has broken through the single functional limitations of traditional materials. For instance, self-healing concrete extends the service life of infrastructure [27], and photovoltaic glass enables buildings to achieve self-sufficiency in energy. The application of these innovative materials has expanded the physical properties of the objects of labor and provided a material basis for the development of new quality productive forces.

Based on the above theoretical analysis, Hypothesis H1 is proposed: The construction of smart cities promotes the development of new quality productive forces.

(2) Indirect impact

The construction of smart cities promotes the improvement of human capital: The construction of smart cities reconfigures the model of human capital accumulation through the embedding of technology, indirectly empowering the development of new quality productive forces. Firstly, immersive education platforms based on digital twin technology (such as urban traffic simulation systems) transform abstract knowledge into visual scenarios, significantly enhancing the efficiency of skill acquisition [23]. Secondly, the urban data middle platform promotes cross-domain knowledge sharing. For instance, medical image data is desensitized and used for training AI-assisted diagnostic algorithms, accelerating the transformation of tacit experience into explicit technology [23]. Finally, the emerging occupations brought about by smart cities (such as digital twin engineers) force workers to transform from single skills to compound capabilities of "data thinking + scene application", forming a positive cycle where human capital and technological innovation coexist [28]. As a result, smart cities drive human capital to become the core lever of new quality productivity through three mechanisms: innovation in educational scenarios, upgrading of knowledge sharing, and reconstruction of the professional ecosystem.

The improvement of human capital level can effectively activate the endogenous driving force of new quality productivity. Under the framework of smart city development, by building a digital technology-oriented education and training system and focusing on cultivating compound talents with digital literacy and innovation capabilities, the connection efficiency between technological research and development and industrial application can be significantly enhanced. Such talents not only master cutting-edge technologies like artificial intelligence and big data analysis, but also possess practical capabilities for the digital transformation of industries. They can effectively promote the optimal allocation of data elements and the industrial transformation of technological achievements. When high-quality human capital is deeply integrated with the information infrastructure and innovation ecosystem of smart cities, it will accelerate the spillover effect of knowledge and the speed of technology diffusion, promoting a leap in total factor productivity.

Based on the above theoretical analysis, Hypothesis H2 is proposed: The construction of smart cities can enhance the level of human capital and thereby drive the improvement of qualitative productivity.

The construction of smart cities has a significant promoting effect on the development of science and

technology. On the one hand, it provides rich application scenarios for technological innovation. For instance, to achieve intelligent functions such as automatic adjustment of street lamps and monitoring of garbage overflow, it is necessary to break through technical challenges such as precise sensor identification, low-energy consumption operation of equipment, and stable networking of large-scale equipment. These practical demands have directly driven the upgrading of Internet of Things (iot) technology. For instance, in urban traffic management systems [29], to conduct real-time analysis of traffic flow data and optimize the timing of traffic lights, artificial intelligence algorithms are constantly improving in complex data processing. Eventually, these technological breakthroughs can also be applied to other fields such as logistics scheduling and disaster early warning. On the other hand, this construction process builds an innovative network of multi-party collaboration. The pilot platform for smart communities built by the government has provided an opportunity for on-site testing of environmental monitoring technologies developed by universities. To address the issue of automatic parking space recognition, enterprises have collaborated with research institutions to develop more efficient image recognition models. These collaborations not only solve practical problems but also give rise to new patented technologies.

The level of science and technology has a significant promoting effect on new quality productivity. First of all, breakthroughs in cutting-edge technologies directly drive the leap in the form of productive forces. The new generation of disruptive technologies represented by artificial intelligence, quantum information and biotechnology have restructured the traditional way of allocating production factors. For instance, deep learning technology has significantly enhanced the accuracy of fault prediction and the efficiency of resource scheduling in industrial production by optimizing algorithm models. Further research on new energy and new materials has promoted the application and development of renewable energy, as well as the application of new materials such as lightweight and high-strength in aerospace, automotive manufacturing and other fields [30]. Finally, the coordinated evolution of data and computing power has strengthened the underlying support for the development of productivity. As a new type of production factor, the value release of data is highly dependent on the iterative upgrade of computing power infrastructure. Large language models represented by DeepSeek and ChatGPT rely on a powerful computing power foundation to collect vast amounts of data from the Internet, and through analysis, processing, and integration, output new knowledge achievements. It has revolutionized human society's perception of data and computing power as production factors.

Based on the above theoretical analysis, Hypothesis H3 is proposed: The construction of smart cities can enhance the level of science and technology and thereby drive the improvement of new quality productivity.

(3) Threshold effect

The promoting effect of smart city construction on new quality productive forces is restricted by the level of regional industrial structure upgrading, presenting a non-linear threshold feature. The essence of new quality productivity lies in the reconstruction of the traditional logic of factor allocation by data and intelligent technologies [31], and the upgrading of industrial structure determines the depth and breadth of technological integration. When regional industries are dominated by labor-intensive or resource-dependent ones, the rigid allocation of production factors and low technological adaptability will inhibit the technological penetration effect of smart cities, and its role is mostly limited to local efficiency improvement. With the transformation of the industrial structure towards knowledge-intensive fields, the accumulation of high-skilled human capital and the increase in the complexity of the innovation network [32] have created conditions for the systematic application of intelligent technologies. At this point, smart cities break down the barriers to factor flow through real-time data streams, driving production factors to aggregate in high-value-added fields. At the same time, they accelerate technology diffusion by relying on the innovative ecosystem of all-domain interconnection, achieving increasing returns to scale from technological dividends [33]. This dynamic adaptation mechanism of "technology - industry" indicates that the upgrading of industrial structure, by expanding the capacity for technology absorption, enhancing the flexibility of factor allocation and optimizing the efficiency of collaboration, promotes the enabling effect of smart cities on new quality

productive forces to show a marginal increasing law.

Based on the above theoretical analysis, Hypothesis H4 is proposed: The promoting effect of smart city construction on new quality productivity increases with the improvement of the level of industrial structure upgrading, and there is a significant threshold effect.

4.Model Setting and Variable Selection

(1) Model Setting

Firstly, the article takes the smart city policies announced by the Ministry of Housing and Urban-Rural Development in 2012, 2013 and 2014 as natural quasi-experiments to analyze the impact of smart city construction on new quality productivity. The specific model is as follows:

$$\mathrm{Nqpf_{it}} = \alpha_1 + \alpha_2 \mathrm{did_{it}} + \alpha_3 \mathrm{X_{it}} + \gamma_i + \mu_t + \epsilon_{it} \qquad \text{Formula (1)}$$

In Model (1), $\mathrm{Nqpf_{it}}$ The table represents the explained variable, $\mathrm{did_{it}}$ indicating the new quality productivity development level of city i in year t. As the explanatory variable, $\mathrm{did_{it}}=\mathrm{Treat_i} \times \mathrm{Time_t}$. First, set the dummy variable Treat for the experimental group and the control group. If it is a pilot city for smart city policies, it is 1; if it is not a pilot city for smart city policies, it is 0. Secondly, set the Time dummy variable time. The year before becoming a smart city pilot city should be 0, and the year of becoming a pilot city and subsequent years should also be 0. $\mathrm{X_{it}}$,The representative control variables are respectively population density, economic development level, urbanization level, degree of government intervention and industrialization level. And respectively represent fixed time and fixed city, ϵ_{it} are random error terms.

Finally, to examine the mediating effect of mediating variables between smart city construction and new quality productivity, this article draws on Wen Zhonglin [34] (2004) and establishes a mediating effect model based on (1). The mediating effect regression model is set as follows:

$$\mathrm{M_{it}} = \alpha_1 + \alpha_2 \mathrm{did_{it}} + \alpha_3 \mathrm{X_{it}} + \gamma_i + \mu_t + \epsilon_{it} \qquad \text{Formula (2)}$$

$$\mathrm{Nqpf_{it}} = \alpha_1 + \alpha_2 \mathrm{did}_{it} + \alpha_3 M_{it} + \alpha_4 X_{it} + \gamma_i + \mu_t + \epsilon_{it} \qquad \text{Formula (3)}$$

(2) Variable Selection

Core explanatory variable

Smart City Construction (did) : According to the three batches of smart city construction pilot list released by the Ministry of Housing and Urban-Rural Development, if a city is a smart city pilot city, the value assigned to the year of pilot implementation and subsequent years is 1, and to the rest is 0. If a city is on the list of smart city pilot projects, all values will be 0 during the study period.

(3) The explained variable

New quality productivity (Nqpf), Marx believed, productivity is the ability of people to transform nature to meet demands, mainly composed of three elements: laborers, means of labor and objects of labor, with laborers being the key (Hu Ying) [35]. Therefore, referring to the research of Han Wenlong (2024) [36] and Ma Dan (2025) [37], this article constructs a new quality productivity index system from three major aspects: labor force, labor materials, and labor objects, with 15 indicators (Table 1), and adopts the entropy method to calculate the development index of new quality productivity.

Table 1 New Quality Productivity Index System

First-leveIndicator	Second-level Indicator	Indicator Explanation	Direction	Weight
Laborers	Number of Employees in Emerging	Total number of employees in listed companies of	+	0.184

	Industries	strategic emerging industries and future industries, aggregated to prefecture-level cities by place of registration		
	Individual Ability of Employees	Average salary of on-the-job employees	+	0.018
	Educational Structure of Human Resources	Number of college and university students (undergraduate and junior college) in school	+	0.101
Means of Labor	Infrastructure	Number of mobile phone users	+	0.047
		Internet usage per 100 people	+	0.079
	Future Development	Robot installation density	+	0.046
	Scientific and Technological Innovation	Number of patent applications	+	0.048
		Ratio of R&D expenditure to local fiscal expenditure	+	0.025
Objects of Labor	Green Environmental Protection	Harmless treatment rate of domestic waste	+	0.024
		Centralized treatment rate of sewage treatment plants	+	0.182
		Comprehensive utilization rate of general industrial solid waste	+	0.002
	Industrial Development	Total volume of telecommunications business	+	0.002
		Ratio of industrial added value to gross regional product (GRP)	+	0.006
	Data Elements	Number of artificial intelligence (AI) enterprises	+	0.222
		Utilization level of data elements	+	0.006

(4)

Control variables

To eliminate the influence of other factors on the improvement of new quality productivity in smart city construction, the following control variables are added in the article: ① Economic development level () : The per capita gross domestic product is selected for representation. ② Population density (Pd) : It is represented by the ratio of population to urban area. ③ Urbanization level: It is expressed as the proportion of the urban population to the total population in a region. ④ Degree of Government intervention (Gov) : It is expressed as the ratio of general government fiscal expenditure to GDP. ⑤ Industrialization Level (Loi) : It is expressed as industrial added value

/GDP.

(5) Mediating variables

Human capital level: Select the number of regular undergraduate and junior college students currently enrolled/the total population at the end of the year.

Scientific and technological level: Select scientific and technological expenditure.

(6) Threshold variables

The upgrading of industrial structure: The added value of the tertiary industry in ten thousand yuan/the added value of the secondary industry in ten thousand yuan is selected for measurement.

(7) Data Sources

The article adopts 287 prefecture-level cities across the country from 2011 to 2022 as panel data. The data mainly come from the statistical yearbooks of prefecture-level cities, provincial statistical yearbooks, "China Rural Statistical Yearbook" and "China Social Statistical Yearbook". A few missing values are supplemented by interpolation method.

5.Empirical Analysis

(1) Benchmark regression

To study the impact of smart city policies on new quality productivity, this article adopted a differentially in-differences model for benchmark regression. The results are shown in Table 2. Columns (1) and (2) are the regression results without control variables and with control variables, respectively. Columns (3) and (4) indicate that no control variables have been added, but control is applied to time and individuals respectively. Column (5) represents the regression results that not only incorporate control variables but also control over time and individuals. The results indicate that. Whether time and individuals are controlled or not, and whether control variables are added or not, the impact coefficient of smart village construction on new quality productivity is significantly positive and passes the 1% significance test, indicating that smart city construction has a significant promoting effect on new quality productivity, and hypothesis H1 is thus established.

Table 2 Benchmark Regression Analysis

Variable	(1)	(2)	(3)	(4)	(5)
	Nqpf	Nqpf	Nqpf	Nqpf	Nqpf
did	0.758***	0.675***	1.345***	0.187***	0.184***
	(10.365)	(9.165)	(23.088)	(2.968)	(2.911)
Pd		0.090**			0.031
		(2.463)			(0.397)
Pergdp		0.429***			0.096
		(5.230)			(1.180)
Urb		0.119			0.305
		(0.384)			(0.755)
Gov		1.757***			0.472***
		(5.870)			(2.944)
Loi		-0.000			0.000***
		(-1.448)			(7.272)
Times	NO	NO	YES	NO	YES
Individual	NO	NO	NO	YES	YES
_cons	1.956***	-3.542***	1.801***	2.106***	0.637
	(52.163)	(-4.319)	(83.204)	(99.506)	(0.648)
N	3990	3990	3990	3990	3990

R2	0.026	0.045	0.745	0.842	0.842
F	107.440	31.440	533.038	8.807	10.523

(Note: ***, **, * respectively indicate significance at the 1%, 5%, and 10% levels. The values in parentheses are t values, "the same below")

(2) Placebo test

In this paper, among the 276 sample cities, a few cities were randomly selected as the treatment group, and the cities not selected were used as the control group. This process was repeated 500 times. As a result, we obtained 500 false estimation coefficients of "Broadband China" for the integrated development of urban and rural areas, as shown in Figure 1. The density distribution of the P-value points that constitute these policies shows that Most of these estimated coefficients are clustered around the 0 value, and their p-values are mostly above 0.1. The estimated coefficient of the actual policy dummy variable Band in this paper (0.213, as shown by the dotted line in the figure) is significantly different from the result of the placebo test, presenting as an outlier. This result indicates that the benchmark regression results exclude the possibility of being influenced by uncontrollable factors.

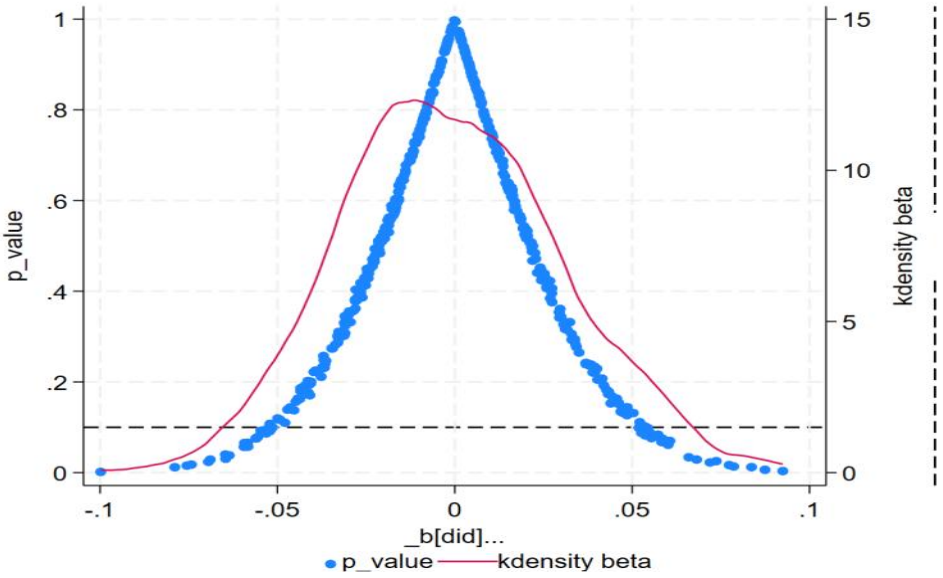

Figure 1 Placebo test

(3) Robustness test

Exclude municipalities directly under the Central Government

The drawback of PSM is that it cannot control the possible impact of unobservable variables on the regression results. As an infrastructure policy for specific regions, the "Smart City construction" policy may vary among municipalities directly under the Central Government due to the influence of their city size and economic development level. Therefore, the article adopts the approach of proposing municipalities directly under the Central Government (Beijing, Shanghai, Tianjin and Chongqing) for robustness tests. The specific results are shown in column (1) of Table 3. We find that after excluding the municipalities directly under the Central Government, the construction of smart cities still has a significant promoting effect on new quality productivity, and the conclusion is robust.

Eliminate the interference of other policies

Considering that the implementation of the "Smart City Construction" policy may confuse other policies of the same period, in order to ensure the validity of the experimental conclusion, this article sorts out other policies within the sample period and finds that the "Broadband China" policy announced the pilot cities of "Broadband China" three times from 2014 to 2016. Therefore, the article incorporates the dummy variable of the "Broadband China" policy into the model to eliminate its interference with the model results. The specific results are shown in column (2)

of Table 3. We find that after substituting the "Broadband China" policy into the model, the construction of smart cities still has a significant positive impact on new quality productivity, and the conclusion remains robust.

PSM-DID

Given that propensity score matching combined with difference-in-differences models can effectively alleviate the "selection bias" problem in pilot policies, this paper adopts this model to further verify the robustness of the aforementioned estimation results. The article first adopts the one-to-one nearest neighbor matching method for matching and selects control variables (economic development level, population density, urbanization level, degree of government intervention and industrialization level) as covariates to screen samples. Secondly, through the balance test in Figure 2, it can be seen that the deviation of control variables in the experimental group and the control group is significantly reduced and remains within 5%. After passing the balance test, the model was finally estimated. The regression results are shown in column (3) of Table 3. We can see that the construction of smart cities has a significantly positive impact on new quality productivity, indicating that the estimation results mentioned above are robust.

Table 3 Robustness Test

Variables	(1) Excluding municipalities directly under the Central Government	(2) Broadband China	(3) PSM-DID	
	Nqpf	Nqpf	Nqpf	Nqpf
did	0.185***	0.179***	0.192***	0.160*
	(2.897)	(2.852)	(3.176)	(1.738)
Broadband China		-0.111**		
		(-2.113)		
Pd	0.121	0.113	0.115	0.234*
	(1.421)	(1.334)	(1.534)	(1.796)
Pergdp	0.140	0.136	0.156*	0.146
	(1.581)	(1.558)	(1.808)	(1.040)
Urb	0.369	0.413	0.438	0.117
	(0.903)	(1.025)	(1.388)	(0.251)
Gov	0.807*	0.760*	0.859**	0.112
	(1.800)	(1.732)	(2.394)	(0.231)
Loi	0.000***	0.000***	0.000	-0.938***
	(7.330)	(7.191)	(1.398)	(-3.688)
Time	YES	YES	YES	YES
Individual	YES	YES	YES	YES
_cons	-0.430	-0.358	-1.446	-1.338
	(-0.400)	(-0.336)	(-1.481)	(-0.837)
N	3892	3962	3963	1986
R2	0.842	0.842	0.448	0.461
F	10.241	8.867	156.489	75.754

Mechanism Verification

To study the mediating role of smart city construction on new quality productivity, the article selects the level of human capital and the level of science and technology as mediating variables. The results of the mechanism test regression are shown in Table 4. Column (1) represents the research on the impact of smart city construction on new quality productivity, and it is concluded that smart city construction significantly promotes the development of new quality productivity at the 1% level. Column (2) indicates the impact of smart city construction on the level of human capital. It is concluded that smart city construction promotes the advanced development of industrial outcomes, which is significant at the 5% level. Column (4) represents the impact of smart city construction on the level of science and technology. We find that the impact coefficient of smart city construction on the level of science and technology has passed the significance test of 5%, and the coefficient is positive. Column (5) represents the research on the impact of scientific and technological levels on new quality productivity. We concluded that scientific and technological levels promote the improvement of new quality productivity and passed the 5% significance test. The level of science and technology and the level of human capital play a mediating role in the construction of smart cities and the new quality productive forces, which proves the validity of hypotheses H2 and H3.

Table 4 Mechanism Test Results

Variable	(1) Nqpf	(2) Level of human capital	(3) Nqpf	(4) The level of science and technology	(5) Nqpf
did	0.184***	0.001**	0.159**	0.001**	0.159**
	(2.911)	(2.504)	(2.545)	(2.504)	(2.545)
Pd	0.031	0.001	0.016	0.001	0.016
	(0.397)	(1.249)	(0.200)	(1.249)	(0.200)
Pergdp	0.096	0.001	0.082	0.001	0.082
	(1.180)	(0.994)	(0.992)	(0.994)	(0.992)
Urb	0.305	-0.003	0.383	-0.003	0.383
	(0.755)	(-1.252)	(0.940)	(-1.252)	(0.940)
Gov	0.472***	0.005***	0.351**	0.005***	0.351**
	(2.944)	(3.344)	(2.303)	(3.344)	(2.303)
Loi	0.000***	-0.000	0.000***	-0.000	0.000***
	(7.272)	(-0.500)	(7.199)	(-0.500)	(7.199)
Level of human capital			22.650***		
			(9.009)		
The level of science and technology					22.650***
					(9.009)
Time	YES	YES	YES	YES	YES
Individual	YES	YES	YES	YES	YES
_cons	0.637	0.006	0.493	0.006	0.493
	(0.648)	(0.885)	(0.492)	(0.885)	(0.492)
N	3990	3990	3990	3990	3990
R^2	0.842	0.823	0.847	0.823	0.847
F	10.523	3.902	20.093	3.902	20.093

6.Threshold Effect

Based on the existing theoretical framework, it can be known that the impact of industrial structure upgrading on the construction of smart cities at different levels on new quality productivity varies. To deeply study this nonlinear relationship, this study selects industrial structure upgrading as the threshold variable and conducts 300 repeated sampling tests using the Bootstrap method. By constructing a triple threshold regression model (see the data in Table 5 for details), it was found that only the double and single threshold indicators passed the significance verification (P<0.05), while none of the triple threshold tests were significant. This indicates that the threshold variable of industrial structure upgrading passed the single threshold test, and a double threshold model should be constructed.

Table 5 Threshold Feature Test

Threshold Variable	Number of Thresholds	F-Statistic	P-Value
	Single Threshold	55.87	0.0033***
Smart City	Double Thresholds	36.30	0.0200**
Construction	Triple Thresholds	18.08	0.6100

In Table 5, we can see that when industrial structure upgrading is taken as the threshold variable, the estimated dual thresholds of smart city construction on new quality productivity are 0.5337 and 1.3028. When the threshold variable of industrial structure upgrading is lower than the first threshold value, the influence coefficient of the level of smart city construction on new quality productivity is significantly -0.696. And it passed the 1% significance test, but the construction of smart cities hinders the development of new quality productivity. When the threshold variable is higher than the single threshold value but lower than the second threshold value, the influence coefficient of the level of smart city construction on new quality productivity is significantly positive (0.254), but it only passes the 10% significance test. When the threshold variable is higher than the second threshold value, the influence coefficient of the level of smart city construction on new quality productivity is significantly positive (0.78), and it has passed the 1% significance test. Therefore, we find that the degree of influence shows an increasing trend, from the initial obstructive effect to the final promoting effect, which can be seen that the promoting effect of smart city construction on new quality productivity It will be affected by the upgrading of the industrial structure. The stronger the level of industrial structure upgrading, the stronger the promoting effect of the two.

Table 6 Threshold Regression Results

Threshold Interval of Industrial Structure Upgrading	Impact Coefficient (on New-Quality Productive Forces)
LQ ≤0.5337	-0.696*** (0.178961)
0.5337< LQ <1.3028	0.254*(1.89)
LQ >1.3028	0.78***(3.36)
Control variable	Yes
_cons	-11.2*** (-7.55)
N	3962

Heterogeneity Analysis

1. Urban location heterogeneity

The impact of smart city construction on new quality productivity varies with different geographical locations. Therefore, in order to study the heterogeneity of smart city construction on new quality productivity, this article divided 285 prefecture-level cities across the country into eastern, central and western regions for group regression. The results are shown in Table 7. The article finds that the construction of smart cities in both the eastern and western regions has a positive promoting effect on new quality productivity. The western region has achieved a

significance level of 1%, while the eastern region has achieved a significant new level of 10%. In the central region, the construction of smart cities has a heterogeneous effect on new quality productivity, but it is not significant. The main reason is that The eastern region usually has a relatively developed economic foundation, which provides sufficient financial support and technical guarantee for the construction of smart cities. The various applications and innovations of smart cities can be rapidly applied and promoted in economic activities, thereby driving the improvement of new quality productivity. To promote coordinated regional development, the central government has given more policy preferences and support to the western regions. These policies will help the western regions achieve breakthroughs in the construction of smart cities, thereby promoting the improvement of new quality productivity. Compared with the eastern and western regions, the economic foundation of the central region is relatively weak, which restricts the research and application of smart city technologies. Meanwhile, the central region may encounter bottlenecks in terms of funds and technology in the construction of smart cities, resulting in an insufficiently significant improvement in new quality productivity.

2. Heterogeneity in urban scale

The differences in urban size imply that cities vary in economic development, technological innovation, and other aspects, leading to heterogeneity in the new quality productivity of smart city construction. According to the "Notice of The State Council on Adjusting the Standards for Urban Size Classification", this article classifies cities into large cities and medium and small-sized cities and conducts group regression. The results are shown in Table 7. The article finds that The construction of smart cities in medium and small-sized cities has a significant promoting effect on new quality productivity, and the impact coefficient has passed the significance test of 1%. However, in large cities, it is not significant and there is an obstructive effect. The reason is that compared with large cities, medium and small-sized cities tend to be more concentrated and efficient in resource allocation. The construction of smart cities can make full use of limited resources and improve the efficiency of urban management and services through information and intelligent means, thereby significantly promoting new quality productivity. The advantage of this concentrated utilization of resources is particularly evident in medium and small-sized cities, as their urban scale is relatively small and it is easier to achieve the optimal allocation of resources. Due to their large scale and large population, the complexity of urban management and services in large cities is much higher than that in medium and small-sized cities. The construction of smart cities needs to confront more challenges and problems, such as traffic congestion, environmental pollution, and uneven resource allocation. These complex issues may lead to a slower pace and less significant effect of smart city construction in large cities.

Table 7 Results of Heterogeneity Analysis

Variable	Eastern China	Western China	Central China	Large Cities	Small and Medium-sized Cities
	Nqpf	Nqpf	Nqpf	Nqpf	Nqpf
did	0.203*	0.534***	-0.129	-0.111	0.343***
	(1.950)	(4.000)	(-1.394)	(-1.216)	(4.178)
Pd	0.208	-0.065	0.459***	0.061	0.198**
	(0.421)	(-1.124)	(4.172)	(0.559)	(2.205)
Pergdp	0.810***	0.423***	-0.620***	0.471***	0.083
	(5.512)	(3.015)	(-3.243)	(3.652)	(0.611)
Urb	0.513	3.054***	-0.694	-0.827	1.303**
	(0.755)	(3.738)	(-1.132)	(-1.543)	(2.306)

Gov	0.293	1.220	0.439	0.020	1.490**
	(0.743)	(1.411)	(0.545)	(0.072)	(2.322)
Loi	0.000***	-0.927**	-0.507***	0.000***	-0.542***
	(6.503)	(-2.421)	(-2.813)	(6.901)	(-3.209)
Time	YES	YES	YES	YES	YES
Individual	YES	YES	YES	YES	YES
_cons	-8.306**	-3.657**	6.484***	-2.958*	-0.643
	(-2.301)	(-2.326)	(2.956)	(-1.854)	(-0.432)
N	1400	1162	1400	1428	2534
R^2	0.837	0.868	0.838	0.842	0.845
F	10.791	7.842	7.777	9.844	8.384

7.Research Conclusions and Countermeasures Suggestions

(1) Research Conclusion

Based on the panel data of 285 prefecture-level cities across the country from 2011 to 2022, this article conducts a quasi-natural experiment with the pilot policies of "Smart cities", constructs a differin-differences model, and studies the direct impact, indirect impact, heterogeneity and threshold effect of smart city construction on new quality productivity The model was subjected to the exclusion of municipalities directly under the Central Government, the elimination of interference from other policies, and the robustness test of PSM-DID. The main conclusions are as follows:

Benchmark regression indicates that the model has a significant positive impact on new quality productivity, whether with control variables added, without control variables added, or with random effects models.

Mechanism tests show that both the level of human capital and the level of science and technology play a mediating role in the impact of smart city construction on new quality productivity.

In the heterogeneity test, among the eastern and western regions of urban location heterogeneity, the construction of smart cities has a significant promoting effect on new quality productivity. The significance in the western region is greater than that in the eastern region, while the influence coefficient in the central region is negative and not significant. In the heterogeneity of urban scale, the influence coefficient of large cities is negative and not significant. In medium and small-sized cities, the construction of smart cities has a promoting effect on new quality productivity.

In the threshold effect, there is a threshold effect in the upgrading of industrial structure. The promoting effect of smart city construction on new quality productive forces will be influenced by the upgrading of industrial structure. The stronger the level of industrial structure upgrading, the stronger the promoting effect of both.

(2) Countermeasures and Suggestions

First, promote the construction of new infrastructure related to smart cities. First of all, first of all, strengthen top-level design, formulate special plans to clarify phased goals, select key cities to carry out pilot demonstrations, and explore replicable paths. Establish a diversified investment mechanism, guide through government special funds, attract social capital to participate in the construction of 5G base stations, Internet of Things perception networks, urban data hubs, etc., and promote the PPP model to reduce fiscal pressure. Secondly, improve the standard system, unify data interfaces, device protocols and security norms, and promote the interconnection and interoperability of systems across departments and fields. Deepen the application of scenarios, give priority to the layout of smart transportation, healthcare, education and other fields related to people's livelihood, and utilize AI algorithms to optimize the scheduling of public resources. Finally, we should build a solid security barrier, establish a data classification protection system, strengthen the protection of critical information infrastructure, and conduct

regular security drills. Strengthen talent cultivation, support universities in setting up interdisciplinary subjects related to smart cities, and encourage the joint construction of training bases by the government and enterprises. Through policy coordination, technological integration and demand traction, an integrated development pattern of "construction, management and operation" is formed, enabling new infrastructure to truly empower the modernization of urban governance.

Second, take human capital and scientific and technological levels as important means to promote the improvement of new quality productivity. In terms of human capital level, first of all, establish an interdisciplinary training system in the field of smart cities. Add the "Smart City Technology and Management" major in higher education institutions, focusing on cultivating compound talents who are proficient in information technology and possess urban governance thinking. Secondly, establish a global talent database for smart cities, implement targeted recruitment for scarce positions such as artificial intelligence trainers and urban digital twin architects, and provide "talent green card" policies such as individual income tax incentives and children's education guarantees for top international talents. Finally, a city-level talent sharing platform should be established, and flexible introduction mechanisms such as "Weekend Engineers" and "Remote Collaboration Experts" should be promoted to achieve cross-domain flow of talent resources. Establish an intercommunication mechanism between skills certification and professional title evaluation, incorporate digital technology certification into the professional title evaluation system, and open up career promotion channels for technical talents. In terms of scientific and technological levels, first of all, efforts should be made to promote cooperation among universities, research institutions and enterprises, and establish a collaborative innovation mechanism among industry, academia and research. By jointly building laboratories, research and development centers and other means, accelerate the transformation and application of scientific and technological achievements, so that technological innovation in smart city construction can better serve the cultivation of new quality productive forces. For example, jointly carry out research and application of projects such as intelligent transportation systems and smart energy management. Finally, a smart city scientific and technological achievement trading platform should be established to provide services such as information release and transaction matching for both the supply and demand sides of technology, reduce transaction costs, accelerate the market application of scientific and technological achievements, and promote the formation of new quality productive forces. At the same time, we should strengthen the protection of intellectual property rights and encourage enterprises and scientific researchers to actively carry out technological innovation and the transformation of achievements.

Third, promote the coordinated regional construction of smart cities. For the western regions, the government should increase policy inclination and financial input for the construction of smart cities in these areas. Establish a special fund to support project construction in key areas such as intelligent transportation, smart energy, and smart governance in the western region. Innovation leadership in the eastern region: The eastern region has a relatively solid foundation and should be encouraged to conduct higher-level innovative explorations in the construction of smart cities. Support the construction of international science and technology innovation centers in eastern cities, such as Shenzhen and other places, for innovative applications in cutting-edge fields like artificial intelligence and big data. For the central region, it is necessary to strengthen the planning and guidance for the construction of smart cities in the central region, avoid blind following of trends, and combine local industrial characteristics. For instance, some major agricultural provinces can focus on developing smart agriculture, and resource-based cities can concentrate on areas such as smart energy management, precisely positioning the direction of smart city construction. For the scale of cities, it is encouraged that small and medium-sized cities develop characteristic smart city applications based on local conditions. For instance, some small and medium-sized cities rich in tourism resources can build smart tourism systems to enhance the quality of tourism services and the experience of tourists, and promote the upgrading of the tourism industry. In terms of funds, through policies such as fiscal subsidies and tax incentives, guide social capital to invest in smart city construction projects in small and medium-sized cities.

Large cities should focus on addressing the "big city diseases" in urban development, and utilize smart city technologies to optimize the management of urban traffic congestion and enhance the efficiency of public service resource allocation, etc. For instance, by leveraging big data analysis to optimize the planning of urban bus routes and enhance the operational efficiency of public transportation.

Fourth, regions and industries at different stages of industrial structure upgrading should be given differentiated policy support. For regions with a high level of industrial structure upgrading and strong innovation capabilities, priority support should be given to their research and development of cutting-edge technologies and the construction of industrial innovation platforms to promote the development of emerging industry clusters. For instance, national-level artificial intelligence innovation centers should be established in some technologically advanced cities, and preferential treatment in terms of funds and land should be provided. For regions with relatively lagging industrial structure upgrading, efforts should be made to increase support for the transformation and upgrading of traditional industries, provide policies such as technological transformation subsidies and tax incentives, and encourage enterprises to phase out backward production capacity and introduce advanced production equipment and technologies. For instance, for traditional manufacturing enterprises that update their equipment, equipment purchase subsidies will be provided at a certain proportion. V. Research Conclusions and Countermeasures Suggestions

(1) Research Conclusion

Based on the panel data of 285 prefecture-level cities across the country from 2011 to 2022, this article conducts a quasi-natural experiment with the pilot policies of "Smart cities", constructs a differin-differences model, and studies the direct impact, indirect impact, heterogeneity and threshold effect of smart city construction on new quality productivity The model was subjected to the exclusion of municipalities directly under the Central Government, the elimination of interference from other policies, and the robustness test of PSM-DID. The main conclusions are as follows:

(1) Benchmark regression indicates that the model has a significant positive impact on new quality productivity, whether with control variables added, without control variables added, or with random effects models.

(2) Mechanism tests show that both the level of human capital and the level of science and technology play a mediating role in the impact of smart city construction on new quality productivity.

(3) In the heterogeneity test, among the eastern and western regions of urban location heterogeneity, the construction of smart cities has a significant promoting effect on new quality productivity. The significance in the western region is greater than that in the eastern region, while the influence coefficient in the central region is negative and not significant. In the heterogeneity of urban scale, the influence coefficient of large cities is negative and not significant. In medium and small-sized cities, the construction of smart cities has a promoting effect on new quality productivity.

(4) In the threshold effect, there is a threshold effect in the upgrading of industrial structure. The promoting effect of smart city construction on new quality productive forces will be influenced by the upgrading of industrial structure. The stronger the level of industrial structure upgrading, the stronger the promoting effect of both.

8.Countermeasures and Suggestions

First, promote the construction of new infrastructure related to smart cities. First of all, first of all, strengthen top-level design, formulate special plans to clarify phased goals, select key cities to carry out pilot demonstrations, and explore replicable paths. Establish a diversified investment mechanism, guide through government special funds, attract social capital to participate in the construction of 5G base stations, Internet of Things perception networks, urban data hubs, etc., and promote the PPP model to reduce fiscal pressure. Secondly, improve the standard system, unify data interfaces, device protocols and security norms, and promote the interconnection and interoperability of systems across departments and fields. Deepen the application of scenarios, give priority to the layout of smart transportation, healthcare, education and other fields related to people's livelihood, and utilize AI

algorithms to optimize the scheduling of public resources. Finally, we should build a solid security barrier, establish a data classification protection system, strengthen the protection of critical information infrastructure, and conduct regular security drills. Strengthen talent cultivation, support universities in setting up interdisciplinary subjects related to smart cities, and encourage the joint construction of training bases by the government and enterprises. Through policy coordination, technological integration and demand traction, an integrated development pattern of "construction, management and operation" is formed, enabling new infrastructure to truly empower the modernization of urban governance.

Second, take human capital and scientific and technological levels as important means to promote the improvement of new quality productivity. In terms of human capital level, first of all, establish an interdisciplinary training system in the field of smart cities. Add the "Smart City Technology and Management" major in higher education institutions, focusing on cultivating compound talents who are proficient in information technology and possess urban governance thinking. Secondly, establish a global talent database for smart cities, implement targeted recruitment for scarce positions such as artificial intelligence trainers and urban digital twin architects, and provide "talent green card" policies such as individual income tax incentives and children's education guarantees for top international talents. Finally, a city-level talent sharing platform should be established, and flexible introduction mechanisms such as "Weekend Engineers" and "Remote Collaboration Experts" should be promoted to achieve cross-domain flow of talent resources. Establish an intercommunication mechanism between skills certification and professional title evaluation, incorporate digital technology certification into the professional title evaluation system, and open up career promotion channels for technical talents. In terms of scientific and technological levels, first of all, efforts should be made to promote cooperation among universities, research institutions and enterprises, and establish a collaborative innovation mechanism among industry, academia and research. By jointly building laboratories, research and development centers and other means, accelerate the transformation and application of scientific and technological achievements, so that technological innovation in smart city construction can better serve the cultivation of new quality productive forces. For example, jointly carry out research and application of projects such as intelligent transportation systems and smart energy management. Finally, a smart city scientific and technological achievement trading platform should be established to provide services such as information release and transaction matching for both the supply and demand sides of technology, reduce transaction costs, accelerate the market application of scientific and technological achievements, and promote the formation of new quality productive forces. At the same time, we should strengthen the protection of intellectual property rights and encourage enterprises and scientific researchers to actively carry out technological innovation and the transformation of achievements.

Third, promote the coordinated regional construction of smart cities. For the western regions, the government should increase policy inclination and financial input for the construction of smart cities in these areas. Establish a special fund to support project construction in key areas such as intelligent transportation, smart energy, and smart governance in the western region. Innovation leadership in the eastern region: The eastern region has a relatively solid foundation and should be encouraged to conduct higher-level innovative explorations in the construction of smart cities. Support the construction of international science and technology innovation centers in eastern cities, such as Shenzhen and other places, for innovative applications in cutting-edge fields like artificial intelligence and big data. For the central region, it is necessary to strengthen the planning and guidance for the construction of smart cities in the central region, avoid blind following of trends, and combine local industrial characteristics. For instance, some major agricultural provinces can focus on developing smart agriculture, and resource-based cities can concentrate on areas such as smart energy management, precisely positioning the direction of smart city construction. For the scale of cities, it is encouraged that small and medium-sized cities develop characteristic smart city applications based on local conditions. For instance, some small and medium-sized cities rich in tourism resources can build smart tourism systems to enhance the quality of tourism services and the experience of tourists,

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Mediation Strategies in L2 Learning from Sociocultural Perspective: A Comparative Analysis of Empirical Studies

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Abstract: This paper evaluates the role of mediation strategies in second language learning (L2 learning), through analyzing two empirical studies about L2 learning. Both studies align with Sociocultural Theory's core tenet that L2 development originates from socially mediated interactions. The comparative analysis reveals three key commonalities in mediation strategies: mediation serves as a critical bridge transforming external social interactions; effective mediation adheres to the "Zone of Proximal Development (ZPD)-aligned" principle, with strategies tailored to learners' current L2 proficiency; mediation is a multi-agent system involving teachers, peers, tools, and learners themselves, rather than a teacher-centric process. Nonetheless, the two studies diverge in core goals, mediator roles, strategy implementation, adaptation to learners,and learner's responses to linguistic contexts due to distinct sociolinguistic contexts and learner characteristics. According to the comparative analysis, three highly feasible mediation strategies for L2 learners are distilled: engaging in multi-agent interactive mediation, adopting ZPD-aligned context mediation, and practicing self-mediation for regulation. This study not only deepens the understanding of the mediating mechanism in L2 learning from the SCT perspective but also provides empirical references for designing adaptive mediation strategies in L2 teaching, improving teaching efficiency, as well as enhancing learner's language proficiency.

Keywords: second language acquisition; mediation strategies; sociocultural theory; L2 learning

Introduction

Second language acquisition (SLA) is a complex, interdisciplinary field of study which has its roots in subjects as varied as cognition and psychology to social applications and actions in anthropology and sociology (Han & Nassaji, 2019). Its complexity stems from the multifaceted nature of language learning, which involves not just the acquisition of linguistic structures but also the integration of these structures into real-world communication. Language, as both a cognitive system and a social practice, demands attention to how learners process information internally, how they interact with others in the target language, and how cultural contexts shape their use of language. This interplay of factors means that understanding SLA requires examining everything from the neural mechanisms of vocabulary retention to the ways community norms influence conversational patterns.

In SLA, learning of L2 vocabulary and grammar is a first step in language learning; once this milestone is covered, L2 learners need to know when and how to use these to convey certain meanings in specific situations (Hymes, 1972). Mastering vocabulary and grammar provides the foundational tools, but true proficiency emerges when learners can adapt these tools to fit social contexts. For example, knowing the past tense of verbs is essential, but recognizing when to use it to share a personal experience versus when to avoid it in a casual greeting requires an understanding of situational norms. This shift from formal knowledge to practical application often proves

challenging, as learners must navigate not just linguistic rules but also the unspoken conventions that govern communication. L2 learners may find it challenging to deal or communicate with L1 speakers because it may vary significantly from what they already know in their mother tongue. It may be essential, then, for L2 learners to clarify aspects of speech (e.g., intonation, certain idioms, etc.) to learn and develop new skills in order to meet these higher standards (Negueruela Azarola & Garcia, 2016). During interactions with others, the L2 learner has access to language forms and functions that are normally exclusively accessible to the latter.

One of the oldest and most influential ideas in SLA comes from the sociocultural perspective and, in particular, the work of Soviet psychologist Lev Vygotsky. Over a century in the past, Vygotsky embarked on a quest to intertwine what seemed like separate realms of society, culture, and thought, through his overarching, broad-spectrum theory known as Sociocultural Theory (SCT). At the core of SCT is the belief that human development, including language learning, is not an isolated, internal process but a social one. Higher mental functions, such as reasoning and language use, originate in social interaction and are gradually internalized as individual abilities. This perspective shifts focus from the learner alone to the dynamic between the learner and their social environment, emphasizing that learning thrives in collaborative contexts where guidance and support are available.

SCT offers a unique theoretical framework that relies on diverse conceptions of human development emphasizing the integrated nature of individual elements in the learning process (Masuda & Arnett, 2015) and stresses context-based language learning providing practical implications for L2 instruction. By highlighting the role of social interaction and cultural tools in learning, SCT underscores that L2 development cannot be separated from the contexts in which it occurs. Whether through teacher guidance, peer collaboration, or engagement with cultural artifacts like books or digital media, learners use these external resources to build their linguistic competence. This focus on context-based learning makes SCT particularly relevant for L2 instruction, as it encourages pedagogical practices that immerse learners in meaningful communication, helping them not just to learn the language but to use it as a tool for participation in social and cultural life.

Theoretical Background

SCT argues that cognition is not a purely psychological process but is instead a process mediated by cultural artifacts and activities such as interaction (Vygotsky, 1986). While this theory aims to provide a wide-ranging, general theory for human learning and cognition, it has been adapted in SLA in a few key areas, in particular, in particular, the Zone of Proximal Development (ZPD). Vygotsky claimed that learning is essentially a mediated process, and that a learner’s abilities at any point in time can be understood as three layers: (1) what the learner can do unaided, (2) what the learner can do with mediation, and (3) what the learner cannot do, even with mediation. It is this middle tier of ability, i.e., what the learner can do with mediation, that Vygotsky identified as the Zone of Proximal Development (Vygotsky, 1986). The Mediation Theory states that the most fundamental concept of sociocultural theory is that the human mind is mediated, and that sociocultural approach is essentially a “theory of the mind” (Lantolf, 2000), maintaining “learning as a mediated external, not just a mental internal phenomenon” (Ellis, 2015, p.221). It explores the social roots of human thinking, or in other words, how social learning mediates cognitive development. This theoretical notion of ZPD and, in particular, the use of mediation strategies in the form of social interaction to increase learning and expand individual knowledge is the basis of the following empirical studies reviewed for this paper.

Sociocultural Theory and Teacher’s Mediation

Vygotsky (1978) saw the child as first doing things in a social context, helped in various ways by other people and language, and gradually shifting away from reliance on others to independent thinking and action. This approach to children’s mental development highlights the critical role of teachers in shaping the most favorable conditions for enhancing and regulating their development. Vygotsky’s theory of learning and development has been transformed and adapted to different educational frameworks, including the L2 class.room (Lantolf & Beckett, 2009; Lantolf &

Thorne 2006). Such adaptations perceive the institutional context, such as a school, as a formative setting for the child's developmental process. In the particular setting of the bilingual classroom, children ac.quire their L2 abilities through interaction with teachers and peers.

In this paper, we explored how major theoretical principles and concepts included in Vygotsky's mediation strategies scaffolding, identification of the child's zone of proximal development, and modeling are realized in the teachers' strategies aimed at encouraging L2 acquisition in the bilingual classroom.

Mediation Strategies

The ability to learn through interaction and mediation is characteristic of human intelligence. Vygotsky (1978) proposed the notion of the human mediator and emphasized that "what the child is able to do in collaboration today he will be able to do independently tomorrow" (p. 211). In a whole range of ways, adults mediate and make the world accessible to children. With the help of adults and peers, children can do and understand much more than on their own.A substantial number of studies have focused on mediation strategies provided by teachers in L2 classrooms, The focus was on strategies such as corrective feedback and its relation to L2 acquisition (e.g., Aljaafreh & Lantolf, 1994; Lyster, Saito, & Sato, 2013), imitation (Ohta, 200l; Saville Troike, 1988), and the zone of proximal development (e.g, Lantolf & Thorne, 2006; Ohta, 2001). Most of these studies drew on observations of students in secondary L2 classrooms. For that reason, our knowledge on how teachers realize main principles and concepts of mediation among preschool children is very limited (but see, for example, Gort & Pontier, 2012).

Teacher's Identification of Student's Zone of Proximal Development

Vygotsky (1978) defined the "zone of proximal development" (ZPD) as "the distance between the actual developmental level as determined by independent problem solving and the level of potential development as determined through problem solving under adult guidance or in cooperation with more capable peers" (p.86). He considered the ZPD as referring to the well-known fact that "with collaboration, direction, or some kind of help the child is always able to do more and solve more difficult tasks than he can independently" (p.209). Thus, teacher-children interaction provides conditions for identifying the child's ZPD and the extent to which the child has actually developed (Chaiklin, 2003). Skillful teachers are very "tuned-in" to their classroom students and can evaluate each child's ZPD. In other words, to activate the "zone", the child's developmental space, the teacher needs to recognize what is known and unknown to the children, and to mediate development by making them aware of what is unknown versus known (Kohler, 2015). This awareness is applied both in lesson planning and in how teachers talk to students minute by minute.

Detailed Review of Empirical Studies

The studies chosen for this analysis around SCT generally and focus on the mediation strategies specifically. While each study takes a different approach to connect language learning to the Vygotskian concept of mediation in the ZPD, they are all unified in their adoption of Vygotsky's (1986) definitions of mediation. While each of the accounts varies slightly on what qualifies as mediation, the analyses sampled for this paper all use the same basis for their findings, making each a unique yet similar example of the impact of SCT on SLA research.

In the first study of this paper, "There is No Need for Translation: She Understands: Teachers' Mediation Strategies in a Bilingual Preschool Classroom" by Mila Schwartz and Naomi Gorbatt, the study explored how major theoretical principles and concepts in the mediation strategies of Vygotsky's sociocultural theory are realized in an Arabic-Hebrew preschool in Israel, aiming at examining how teachers encourage children to use their second language (L2) during teacher- child conversations, as well as gaining a deeper understanding of the type of language mediation that occurs during learning events and free communication between teachers and children in a bilingual preschool.

The authors first introduced the background of the research. Israel is officially a bilingual nation, with Hebrew and Arabic as its state languages. However, a clear functional asymmetry exists between them. Hebrew serves as the dominant language across most societal domains, including government, media, and popular culture. In

contrast, Arabic, although the mother tongue of roughly one-fifth of the Israeli population, is a minority language in terms of institutional support and daily usage prevalence. For L1 Arabic-speaking children, Hebrew is learned as a second language (L2) from the second or third grade onward within the school curriculum, continuing until twelfth grade. Meanwhile, L1 Hebrew-speaking children have limited daily exposure to Arabic. This is due to long-standing social tensions between Arab and Jewish communities, which has led to a pattern of largely separate living and cultural environments. Such separation results in restricted Arabic language input for Hebrew-speaking children, reducing their motivation to learn Arabic. The Center for Bilingual Education, established in 1997 to promote bilingual and bicultural education and mutual respect from early childhood, operates a target bilingual preschool (founded in 2004) with a two-way language program teaching both Hebrew and Arabic. However, there is limited research on how teachers mediate to enhance the minority Arabic' s status and promote language socialization in early L1/L2 acquisition stages, so this study aims to examine teachers' mediation strategies in this bilingual preschool learning environment.

Given the cultural background, this study, set in the bilingual Arabic-Hebrew preschool context in Israel, selected two preschools within the network of the Center for Bilingual Education as the research sites. For participants, it involved teachers from these preschools, specifically, pairs of teachers (one Arab, one Jewish) in each class, as well as young children in the early stages of L1 (Hebrew or Arabic) and L2 (the other language) acquisition. In terms of the research method, the authors employed a combination of quantitative and qualitative approach, including classroom observations to record teachers' instructional strategies and interactions related to mediating the minority language (Arabic) learning, combined with teacher reflections and interviews. Through these means, they analyzed how teachers implemented mediation strategies to address the need of elevating the socially weaker minority language within the framework of the bilingual preschool environment, aiming to understand the mechanisms of language socialization and minority language promotion in early childhood bilingual education.

The analysis first categorized observed mediation strategies (e.g., language modeling, avoidance of direct translation) from observational records. Then, it triangulated these with interview data: researchers coded and interpreted teachers' reflections to contextualize strategy use, examining how behaviors aligned with goals of promoting the minority language (Arabic) and fostering cross-cultural socialization. By integrating qualitative coding of strategies and thematic analysis of teacher narratives, the study unpacked the mechanisms of instructional mediation in the bilingual preschool setting, highlighting how specific practices addressed linguistic status inequalities and supported early L2 acquisition.

Finally, The study concludes that teachers' mediation strategies, including purposeful avoidance of direct translation, modeling of minority-language (Arabic) use, and peer-expert facilitation, effectively activate young learners' ZPD, promoting minority-language acquisition and cross-cultural socialization in the bilingual preschool context. These strategies mitigate linguistic status inequalities, though challenges persist due to the broader sociopolitical marginalization of Arabic in Israel. For future research, the study calls for longitudinal investigations tracking strategy impacts on learners' long-term language proficiency and intergroup attitudes, as well as explorations of digital tools' potential to enhance minority-language mediation. Expanding the scope to diverse bilingual educational settings worldwide could further refine understanding of how mediation bridges sociocultural divides and fosters equitable language learning.

In the second study sampled for this paper, "Use of Language Learning Strategies among Learners of Chinese as a Second Language from the Perspective of Mediation Theory", Lu Chen (2021) conducted a research on the Chinese learning strategies of overseas students in a provincial university in central China, aiming at exploring the characteristics of Chinese learning strategies used by international students, the individual differences in the use of Chinese learning strategies by international students, and the factors that affect the use of Chinese learning strategies by overseas students. In her study, quantitative and qualitative methods, including questionnaire survey

and semi-structured interview were adopted to collect data. Sociological statistical software SPSS 22.0 was used to conduct descriptive analysis and independent sample t-test for quantitative data.

The author first discussed the theoretical basis of sociocultural mediation theory and its connection with L2 Chinese learning strategies, citing research from Vygotsky (1978), Oxford (1990), and relevant domestic scholars in the field of Chinese as a second language (CSL) research. However, the majority of the literature review in this master's thesis focused on the application of learning strategies in CSL and the uniqueness of Chinese language learning. The author quoted Vygotsky directly, highlighting that "human mental activity is essentially a mediated process" (Vygotsky, 1978). Chen went on to connect the sociocultural mediation theory to the actual learning process of CSL learners, wherein learning strategies first emerge in social interactions, such as communication with teachers and peers, then are internalized at the individual cognitive level, which she analyzed in terms of the "appropriation" process in sociocultural theory. The researcher then explained the classification system of learning strategies, highlighting the integration of sociocultural elements such as the role of important others, cultural artifacts, into the analysis of CSL learning strategies.

After drawing on the classifications proposed by Lantolf (2000) (significant others, self-mediation, and cultural quality), this study ultimately divides the framework of Mediation Theory into seven categories: significant others, self-mediation, cultural quality, learning contexts, rule mediation, community mediation, and role mediation. Chen defined the research scope and objectives in line with her study focus, outlining the roles of various mediation factors, including important others, self-mediation, cultural artifacts, etc., in the use of CSL learning strategies, summing up her argument setting that sociocultural mediation theory provides a comprehensive framework to understand how CSL learners use strategies in social-cognitive interactive processes. Tying this to the research, Chen noted that "exploring the diverse mediation factors and their impacts on CSL learning strategy use is at its core--a process that unfolds in the interactive activities between learners and their social and cultural environments". This study claimed that the use of CSL learning strategies is crucially influenced by sociocultural mediation provided by various elements in the learning context. Questionnaires, semi-structured interviews, and data from the learning behaviors of CSL learners in a provincial university in central China were used to analyze the characteristics and influencing factors of learning strategy use.

The author went on to present a detailed analysis of strategy use differences in terms of individual variables, such as gender, length of study, as well as the regulatory role of mediation factors. According to the analysis of strategy use patterns with each learner group, there was a clear progression in strategy application as learners' Chinese proficiency improved, including changes in the use of memory strategies, cognitive strategies, etc. Learners received different levels of mediation support,such as from teachers' instructions to peers' assistance, and as a result, their ability to self-regulate learning strategies developed, leading to a transformation in the dependence on external mediation over time.

Finally, under the guidance of mediation theory, the interview content with overseas students in China is further analyzed. The research claimed that among the six sub-strategies of learning strategies, the frequency of using them from high to low was as follows: affective strategy > social strategy > meta-cognitive strategy>cognitive strategy > compensation strategy > memory strategy. There were no significant differences in the use of learning strategies by gender and learning duration, but there were differences in the use of specific strategies, and factors affecting the use of Chinese learning strategies include important others, self-intermediation, cultural quality, learning context, rule intermediation, community intermediation and role intermediation. The author concluded that great individual learner discrepancies exist in CSL learning strategy use under the influence of sociocultural mediation. Chen suggested further studies to analyze the long-term impact of such mediation on CSL learning outcomes, which provides implications for subsequent related research. The results of this study provide a positive reference for international Chinese language teachers to improve their teaching strategies and improve their

teaching efficiency, and contribute to the improvement of Chinese language learning effects of international students in China.

A Comparative Analysis of Empirical Studies

Having elaborated on the core elements of the two empirical studies respectively, this paper will now shift its focus to a comparative analysis of the two works. The comparison will center on how they operationalize mediation theory in distinct L2 learning contexts, the differences and similarities in their research designs, core findings regarding mediation strategies, and the practical implications derived, so as to reveal the contextual adaptability and universal laws of mediation strategies in L2 learning from a sociocultural perspective.

Commonalities in Mediation Strategies Between the Two Studies

Both studies adhere to the foundational proposition of sociocultural theory: mediation serves as the critical link transforming external social experiences into internal L2 competence. For Schwartz & Gorbatt (2017), this is manifested in teachers' and peer experts' mediation that guides young Hebrew-L1 learners toward Arabic acquisition. Teachers avoid direct translation to push children to actively engage with L2, while L2-proficient Arab peers, who are labeled "language experts", mediate interactions by clarifying misunderstandings between Hebrew-L1 and Arabic-L1 children. These social-mediated activities gradually enable children to internalize Arabic knowledge, for instance, Hebrew-L1 children who initially rely on peers to interpret Arabic instructions eventually use basic Arabic phrases independently.

Similarly, Chen (2021) emphasizes that multi-dimensional mediation facilitates the internalization of Chinese learning strategies among international students. "Significant others" create social interaction contexts; "cultural quality" offer tools for knowledge scaffolding; and "self-mediation" bridges external support and individual mastery. Together, these mediated experiences help students transform discrete learning strategies into automatic L2 communication skills, such as using WeChat to practice Chinese daily with native speakers, a behavior rooted in social mediation and tool mediation.

A second key commonality is that both studies prioritize "ZPD-aligned mediation", which means designing and adjusting mediation strategies to match learners' current L2 proficiency, a core tenet of Vygotsky's theory. Schwartz & Gorbatt (2017) document how teachers in the Arabic-Hebrew preschool dynamically calibrate mediation based on children's ZPD. For example, at the start of the academic year, when Hebrew-L1 children have minimal Arabic exposure, teachers use concrete scaffolding, e.g., pointing to a "big bottle" while repeating the Arabic term qanineh kbeereh to anchor understanding. As children progress, teachers reduce scaffolding — instead of gesturing, they ask children to identify cognates to activate prior knowledge, ensuring mediation stays within the zone of potential development.

Chen (2021) similarly finds that international students' use of mediation strategies is tightly tied to their L2 (Chinese) ZPD, shaped by learning duration. Learners within 6 months of Chinese study rely on basic mediation tools aligned with their limited proficiency. They use memory strategies mediated by textbooks and compensation strategies mediated by mother tongues, e.g., using Russian or English to clarify Chinese meanings. In contrast, learners with over 12 months of study adopt more complex mediation. They use meta-cognitive strategies mediated by self-reflection such as planning daily oral practice, and social strategies mediated by Chinese communities that provide topic-based conversations. This differentiation confirms that effective mediation depends on matching strategies to learners' current developmental level.

Thirdly, Both studies move beyond the traditional "teacher-centric" view of mediation, recognizing it as a multi-agent system involving diverse mediators, which includes teachers, peers, tools, and even learners themselves. Schwartz & Gorbatt (2017) identify two primary mediator groups in the preschool: teacher mediators, who take on dual roles as L2 models and strategy designers; and peer mediators, who mediate peer interactions by translating contextually and modeling L2 use. Notably, the study highlights that peer mediation complements teacher efforts--experts bridge linguistic gaps that teachers may miss, especially during unstructured activities like free play.

Chen (2021) expands the mediator scope further, categorizing mediators into seven interconnected types under the mediation theory framework: “Significant others”, “self-intermediation”, “cultural quality”, “learning contexts”, “rule intermediation”, “community intermediation”, and “role intermediation”. This multi-agent system reflects that L2 mediation is not a unidirectional process but a synergistic interplay of social, material, and individual factors, consistent with Schwartz & Gorbatt’s (2017) emphasis on mediation as a collective rather than individual act.

Differences in Mediation Strategies Between the Two Studies

While both studies anchor mediation strategies in sociocultural theory, they diverge in core goals of mediation, roles of mediators, types and implementation of strategies, adaptation to learner characteristics, and responses to linguistic context challenges—all rooted in their distinct L2 learning scenarios.

The fundamental goal of mediation strategies in Schwartz & Gorbatt (2017) centers on addressing language status inequality and promoting the minority language. In Israel’s sociolinguistic context, Hebrew dominates daily life, media, and institutions, while Arabic faces marginalization. Hebrew-L1 children have limited exposure to Arabic and low motivation to use it. Thus, teachers’ mediation strategies are intentionally designed to counteract this imbalance: for example, avoiding direct translation of Arabic to Hebrew, explicitly requesting Hebrew-L1 children to respond in Arabic during circle time, and using peer “language experts” to model Arabic use. The overarching aim is to construct a “protected space” for Arabic in the classroom, ensuring it is not overshadowed by Hebrew.

In contrast, Chen (2021), focusing on international students learning Chinese, a majority language in China, frames mediation strategies as tools to facilitate L2 skill mastery and adapt to the target language environment. Unlike Arabic in Israel, Chinese is the dominant language in the learning context. Thus, mediation strategies are not aimed at “protecting” the L2 but at supporting learners to leverage available resources. The core goal here is to help learners efficiently acquire Chinese skills by aligning mediation with their practical learning needs.

Secondly, from the perspective of roles of mediators, Schwartz & Gorbatt (2017) limits mediators to two primary, interaction-focused groups: teachers and peer “language experts,” with teachers as the dominant drivers. Teachers take on dual roles: on the one hand, “L2 models”, and on the other hand, “strategy designers”. Peer experts, while valuable, act as auxiliary mediators. They clarify misunderstandings but do not independently design strategies. Mediators here are “active interactors” who engage in real-time, face-to-face scaffolding.

Chen (2021) expands the mediator system to seven interconnected, multi-functional types, moving far beyond a teacher-peer system, which include “significant others”, “self-intermediation”, “cultural quality”, “learning contexts”, “rule intermediation”, “community intermediation” and “role intermediation”. Critically, many mediators here are “passive tools” or “contextual factors” that learners actively utilize: mediation is not limited to face-to-face interaction but includes self-directed use of resources.

Thirdly, from the perspective of the implementation of mediation strategies, Schwartz & Gorbatt (2017) emphasizes immediate, interactive mediation strategies tailored to young children’s cognitive needs. These strategies are implemented in real-time during teacher-child or peer interactions: avoidance of direct translation, explicit L2 requests, teacher modeling of L2 learning, and peer expert guidance. Strategies are concrete, sensory-focused and require continuous adult/peer guidance.

Chen (2021) focuses on learner-initiated, resource-based mediation strategies suited to adult learners’ autonomy. These strategies are often pre-planned or self-adjusted, not dependent on real-time interaction, which include “cultural quality use”, “self-mediation”, “community participation” and “rule-driven strategy selection”. Strategies are abstract, goal-oriented and leverage learners’ ability to independently access and use resources.

Regarding the adaptation to learner characteristics, Schwartz & Gorbatt (2017) designs mediation strategies to align with 5-6-year-old children’s concrete operational thinking and limited self-regulation. Young learners rely on external guidance and sensory cues to process L2. Mediation also prioritizes emotional comfort. When children feel frustrated, teachers use gentle prompts instead of pressure, recognizing young children’s vulnerability to L2

anxiety.

Chen (2021) adapts mediation strategies to adult learners' formal operational thinking and strong self-regulation. Adult students can set learning goals, select appropriate tools, and reflect on strategy effectiveness: for example, learners with over 12 months of Chinese study use meta-cognitive mediation to optimize learning, while beginners use compensation mediation to overcome gaps. Strategies also respect adults' autonomy, for students choosing mediation tools based on their preferences rather than relying on teacher directives.

Last but not least, regarding learner's responses to linguistic context, Schwartz & Gorbatt (2017)'s mediation strategies are explicitly designed to combat the marginalization of the minority language. In Israel, Hebrew permeates children's daily lives, making Arabic easy to ignore. Thus, strategies intentionally restrict majority language use: teachers refuse direct translation to Hebrew, enforce Arabic-only tasks during circle time, and frame Arabic use as a "shared rule". The goal is to create an "Arabic-rich micro-environment" that offsets the broader societal dominance of Hebrew.

Chen (2021)'s mediation strategies leverage the target language environment rather than countering marginalization. In China, Chinese is the language of daily life, campus communication, and media—students have abundant opportunities for natural L2 input. Thus, strategies encourage learners to integrate with the environment: "social mediation", "contextual mediation", and "cultural mediation". Unlike Schwartz & Gorbatt (2017), there is no need to "protect" the L2. Instead, mediation helps learners capitalize on the surrounding Chinese context to practice strategies.

Conclusion

Grounded in Vygotsky's sociocultural theory, this comparative analysis of two empirical studies, one on Arabic-Hebrew bilingual preschool in Israel (Schwartz & Gorbatt, 2017) and the other on Chinese L2 learning for international students in China (Chen, 2021), has distilled three highly viable mediation strategies for L2 learners. These strategies are in consonance with the theory's central tenet that L2 development is a product of socially mediated interactions.

The first strategy is engaging in multi-agent interactive mediation. Learners are advised to actively utilize "significant others". Teachers can offer targeted feedback on grammar, pronunciation, and vocabulary usage, while native speakers can offer authentic language input and cultural insights. By interacting with these "significant others", learners can transform external social support into internalized L2 competence. The second strategy is adopting ZPD-aligned context mediation. Learners should match mediation tools to their current proficiency levels. Beginners may rely on more basic and concrete tools such as picture flashcards, simple textbooks with large fonts and many illustrations, and language learning apps that focus on basic vocabulary and phrases. As learners progress, they can use more advanced tools in the target language, and language exchange platforms for in-depth discussions. Moreover, they should capitalize on contextual resources. The last strategy is practicing self-intermediation for regulation. Learners can use private speech to rehearse L2 sentences, which bridges the gap between external support and individual mastery.

This research has a few shortcomings. Its findings are limited in scope because they rely on particular contexts and tiny, unrepresentative samples. Furthermore, the studies did not delve into how mediation methods might affect L2 abilities in the long run. Moving forward, it's crucial for subsequent research to branch out to various L2 environments and adopt longitudinal approaches to monitor strategy efficacy over an extended period, thereby bolstering ecological validity. Incorporating mixed-methods analysis could also shed light on the underlying cognitive processes of mediation, fine-tuning how sociocultural theories are applied to L2 acquisition. Exploring digital mediators, particularly AI-powered language tools, would plug the holes in our understanding of how technology shapes L2 progress, ensuring that the theory keeps pace with current educational settings.

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Applying American Thanksgiving Culture in Senior Secondary English Reading-into-Writing Instruction

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Abstract: Anchored in the core competency orientation of the General Senior High School English Curriculum Standards (2017, revised 2020), this paper argues that cultural integration is central to effective reading-into-writing instruction at the senior secondary level. It first diagnoses persistent classroom challenges—disjunction between reading and writing, weak learner foundations coupled with single-track pedagogy, and insufficient cultural infusion—before proposing American Thanksgiving culture as a productive context because of its salient values of gratitude, reunion and service. Building on this premise, the study delineates a practical pathway comprising four mutually reinforcing components: embedding cultural background to create authentic reading contexts; mining the gratitude theme to guide continuation planning; enriching language input to ensure culturally appropriate and idiomatic expression; and emphasising process guidance with diversified assessment aligned to thematic conception, plot coherence, cultural integration, language control and stylistic effect. The approach aims to synchronise language ability and cultural awareness, enhance learners' engagement, and support coherent, audience-aware narrative continuations. A concise research agenda is outlined to strengthen causal inference, refine assessment instruments, test cultural scope and sequencing, and ensure equitable, scalable implementation. The paper contributes a culturally grounded instructional framework and concrete classroom procedures that can inform English writing pedagogy in senior secondary schools, while signposting future empirical work on durability, transfer and differential impact across learner groups.

Keywords: American Thanksgiving culture; reading-into-writing; senior secondary English writing instruction; cultural awareness; intercultural communicative competence

1. Introduction

The *General Senior High School English Curriculum Standards (2017 Edition, Revised in 2020)* emphasise that English courses should cultivate students' language ability, cultural awareness, thinking quality and learning ability. Cultural awareness includes "acquiring cultural knowledge, understanding cultural connotations, comparing cultural similarities and differences, drawing on cultural quintessence, forming correct values, strengthening cultural confidence, and possessing the ability to engage in intercultural communication and to disseminate Chinese culture". In English learning, understanding the culture embedded in language is indispensable; cultivating cultural awareness can effectively enhance students' interest in learning English(Li, 2024). Research shows that integrating intercultural content into English teaching not only helps learners understand and remember linguistic knowledge more intuitively and increases learning interest, but also optimises their language use ability (Chen & Pan, 2023). As a combined reading and writing task, reading-into-writing (continuation writing) requires learners to create a continuation on the basis of reading comprehension, which is conducive to developing

comprehensive language use and thinking quality. Yet the effectiveness of reading-into-writing instruction at senior secondary level remains sub-optimal, with multiple issues to be addressed. To this end, this paper proposes embedding American Thanksgiving culture into reading-into-writing instruction, with a view to offering new ideas and pathways for senior secondary English writing pedagogy.

2. The Cultural Connotations of American Thanksgiving

American Thanksgiving originated in harvest celebrations in the early 17th-century colonial period and is now a national holiday observed on the fourth Thursday of November each year. On Thanksgiving Day, Americans commonly reunite with family and friends, share a plentiful dinner and express gratitude (The White House, 2020). Thanksgiving reflects American society's emphasis on faith, family and friendship, embodying core values such as gratitude, freedom and democracy (National Archives, 2021) Traditional practices include prayers of thanks, family meals and charitable giving. For example, people often participate in charity activities and thank others for their help during the holiday, demonstrating the philanthropy and community spirit inherent in Thanksgiving. These cultural connotations provide rich resources for reading-into-writing instruction: by learning about the history and customs of Thanksgiving, students can deepen their understanding of values in English-speaking countries. Incorporating Thanksgiving elements into continuation writing not only brings the storyline closer to real life but also guides students to appreciate the importance of gratitude and sharing, thereby integrating language learning with affective education. The ideas of being grateful to others, cherishing reunion and mutual support inherent in Thanksgiving culture positively contribute to cultivating students' sound values and intercultural understanding. Therefore, fully tapping the educational value of Thanksgiving culture and integrating it as material into senior secondary English reading-into-writing can broaden students' cultural horizons and provide authentic, vivid situational support for continuation writing.

3. Practical Challenges in Current Senior Secondary Reading-into-Writing Instruction

A number of problems and difficulties persist in current practice and merit attention and improvement.

3.1 Disjunction between reading and writing, with no integration mechanism

Some teachers over-emphasise test routines, directly transplanting university entrance examination item types into teaching. Task design is homogeneous and lacks overall planning, so learners' writing after reading is poorly supported. Reading lessons and writing lessons operate in silos; bridges for subsequent writing are not laid during reading instruction. Writing practice becomes a formality, feedback is single and delayed, and issues such as vacuous content, missing key points, limited linguistic techniques and inappropriate pragmatics are salient. As a result, integrated reading-writing competence is hard to improve effectively (Luo & Huang, 2023).

3.2 Weak learner foundations and single-track teaching methods

Studies indicate that students' English writing often features Chinese-style thinking, grammatical errors and spelling mistakes (Xue, 2011). Many perceive writing tasks as dull and difficult, lacking interest and motivation. Manifestations include limited vocabulary, monotonous sentence patterns and "Chinglish" expressions. Meanwhile, teaching methods are constrained. Many teachers rely on traditional approaches, frequently providing model texts and asking students to imitate templates, while neglecting guidance on learners' own writing experiences and imagination. Continuation practice is often assigned as homework, with little in-class guidance and practice. This leads to perfunctory completion, inadequate pre-writing input and during-writing practice, and limited development of writing skills (Mo, 2019).

3.3 Insufficient cultural integration and weak intercultural awareness

Researchers point out that foreign language teaching often stresses linguistic knowledge at the expense of introducing Chinese and Western cultural backgrounds and values, with inadequate cultivation of students' cultural understanding (Wang & Jiang, 2020). Influenced by traditional views, many teachers consider intercultural education too complex for senior secondary contexts and thus focus on linguistic form training, investing insufficiently in nurturing intercultural communicative awareness and ability. Consequently, learners may master

grammar and lexis yet lack the capacity to use language effectively in authentic contexts (Xue, 2007). In reading-into-writing tasks, story settings are often grounded in Anglophone cultures; without requisite background knowledge and intercultural thinking, students struggle to produce coherent, context-appropriate continuations. These challenges suggest that both instructional philosophy and strategy need recalibration to better integrate reading and writing and to strengthen students' interest in writing and cultural awareness.

4. Practical Pathways for Integrating Thanksgiving Culture into Reading-into-Writing

To address the issues above, this paper proposes embedding American Thanksgiving culture into senior secondary reading-into-writing as a carrier within integrated reading–writing pedagogy, enriching continuation content and context and enhancing instructional effectiveness. On the basis of the curricular goals of language ability, cultural awareness, thinking quality and learning ability, practice can proceed as follows.

4.1 Embed cultural background to create authentic reading contexts

Teachers may select level-appropriate texts that directly reference Thanksgiving practices or values so that cultural knowledge is not treated as decorative but as meaning-bearing context for comprehension. Prior to reading, a concise cultural primer introduces the historical origins of the festival, its contemporary observance across diverse communities and its core values of gratitude, reunion and service. Multimodal prompts such as captioned images, short transcripts of table toasts and brief notices for community food drives can be used to prime genre expectations and situational frames. During reading, guided cultural noticing tasks draw attention to value statements, behavioural norms and symbolic objects that influence character motivation and plot development. Students annotate where gratitude is shown through action, where reconciliation is attempted and where communal belonging is affirmed, thereby linking cultural detail to narrative causality. After reading, the class consolidates new knowledge through short reflective summaries that restate the text's cultural cues in their own words and relate them to the prospective continuation task. The sequence ensures that cultural input activates prior knowledge, raises interest and furnishes an authentic situational scaffold for the writing that follows. In this way, Thanksgiving is not reduced to food or spectacle but functions as a coherent frame that shapes setting, character choices and the moral direction of the story.

4.2 Mine the theme of gratitude and guide continuation planning

Thanksgiving culture centres on gratitude, family bonds and mutual care and therefore provides a clear emotional thread for continuation writing. Following comprehension, teachers guide students to reconstruct the source text's chain of cause, feeling and action so that any new development arises naturally from established motives. Learners identify the moment at which the protagonist recognises a debt of kindness, articulate the emotion that follows and plan a culturally plausible response such as a public thanks at the table, an act of service for the community or a gesture of reconciliation with a family member. Planning is strengthened through a two-track outline in which one track records the concrete story beats of time, place and conflict resolution and the other records the realisation of values through choices and consequences. Perspective shifts are encouraged to widen the range of options while maintaining thematic coherence, for example by retelling a key scene from the viewpoint of a parent, neighbour or volunteer coordinator. Teachers model the opening of a continuation paragraph that links tightly to the last sentence of the source text, demonstrating controlled progression, clear causality and an avoidance of contrived turns. Students then draft brief scene sketches that test the feasibility of their plans, after which whole-class discussion examines whether the theme of gratitude is shown rather than merely asserted and whether the envisioned actions align with the cultural frame introduced earlier. Through this iterative planning, the continuation retains logical cohesion with the source while achieving affective uplift.

4.3 Enrich language input and foreground culturally appropriate expression

Targeted pre-writing input equips learners to depict Thanksgiving credibly and idiomatically and reduces lexical poverty during drafting. Teachers co-construct a bank of reusable expressions that cover gratitude formulae, ceremonial language for table toasts, precise lexis for family gatherings and community service, and cohesive

devices that support narrative flow. Short mentor passages such as a compact thanksgiving speech or a dialogue at a volunteer sign-up desk are examined for register, stance and softening strategies so that students internalise how appreciation is expressed with sincerity and tact. Contrastive noticing helps learners avoid literal translation from Chinese and replace vague verbs with concrete actions that show feeling through behaviour. Ten-minute micro-practice transforms a single sentence of thanks into a short scene with sensory detail and controlled pacing, reinforcing the link between lexical choice and emotional effect. Prior to full drafting, students highlight in their plans where specific expressions and cohesion markers will be deployed so that language input is visibly connected to rhetorical purpose. During drafting, teachers provide brief nudges that steer register and idiomaticity without overwhelming fluency. The result is a continuation that sounds natural in English, reflects the cultural expectations of the setting and advances the story through precise, culturally aware depiction.

4.4 Emphasise process guidance and strengthen diversified assessment

High-quality continuations emerge when process guidance and evaluation are aligned with cultural and narrative aims. Instruction proceeds through clear stages of planning, scene sketching, full drafting and revision so that feedback arrives while ideas are still malleable. Early checkpoints verify continuity with the source text and plausibility within a Thanksgiving setting, while mid-draft conferencing addresses the clarity of the gratitude theme, the accuracy and naturalness of cultural elements and the coherence of plot resolution. Peer review is organised with a concise checklist that focuses on theme visibility, cultural fit, narrative causality and appropriateness of register. After drafting, students submit a short revision note that explains one cultural adjustment and one narrative improvement, thereby making their decision-making explicit and reflective. Assessment is conducted with an analytic rubric that balances meaning and form through five dimensions, namely thematic conception, plot coherence, cultural integration, language control and stylistic effect, each described in concrete terms to guide self-assessment and teacher feedback. Exemplars are briefly discussed to illustrate effective integration of cultural detail without cliché and to demonstrate how modest linguistic choices can yield strong affective impact. Throughout, the principle remains that cultural material should be woven naturally from the theme and plot logic rather than inserted mechanically. When handled with this degree of care, cultural integration strengthens language output, deepens cognitive engagement and measurably improves the quality and authenticity of students' continuation writing.

5. Recommendations for Further Research

5.1 Research design and longitudinal impact

Future studies should employ designs capable of supporting stronger causal claims and tracing development over time. Beyond small-scale teaching demonstrations, quasi-experiments and, where feasible, randomised controlled trials comparing culturally integrated reading-into-writing with business-as-usual instruction would help estimate effects on writing quality, cultural awareness and intercultural communicative competence. Longitudinal tracking across a term or academic year is needed to examine durability of gains in language control, genre awareness and value internalisation, and to test transfer to tasks not explicitly tied to festive themes. Fidelity-of-implementation data should be collected alongside outcomes to document dosage, adherence and teacher adaptations in authentic classrooms, thereby clarifying which components are necessary and sufficient for impact.

5.2 Assessment and instrument refinement

Reliable evaluation requires tools with demonstrated validity in senior secondary EFL contexts. Future work should develop and validate analytic rubrics aligned with this study' s emphasis on thematic conception, plot coherence, cultural integration, language control and stylistic effect, ensuring acceptable inter-rater reliability across tasks and school settings. Parallel measures of cultural awareness and intercultural disposition should be adapted or constructed with clear construct validity and sensitivity to curricular aims. Mixed-methods designs that triangulate rubric scores with think-aloud protocols, learner journals and classroom observations can illuminate

how students mobilise cultural schemata during planning and how affective understandings of gratitude are converted into concrete narrative choices, strengthening explanatory power beyond surface scores.

5.3 Cultural scope, sequencing and transferability

While Thanksgiving provides clear values and rich narrative affordances, comparative research should test the generality of findings across cultural themes and sequencing choices. Cross-theme studies could contrast Thanksgiving with other Anglophone topics such as community volunteering traditions or historical biography, and with Chinese cultural narratives that foreground reciprocity and filial piety, to determine whether improvements stem from the specificity of the festival or from the broader mechanism of value-centred contextualisation. Sequencing effects merit attention: starting with culturally familiar Chinese narratives before moving to Thanksgiving may reduce cognitive load and scaffold comprehension, whereas immediate engagement with unfamiliar material may heighten curiosity and uptake. Transfer should be probed through delayed post-tests and by examining performance on independent writing genres, thereby assessing whether cultural integration supports broader gains in narrative thinking and audience-aware expression.

5.4 Implementation, equity and scalability

Impact depends on how pedagogy is enacted across diverse learners and settings. Research should analyse moderation by proficiency band, prior writing attainment, socio-economic background and urban–rural context, ensuring that culturally integrated instruction benefits lower-proficiency students as well as high-attaining peers. Teacher professional learning that integrates cultural literacies, genre pedagogy and process-oriented assessment deserves systematic trial to identify effective models and to track shifts in teacher beliefs and practices. The role of technology and multimodal input should be specified in terms of measurable contributions to vocabulary uptake, scene construction and register control, with careful attention to data privacy and ethical use. Finally, policy-relevant studies should estimate time and resource requirements for large-scale adoption, map alignment with curriculum standards on language ability, cultural awareness, thinking quality and learning ability, and provide open-access repositories of validated texts, prompts, rubrics and anonymised exemplars to support replication and adaptation. Such work will clarify for whom culturally integrated reading-into-writing is most effective, under what conditions, and with which core components essential for sustained improvement.

6. Conclusion

In sum, American Thanksgiving culture, as a distinctive Anglophone cultural resource with rich educational value, can be organically integrated into senior secondary reading-into-writing to improve writing outcomes and cultivate cultural awareness and intercultural communicative competence. By creating authentic Thanksgiving scenarios, guiding the mining of the gratitude theme, enriching linguistic and cultural input, and strengthening process guidance and assessment, students can both enhance reading-writing ability and deepen their understanding and identification with English-speaking cultures. Such integration accords with the core competency orientation of the English curriculum and contributes to developing learners' comprehensive English application and humanistic literacy. In practice, teachers should choose suitable cultural entry points and strategies according to different texts and learner profiles. Future work can extend integrated reading-writing practice to other cultural themes (e.g., traditional festivals, historical figures) and continue to explore effective pathways for embedding culture in language teaching. Through ongoing practice and reflection, we have reason to believe that integrating Thanksgiving culture into reading-into-writing can realise the dual goals of educating through culture and through texts, improving students' writing while cultivating intercultural awareness and laying a solid foundation for holistic development.

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A Cultural Cognitive Linguistic Study of Male Garment Description in The Scholars (Chapter1-30)

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Abstract: Since the mentioning of cultural cognitive linguistics, there is a shift of cognitive linguistics. However, previous studies have primarily focused on simple feature analysis of the Scholars, failing to either uncover the internal dynamic mechanism of how Wu trying to unveil satire topic through males' garment. To address this gap, this study adopts Wen Xu's partial concepts about cultural cognitive linguistics by establishing effective framework to find how Wu construct social identity, shape character's fate, and reflect the rigid Confucian social hierarchy of mid-18th century China. The study intends to address the following three questions: (1) What cultural metaphors, metonymies, framings are embedded in the male garment descriptions in the first thirty chapters of The Scholars, and how do they project the hidden social hierarchies and ideologies of the Ming and Qing dynasties? (2) How does the framework collectively and dynamically contribute to our understanding of the interplay between language, culture, and cognition? (3) What is the cognitive function of male garment descriptions in the first thirty chapters of The Scholars in terms of activating cultural frames and reflecting the socio-cultural context of Wu's time? Using AntConc for content collection and extraction, the study analyzes the first 30 chapters of this classic book. The findings reveal that cultural metaphorization, cultural metononymization, and cultural framing are effective in analyzing Chinese tradition classics. Interestingly, this paper also finds the internal operation logic among them. Cultural framing, no matter matched or mismatched one, can trigger or map the happenings of cultural metaphorization or cultural metononymization, or both, which is dependent on the specific context and garment descriptions. It also provides practical insights for future classic study.

Keywords: Cognitive Linguistics; Cultural Analysis; Cultural Metaphorization; Cultural Metononymization; Cultural Framing; Garment Description; *The Scholars*

Introduction

This opening chapter contextualizes the thesis from the following four aspects: research background, research purpose, and research significance.

1.1 Research Background

With the advancement of society, material civilization has made great progress in China. Spiritual civilization, particularly in its emphasis on cultural diversity, dimensionality, and revolution, has garnered attention from modern scholars. It is thus rational to conclude that culture is a continuously reconstructed, re-contextualized, renegotiated, and recreated soft power. Culture is not only the sum of knowledge and customs, but also a multifaceted embodiment in terms of systems of knowledge, symbols that empower the world with meaning, behavioral patterns, power structures, and social realities. What's more, it constitutes the shared models that shape human cognition and conduct (Wen Xu, 2025).

Classics are the microcosm of Chinese culture, among which can be found in the satirical literature of Wu Ching-tzu, the author of *The Scholars*. This book depicts the greed, hypocrisy, and ugliness of various types of scholars, exposes the decadence and darkness of feudal society, and criticizes and satirizes the imperial examination system and the feudal ethical code. It is most conspicuously characteristic of "being a lengthy novel but similar to short stories" in structure, "castigating the errors of the times out of unselfish motives, and "sorrow with harmony, elegance with much satire" (Lu Xun, 1930) in the art of irony. This masterpiece manifests various aspects of the Ming and Qing dynasties, such as rituals, beliefs, examinations, attire, etc.

This paper mainly investigates the male's garment description for clothing can be attributed as a cultural phenomenon, showing both the material production of its era and spiritual dimensions. Specifically, it serves as the practical purpose of physical protection and as an integral component of the collective outlook of a society in a particular history. Its dual nature is rooted in the feudal philosophy that establishing strict regulations could effectively safeguard a country's authority (Tang Zihui, 2017).

This paper focuses on first thirty chapters by adopting the Chinese version from People's Literature Publishing House and the English version by Yang Hsienyi and Gladys Yang, who have made great contributions to the spread of Chinese literature and culture. While existing studies have primarily focused on the historical value, social symbolic functions, and translatability of the garment descriptions in *The Scholars*, there remains a limited perception of how the garment, as a cultural symbol, showing the underlying cultural cognitive mechanisms, still warrants further in-depth exploration.

1.2 Target of Research

This study seeks to employ Wen Xu's (2025) concepts about cultural cognitive linguistics. However, the proposed framework is not borrowed plainly for my analysis; instead, I argue that the existing frameworks can be adapted and combined, forming a tripartite cultural cognitive framework, i.e., cultural metaphorization, cultural metonymization, and cultural framing, to analyze new discourse types and address new research problems in new contexts, i.e., in the male garment descriptions in *The Scholars*, thereby advancing a new paradigm for analyzing classical Chinese garment. Specifically, this study aims to 1) reveal cultural metaphors in garment descriptions, projecting the hidden social hierarchies and ideologies in the Ming and Qing dynasties. 2) decode cultural metonymy in specific garment delineations, triggering associations with feudal examination systems and ethical conduct. 3) activate cultural frames for literature interpretation, reflecting upon the socio-cultural context of Wu's time.

1.3 Significance of the Research

Theoretically, this study pioneers a tripartite analytical framework, thus bridging the gap between abstract cultural cognitive theories and concrete discourse analysis. By focusing on the cultural cognitive mechanism, this study has the potential to significantly deepen our understanding of how cultural symbols convey feudal social hierarchies, thus uncovering the complex but intimate interplay between language, culture, and cognition (Wen Xu, 2025) It also challenges traditional literary studies by extending its scope beyond the textual analysis, personage characteristics, plot development etc., thus offering a more holistic view of analysis of the classics. This approach breaks new ground by examining not only the linguistic components but also the cognitive elements such as cultural cognitive metaphor, metonymy, and frame, which have often been underexplored in previous studies.

Practically, this study presents a new orientation for interpreting classical Chinese literature with a focus on those rich but specific descriptions such as garments. It also has pedagogical implications for teachers to guide students how to better appreciate the cultural nuances, thereby enhancing their critical thinking about heritage preservation. Additionally, this study can facilitate cross-cultural communication especially for translators, which requires conveying not only literal meaning, but also metaphorical, metonymical features in other Chinese literature. Furthermore, the insights from this research could be used to study other satirical novels during the Ming and Qing dynasties by grasping this unique artistic technique and applying it to the creation of contemporary novels (Tang Zihui, 2017).

Literature Analysis

This chapter reviews the pertinent literature from two key fields that inform this study: the definition and classification of garments in the Ming-Qing Dynasties. With major findings of previous studies introduced and critically evaluated, the research scope for the current study will be established.

2.1 Studies on Garments in the Ming-Qing Dynasties

2.1.1 Definition of Garments

According to the *Han Yu Da Ci Dian* (*The Great Chinese Dictionary*), the term“服饰”(fúshì) has three definitions. Firstly, the ornaments for jade pendants, or decorative colors of jade artifacts. Secondly, garments and decorations. Thirdly, the practice of dressing and adorning (Cheng Jia, 2008).

Specifically, garments are referred to as “服饰” in Chinese, which can be analyzed from the perspectives of “服” and “饰”. Here is the working definition in this thesis to better meet the needs of further exploration of male garments in this field: Garments or “服饰”(fúshì) consist of wearings, including headwear, bodywear, and footwear in this study, and accessories accompanying the male clothing. Despite the inclusion of female descriptions of wearings and accessories, they occupy a very limited space for discussion, which is also the reason for not covering female suits.

2.1.2 Classification of Garments

Here is the brief form of different body parts of wearings and accessories in *the Scholars*, which summarize the previous literature including Yin Zhihong (2009), Ning Feng and Wang Yangyang (2015), Chen Qun (2016), Liu Ziyun (2016) Tang Zihui (2017).

Table 2-1 Classification of Garments (combined from previous literature)

首服	方巾	纱帽	黑帽	瓦楞帽	毡帽	高帽	小帽	青衣小帽	孝帽	网巾	浩然巾	乌纱帽	草帽	僧帽	和尚帽子
主服	直裰	蟒袍(蟒衣)	补服	青衣(青布衣服)	孝服									
足服	皂靴	履(朱履、丝履)	草鞋(麻鞋、蒲鞋、芒鞋)											
配饰	金带、丝绦	扇子(诗扇、金扇)												

2.2 Status quo of Descriptions of Garments in the Ming-Qing Dynasties

In retrospect, existing scholarship on garments in the Ming and Qing Dynasties has primarily focused on such aspects as social and ritual symbolism of hearwear from Yin Zhihong (2009), with an aim to unravel the political symbolism, ethics, and symbolic system of Chinese apparel development; general textual analysis of the garments description from Yan Xiang jun (2002, 2006), and Ning Feng, Wang Yangyang (2015) with a dedication to emphasize their value or function in character portrayal, topic accentuation and realistic reflection. However, theoretical

analysis especially the cognitive exploration in explaining the male garments presentation in *the Scholars* has been marginalized in current literature. In light of this, we explore how a tripartite cultural cognitive framework established in this study will contribute to the specific analysis, which is intend to break the single-disciplinary perspectives in the previous investigation. The findings will provide valuable insights into the cognitive drivers behind male garments description, striving for elucidation the interplay between cognition, culture, and text.

Theoretical Framework

This chapter focuses on the theoretical basis of this study, which includes cultural metaphorization, cultural metonymization, and cultural framing.

3.1 Cultural Metaphorization

3.1.1 Definition of Cultural Metaphorization

Metaphor, not only seen as a mere linguistic device, but rather, the cognitive and cultural structures. It is based on both embodied and cultural experiences. Different cultures, rooted in their specific historical backgrounds, philosophical systems, and social practices, form unique metaphorical systems that shape our ways of cognition and expression towards core concepts such as life, time, feeling, and social orders (Wen Xu, 2025).

Cultural metaphorization is a cross-domain mapping process whereby abstract concepts, ethical values, and social phenomena can be made concrete and vivid through the metaphorical mechanism. For example, as for the idea "LIFE IS X", different words can be filled in this slot: JOURNEY, DRAMA, GAME, STORY, BATTLE, etc. In Chinese culture, we tend to use the image of water. We have sayings in *the Laws Divine And Human* (also known as *Tao Te Ching*): "The highest good (virtue) is like water. Water benefits everything by giving without taking or contending. It likes the low place others dislike, so it follows closely the divine law.", "Nothing in the world is softer and weaker than water, but nothing is better to win over the hard and the strong, for it cannot be replaced." etc. (Xu Yuanchong, 2012). The virtue of water aligns with the virtue of non-contention, which conforms to the divine law. In a brief conclusion, LIFE IS WATER, under the Chinese context, reflects culture-specific thought patterns and worldviews.

In this research, we'd like to offer a working definition to have further exploration in *the Scholars*. Cultural metaphorization refers to the cognitive mechanism through which sociocultural values can be projected through males' garments.

3.1.2 Garments Classification of Cultural Metaphorization

Previous literature does not equip us with operational cultural metaphorization, metonymization, and framing classification; it is thus necessary to put forward the targeted cultural metaphor, metonymy, and framing naming(s) based on the concrete texts. Through meticulous analysis, we assume that there exist three sub-categories of cultural metaphorization in the male garments descriptions: HIERARCHICAL DEMARCATION ARE GARMENT EMBLEMS, SCALE DESCENDING IS GARMENT DAMAGE, and SCALE AESCENDING IS GARMENT OPULENCE. To better explore the features of the text, the author would like to give the operational definitions initially.

Firstly, HIERARCHICAL DEMARCATION ARE GARMENT EMBLEMS means Chinese ancient officials' rank can be understood by their garment declarations. In another words, it is a cognitive mechanism by which material properties, patterns, and colors of garments are visual embodiment of officials' social hierarchies. It transforms abstract stratification into concrete/physical traits. Secondly, SCALE DESCENDING IS GARMENT DAMAGE means the disposed scale can be judged upon their garment damage situation. Its opposite situation SCALE AESCENDING IS GARMENT OPULENCE means the reversed connotation. Specifically, the two refers to a metaphorical mechanism that qualifies identity ups or downs through garment ascending or descending.

Table 3-1-2 Two Categories of Garments Classification of Cultural Metaphorization

Structure			Cognitive Principles
HIERARCHICAL DEMARCATION	ARE	GARMENT EMBLEMS	Material/pattern/color symbolizing social stratification boundaries

SCALE DESCENDING	IS	GARMENT DAMAGE	Garments deterioration symbolizing identity devaluation
SCALE AESCENDING	IS	GARMENT OPULENCE	Garments enhancement symbolizing identity elevation

(The structure “A” is “B” means “A maps B”)

3.2 Cultural Metonymization

3.2.1 Definition of Cultural Metonymization

Metonomy can be defined as a cognitive process in which one cognitive category, the source, provides mental access to another cognitive category, the target, within the same domain. It is molded as the Idealized Cognitive Model (ICM) by Lakoff in 1987. Different from metaphor, which relies on the structural mappings from two domains, metonymy is dependent on the actual associations between concepts, such as part-whole, container-content, and location-institution (Wen Xu 2014).

Cultural metonymization is the conceptual process through which cultural concepts can be transferred within a single cognitive domain or ICM via contiguity relations. This enriches linguistic expressions on the one hand and embodies the reshaping functions of culture on the other. Regarding the part-whole relation, dragon bone, or “龙骨” (lóng gǔ), stands for traditional Chinese medicine. Black silk, or “青丝”(Qīng sī), stands for hair metonymically. The most famous line is from Li Bai’s poem: “Do you not see the mirrors bright in chambers high, grieve over your snow-white hair though once it was silk-black?” Concerning the container-content, the inkstone, or “砚”(yàn), stands for calligraphy, which is an essential writing tool for grinding ink. Similarly, the jug or “壶”(hú) frequently serves as a metonym for wine in Chinese cultural contexts. In terms of location-institution, “梨园”(líyuán) can be literally translated as Pear Garden, metonymically denotes the operatic world, tracing back to the training community for musicians and actors established by Emperor Xuanzong of the Tang Dynasty in the imperial pear orchard. These examples demonstrate the rich phenomenon of metonymy within Chinese culture, exemplifying the profound interconnection between the language and its cultural heritage. In this study, the working definition of cultural metonymization means the cognitive mechanism where garment components can activate their corresponding social order symbols or holistic image representation.

3.2.2 Garments Classification of Cultural Metonymization

As the previous section 3.1.2 has mentioned, schematizing the effective operation of garments classification of cultural metaphorization is also of great importance. Through meticulous investigation, we have found the following cultural metonymization: Garment state→Identity label, garment signs→Authoritative symbol, Garment compliance →Ethic carrier, and Accessory marks→Cultural capital.

Garment state→Identity label means an official’s makeup state can activate readers’ association to his identity in the ancient Ming-Qing Dynasties. Specifically, it refers to how the garment (the property) reflect his social classification (category). Garment signs→Authoritative symbols signifies the costume of an official can spark readers’ cognitive connection to his authority. It is the representation of “PART FOR WHOLE” just as the saying “peering at a leopard through a bamboo tube”, which means to infer the whole from a partial glimpse. Garment compliance→ Ethic carrier means some headwear like “孝帽” (a hat used to wear to honor the dead in the mourning) act as a reminder to the hold ethic rituals. Through the state of wearing the specific headwear, it can be associated the reason why the character wears such a hat in that situation. Lastly, accessory marks→cultural capital means some affiliated decoration with scholars like silk fan can be served as a particular cultural capital for some community.

Table 3-2-2 Four Categories of Garments Classification of Cultural Metonymization

Structure			Cognitive Principles
Source Domain	→	Target Domain	
Garment State	→	Identity Label	PROPERTY FOR CATEGORY
Garment Signs	→	Authoritative Symbol	PART FOR WHOLE
Garment Compliance	→	Ethic Carrier	EFFECT FOR CAUSE
Accessory Marks	→	Cultural Capital	SIGN FOR POSSESSOR

(The sign "→" represents "stand(s) for" or "activate(s)")

3.3 Cultural Framing

3.3.1 Definition of Cultural Framing

Different scholars have given their definitions of frame, to name just a few:

A frame is a data structure for representing a stereotyped situation, like being in a certain kind of living room, or going to a child's birthday party (Minsky 1974:1-2). When the individual in our Western society recognizes a particular event, he tends, whatever else he does, to imply in this response (and in effect employ) one or more frameworks or schemata of interpretation of a kind that can be called primary (Goffman 1974). A frame is a mental structure that people use to understand reality and construct what we think is real; it influences our perception and behavior (Fillmore 1985). "Framing" is not primarily about politics or political messaging or communication. It is far more fundamental than that: Frames are the mental structures that allow human beings to understand reality—and sometimes to create what we take to be reality (Lakoff 2006).

We can make an observation that the concept of frame has evolved into a cognitive notion based on its timeline, which can be summarized as the following table.

Table 3-3-1 Timeline of Frame (adapted from Charles, J. Fillmore's explanations to frames)

Timeline	Content	Nature
1982:112	"Frame" is characterizing a small abstract 'scene' or 'situation', so that to understand the semantic structure of the verb it was necessary to understand the properties of such schematized scenes.	case frame
1985:86	"Frame" is any system of language choice which includes the combination of words, the grammar rules and the choice of language category.	linguistic frame
1985:223	Frames are specific unified frameworks of knowledge or coherent schematizations of experience.	cognitive frame

Based on this, it can be concluded that frame is a cognitive system or model with many elements such as related roles, attributes, relations or typical cases which are tightly associated with each other. They are an entity which means the interpretation of any of them will activate the other elements, which are easily found as they are preinstalled in humans' minds in the form of experience and beliefs.

Cultural framing refers to the frame that shapes the cognition of individuals or communities to social events, concepts, or phenomena, the way we selectively emphasize and organize information, and the process by which we choose to judge the world we are in. It plays the role of a "cultural operating system", influencing information understanding, determining the formation of cognition, attitudes, and behavior, and constituting personal and social identities to some extent. For this study, cultural framing signifies the cognitive mechanism by which garments activate socially scripted identity performances in the imperial examination context.

3.3.2 Garments Classification of Cultural Framing

While cultural metaphorization and metonymization decode how individual garments project abstract values or

underlying social orders, cultural framing operates at a systemic level by illuminating how garments trigger preexisted, tacit, or prepackaged social scripts that govern the scholars' performances. The author contends that Wu Ching-tzu masterfully deploys garments not merely as decorative elements but as cultural switches that instantaneously call forth three distinct culture-specific frames: matched frame, mismatched frame, and collapsed frame.

The author would like to give an analogy by referring to the Field Theory from Systemic Functional Linguistics in order to explain matched frame, containing three variations: field, mode, and tenor. Matched frame can be regarded as the right "Field Theory": the character does the right thing in the right situation using the right way. Specifically, the scholars wear right garments in the situation that that social environment requires with no more or less degree. The mismatched frame goes against with matched frame, which represents the disintegrated signifier-signified garment codes, where the disconnect between the clothing symbols and the wearer's identity

Table 3-3-2 Two Categories of Garments Classification of Cultural Framing

Categories	Core Logic
Matched Frame	Seamless signifier-signified garment codes aligning with social requirements or expectation
Mismatched Frame	Corrosive signifier-signified garment codes against with social requirements or expectation

3.4 Summary

In summary, this chapter introduces the definition of cultural metaphorization, cultural metonymization, and cultural framing. Table 3-1-2, 3-2-2, and 3-3-2 provide the classification of the three concepts respectively, which outlines the framework of this study.

Research Design

Based on the analysis from the literature review in Chapter Two and the theoretical framework presented in Chapter Three, this chapter will introduce three research questions and delineate the methodology for constructing the required corpus.

4.1 Research Questions

The existing scholarship on the analysis of garments descriptions of *the Scholars* has primarily focused on characteristic and social-political aspects. However, hidden mechanism through which garments are cognitively represented from the males' dressings has been marginalized in current literature. In light of this, this thesis intends to explore how cognitive perspective will contribute to the understanding of male garments beyond code symbol level and puts forward the following three research questions:

(1) What cultural metaphors, metonymies, framings are embedded in the male garment descriptions in the first thirty chapters of *The Scholars*, and how do they project the hidden social hierarchies and ideologies of the Ming and Qing dynasties?

(2) How does the framework collectively and dynamically contribute to our understanding of the interplay between language, culture, and cognition?

(3) What is the cognitive function of male garment descriptions in the first thirty chapters of *The Scholars* in terms of activating cultural frames and reflecting the socio-cultural context of Wu's time?

4.2 Research Methods

This paper uses AntConc software to cover all garments description including verbs or verbal phrases like "wear", "change", "drape", "pick", "pluck", "snatch", "seize", "wrap", "bind", "remove", "dress up", "put on", "take off" etc. to cover all situations based on KWIC. Figure 4-2 presents the number of the English text tokens collected in this thesis.

Left Context	Hit	Right Context
don't live on their inheritance; good daughters don't	wear	clothes from their own homes after they marry. I
right in our profession to wear those clothes. If you	wear	clothes like that, what can the scholars wear?" "That
of my beast of a son that I can't	wear	a real official cap.' Judging by this, a son'
about in straw sandals all summer. Yet now she will	wear	furs and be a fine lady. Fancy that!" They
But when Lou Feng saw that Chuan had nothing to	wear,	he made him a present of a light blue
for each house. The new wife insisted that she should	wear	heavy mourning, but on this point the Wang brothers
trip, and the shoes and jacket are for you to	wear	in the early morning and evening." Kuang shed tears
a scholar's* cap," he said, "but you had better	wear	it until we come to a town where you
a younger sister mourning for her elder sister should only	wear	mourning for one year — fine linen and a white
chaplet and fine scarlet costume an official's wife should	wear,	so I've made £ paper chaplet (or myself. Let
salt merchants in our yamen!" he declared. "How dare you	wear	such a cap? Take it off, officers! Tie him
If you wear clothes like that, what can the scholars	wear?" "	That was true twenty years ago," retorted Chien. "But
our host. Wan Hsueh-chai," he said. "You had better	wear	this cap and gown." They hired two sedan-chairs
Pao. "But it's not right in our profession to	wear	those clothes. If you wear clothes like that, what

Figure 4-2 The Situation of the Partial Verb "Wear" Based on KWIC

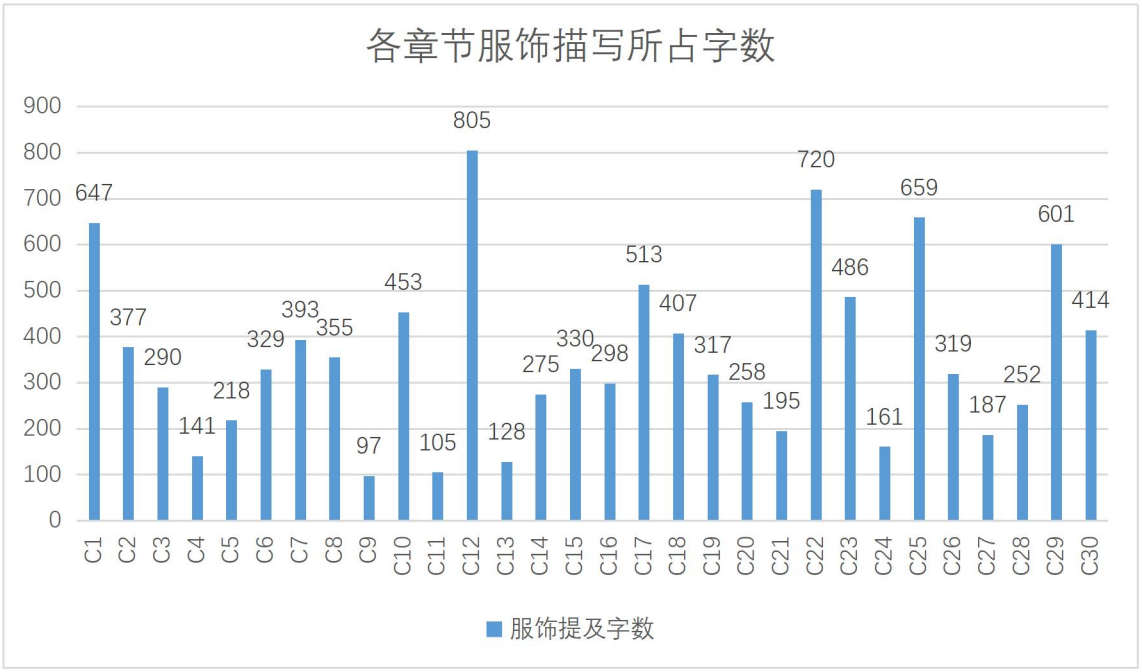

Figure 4-2 The Results of Garments Description in Each Chapter (1-30)

Research Results

This chapter is trying to use specific examples to explain how the internal relationship among cultural metaphorization, cultural Metonymization, and cultural framing dynamically works. Since headwear, bodywear, footwear and accessories won't mention separately in the original text, this paper thus chooses to analyze four elements of males' garments collectively.

5.1 Cultural Metaphorization

5.1.1 HIERARCHICAL DEMARCATION ARE GARMENT EMBLEMS

On the sixteenth the villagers sent in contributions to Shen Hsiang-fu, who prepared a feast for the new teacher to which he also invited Mei Chiu, the new scholar of the village. Mei Chiu arrived early, wearing his new square cap, but Chou Chin did not turn up till nearly noon. When dogs started barking outside, Shen Hsiang-fu went out to welcome the guest; and the villagers stared as Chou Chin came in. He was wearing an old felt cap, a tattered grey silk gown, the right sleeve and seat of which were in shreds, and a pair of shabby red silk slippers. He had a thin, dark face, and a white beard.

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The imperial examination system in ancient China and the modern college entrance examination are two crucial educational and talent selection systems in Chinese history and contemporary society. There are different levels of examination ranging from Tongshi, to Xiangshi, Huishi, and finally to Dianshi. Tongshi is also known as the county examination, it was the preliminary level. Successful candidates were called "shengyuan" or "xiucai" (licentiate). Xiangshi is held at the provincial level, successful candidates were known as "juren" (recommended man) Huishi is conducted in the capital, successful candidates were referred to as "gongshi" (tribute scholars). Dianshi is the highest level of examination, conducted by the emperor himself, and successful candidates were titled "jinshi" (presented scholar). Here, Chou Chi is at the lower level than Mei Chiu even Chou is much older than Mei. Those who have passed the prefectural examination are considered senior to those who have not, regardless of age. Ming Dynasty scholars called all those who passed the prefectural examination "classmates," and those who only qualified for this examination "juniors." A young man in his teens who passed was considered senior to an unsuccessful candidate, even if the latter were eighty years old.

It is no surprising that Mei wears "a new square cap" while Chou wear an "old felt cap". This is the external representation of their hidden social ladder. The square hat can also be called the Confucian hat, which can only be worn by scholars in the Ming Dynasty, serving as a visual symbol of social ritual norms. This is conducive to representing identity and morality. Moreover, differences in material (plain black silk for scholars, gold trim for provincial graduates, and black gauze hats for imperial graduates) act as markers of social mobility, illustrating the hierarchical sequence of examination success.

5.1.2 SCALE DESCENDING IS GARMENT DAMAGE

It was a rat which had slipped from the rafters! The hot soup gave it such a fright that it knocked over the bowl as it scuttled for safety, jumping on the bridegroom's knee and smearing his red silk official gown with grease. All present were aghast. They hastily removed the dish, wiped the table clean and brought the bridegroom another gown into which to change.

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In this example, Chu Hsien-fu is the bridegroom who marries Mr. Lu's daughter. In the previous description, Mr. Lu's family is rich with an old hall of an ancient mansion. However, Chu is not a real talented scholar. Here, the details in destroying the bridegroom's garment and changing of his gown act as the hidden meaning to infer that he cannot compete with and is not as good as Mr. Lu's daughter who is an intelligent girl with a good memory. Such move is an indication of his identity devalue.

5.1.3 SCALE AESCENDING IS GARMENT OPULENCE

Yang was shocked to see the state Chuan was in.

"Haven't you even got a hat?" he asked with a frown.

He made them sit down on a bench in the gate-house while he hurried in to fetch an old scholar's cap for Chuan.

"Who is this stalwart?" he inquired next.

"This is the famous Iron-armed Chang of whom I was always telling you."

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In the Ming Dynasty, the society attaches great importance to wearing makeup, especially the cap as an identity identification. Chuan loses his cap, meaning he cannot give a visual code to others about the information who he is, which is the reason why Yang was shocked. Yang hastily takes the old scholar's cap for him. Chuan does not have such honor and qualification to wear this cap despite being old for he is not a scholar. He naturally wears this cap, giving tacit consent to such move to deceive the master. Such ascending can be elevated to another social ladder with voice power to some extent.

5.2 Cultural Metonymization

5.2.1 Garment state→Identity label

Mei Chiu and Hsun Mei arrived first at the temple on the morning of the feast, and were greeted by the monk. They bowed before Buddha and nodded to the monk, who said, “Congratulations, Mr. Hsun, on becoming a scholar! This is a reward for all the good deeds your worthy father did to the glory of Buddha. You were just a child, with your hair in tufts, when you studied here.”

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The Chinese translation version of “Congratulations, Mr. Hsun, on becoming a scholar!” is “恭喜荀小相公，而今挣了这一顶头巾”, which is not literally translated as things like “...earn this square cap”. This is for the fact that square is an entry ticket for a normal person to become a scholar. This approach in translating such cultural metonymization (Garment state→Identity label) is based on the rules operating in the Ming Dynasty. Here, the square cap is not merely a normal garment, but the consensus regulated by the strict rituals. The monk’s words can be interpreted as such cognitive mechanism: the attire codes directly map the abstract social identity. This cultural metonymization is deeply rooted at the mandatory of Ming Dynasty’s garment system.

5.2.2 Garment signs→Authoritative symbol

On the third day the Lou family sent scores of bearers with gold, silver, pearls. emeralds, jewelry, silk, embroidery, sheep, wine and fruit as gifts for the bride’s family. And after these presents had been dispatched they gave each go-between twelve taels of silver for new clothes and four taels of silver for wine and fruit.

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This example describes the situation that Lou family presents gifts to the Lu’s family. The details like “scores of bearers with gold, silver, pearls. emeralds, jewelry, silk, embroidery” exemplifies the cultural cognitive metonymy mechanism. “蟒纹” or bearers with gold, silver are by no means ordinary finery. Through the Ming Dynasty’s strict costume regulations, they are metonymized as markers of specific political status and bureaucratic rank. We can interpret such move as the following messages: The Lou families were not merely giving luxurious textiles but using the specific political symbols borne by the garments as a part to represent and convey the entirety of the Lu family’s bureaucratic status, privileges, and social prestige. The garment here transcends mere ornamentation; it becomes a condensed, visual code of power, its value far exceeding the material realm and transforming into a concrete symbol of the Lu family’s superior authority. In summary, these presents, especially the garments, are both a precise recognition and deliberate accommodation of the Lu family’s exalted status and a public declaration of the impending political alliance through the sartorial codes within the betrothal gifts.

5.2.3 Garment compliance→Ethic carrier

Reading the summons from the nether world as he lay in bed, Old Pu knew that his time had come. He immediately called his two sons and their wives to his side to say a few last words to them and describe what he had just seen.

“Dress me quickly in my funeral clothes 1” he said. “I am going to my last rest.” Pu Cheng and Pu Hsin wept as they hastily brought the burial clothes and put them on him.

“I’m glad my old friend and I are on the same list,” he muttered. “He is the first and I am the last. He has stolen a march on me, but I shall overtake him!”

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This example shows that burial or the mourning garments are not simply the shrouds. In Chinese history, we have the sacredness of traditional funeral rites, which are metonymized as a concrete representation of Confucian ethical principles and the ultimate order of life. We have such saying “Crowns rectify life; garments rectify death” to describe the meaning of the garment when a person at the dying time. When Old Pu, upon receiving the summons from the underworld, immediately instructs his son to “dress him quickly in his funeral clothes”, representing his

complete observance of life’s ethical order to achieve a “dignified death”.

5.2.4 Accessory marks→Cultural capital

From the chair alighted a man in a scholar’s cap and sapphire-blue gown, who was holding a white paper fan, with a poem on it, from which hung a square ivory seal. Followed by a servant carrying a medicine chest, this man was about to enter a house, when Ching called to him: “Dr. Chao! I haven’t seen you for a long time! Where are you going?”

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This example is to describe the scholarly accessories accompanying Doctor Zhao’s image. The details of the “a white paper poetry fan” and the “square ivory seal” show the cultural cognitive metonymy mechanism. Theses accessories are far from ordinary personal items; but tangible carriers of scholarly cultivation, artistic taste, and social prestige, collectively representing his complete cultural capital as a renowned physician and distinguished scholar.

5.3 Cultural Framing

5.3.1 Matched Frame

(When Magistrate Hsiang opened the commissioner’s letter he was amazed and hastily ordered his men to open the gate of his house and invite Mr. Pao in, going out himself to welcome him.) Pao Wen-ching came in, in a black gown and small cap, and knelt to pay his respects.

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This example is from the 24th chapter of *the scholar*, depicting Pao Wen-ching meets the Magistrate Hsiang. “青衣小帽” is translated as “a black gown” and “小帽” is “small cap”. They are the normal person’s garments with nothing special. However, Mr. Pao is praised by the Magistrate Hsiang, which means Mr. Pao should wear something honorable or glorious to show their intimacy. Mr. Pao still chooses his original attire for the fact that he knows the whole social frame with no permission to transcend the boundary, depicting a humble image. He sticks his moral standards.

5.3.2 Mismatched Frame

Hsun Mei was about to send in a petition asking to go home (or the period of mourning, when Wang said: “Think it over. It will soon be time for the appointment of officers, and we both stand a good chance; but if you announce your mourning you will have to go home and wait for another three years. Wouldn’t that be a pity? Better hush this up until after the appointment.” “You are a real friend,” said Hsun. “But I don’t see how this can be hidden.” “Quickly order the man from your home to take off his mourning, and forbid him to let outsiders know of this. Tomorrow morning I will see what I can do.”

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This is the contrary example compared with the matched frame example. As we mentioned in the 5.2.3, if one of the elder family members passed away, son or daughter must go home to serve the mourning rituals and wear funeral clothes to show observance of life’s ethical order. However, Wang tempted Mei to conceal the mourning fact because he wants to take advantage of Mei’s fame, talent, resource, and relationship to go a higher social ladder. He shouldn’t forbid outsiders to take off the mourning garments not to let others know such case, which violates the moral code in the Ming Dynasty. Mei should have not accepted such advice, but according to the following plot “That evening Hsun Mei changed into a blue gown and a small cap, and went secretly to beg his two teachers, Vice-President Chou and Examiner Fan, to recommend him; and they both thought this might be arranged.”, he changes his makeup into a gown and a small cap, which is the normal person’s suite. His action is trying not to call other’s attention, which is not suitable to his identity. We can see that in these two situation, the characters break the social frame by saying or doing corresponding words or deeds.

Discussion

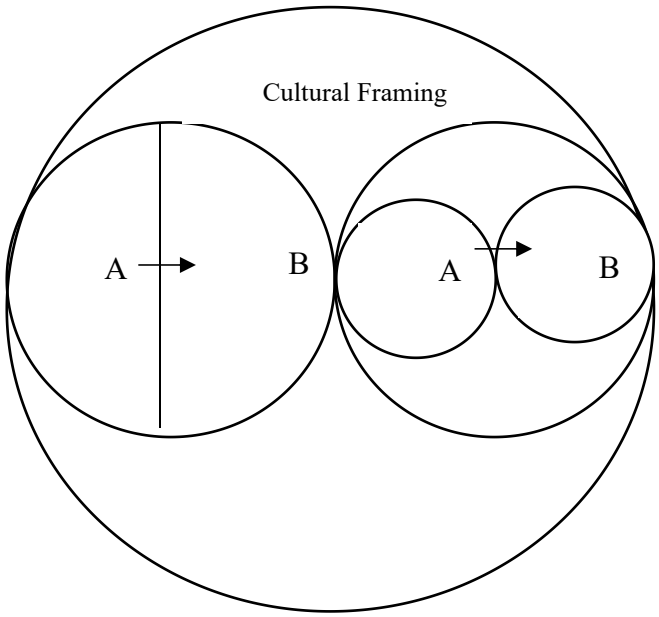
This chapter is trying to schematize a modal to analyze the dynamic relationship among cultural

metaphorization, cultural metonymization, and cultural framing. Since headwear, bodywear, footwear and accessories won't mention separately in the original text, this paper thus chooses to analyze four elements of males' garments collectively. Additionally, we have analyzed functions of males' garments in the following aspects: depicting characters' profile, pushing plot development, accentuating satire topic.

6.1 Dynamic Working Mechanism of the Three Frameworks

Through meticulous investigation using specific examples, this study is intended to build such a modal in figure 3-4 to unravel the underlying operational mechanism about the relationship among cultural metaphorization, cultural metonymization, and cultural framing. We have found that cultural framing is at the external place, which can map the next level of analysis either cultural metaphorization (the right side) or cultural metonymization (the left side) or both in some specific exmaples. Since the above modal is an initial and tentative symbol, we will use specific examples to verify.

Figure 3-4 A modal of Internal Relationship among Cultural Metaphorization, Cultural Metonymization, and Cultural Framing



Example One:

Wang Mien had genius. While still in his teens, he mastered the whole field of astronomy, geography, the classics and history. He was, however, eccentric. He did not look for an official post, and did not even have any friends. All day he studied behind closed doors; and when he saw in an edition of the poems of Chu Yuan a picture of the poet's costume, he made himself a very high hat and a loose flowing gown. In the fresh and flowering spring he would take his mother out in a buffalo cart, and, dressed in his high hat and loose gown, flourishing the whip and singing songs, would drive all over the countryside and around the lake. Small groups of village children would tag after him, laughing; but he did not mind them.

Chapter 1, Page 5

Wang Mien is the first character in this book. In this case, Wang Mien's garments are not restricted by the social norms, thus constituting the mismatched frame. He refused to follow the currents that most scholars pursue. His act of wearing a tall hat and loose robes completely deviated from the norms of Ming Dynasty clothing as hierarchical symbols—he rejected the imperial examination, breaking the metonymic chain of "square scarf" mapping "official rank" but imitated Qu Yuan's clothing from the previous Chu Dynasty. This conflict between individual symbolic

practice and the social framework creates an ironic tension.

6.2 Cognitive Functions in the Male Description Garments the Scholars

6.2.1 Depicting Characters' Profile

Now it had been raining heavily for two days and, although the rain had stopped, the ground was still wet; so the players in their new boots had to make a detour as they entered from the courtyard.

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This detail indirectly depicts that the master is meticulous person. Even if the rain just stopped and the ground was still wet, the players employed by the master still were in their new boots when entering from the courtyard. This is the embodiment of character's profile. To make the wedding ceremony graceful and refined, the maser does not spend less money to stay within budget, showing the master is the rich man at the same time.

6.2.2 Pushing Plot Development

The two brothers were wearing official robes and the go-betweens auspicious dress. Mr. Lu, in gauze cap and embroidered gown, satin shoes and gold belt, came out to welcome them, bowing as he invited them to ascend the steps. Then the musicians and sixteen lantern-bearers ushered in Chu Hsien-fu. In gauze cap and official gown, he was wearing flowers and had red silk over his shoulders.

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The elaboration of garments of different characters in this paragraph employs a masterful narrative technique, functioning on multiple levels to propel the plot.

To begin with, it establishes a dissonant or inharmonious tone or melody through official robes "gauze cap and embroidered gown". Such auspicious dresses, and lavish lanterns and candles, which elevates readers' original expectations. This artfully crafted but superficial perfection will starkly contrast with the subsequent chain of slapstick misfires (the rat plunging into the soup because of the servant's disastrous blunder), creating an unexpected effect that renders these accidents absurdly conspicuous and directly fuels Mr. Lu's foreboding sense of inauspiciousness, casting an immediate shadow over the marriage. Moreover, the garments reveal character and foreshadow tragedy. Mr. Lu's insistence on wearing his full official attire even for his daughter's wedding at home, visually embodies his core identity as a bureaucrat obsessed with official rank and prestige, not a father. This sartorial choice directly indicates his future demand that his son-in-law should pursue the hierarchical examinations, laying the groundwork for the couple's ideological conflict. Meanwhile, Chu Hsien-fu's passive role as a well-dressed "puppet groom" in his red silk official gown hints at his powerlessness within arranged familial and social structures.

6.2.3 Accentuating Satire Topic

In the tea-shop he saw a man in a tall hat, sapphire-blue gown and black shoes with white soles, drinking tea alone. Going closer, Pao saw that it was Pock-marked Chien, who played old men's parts in his company.

…

"That's not what I meant," countered Pao. "But it's not right in our profession to wear those clothes. If *you* wear clothes like that, what can the scholars wear?"

…

As Pock-marked Chien dealt him a blow, laughing, the waiter brought them cakes. While they were eating, an old man walked in leaning upon a dragon-head stick. He was wearing a hood, a dark purple silk gown and black shoes with white soles.

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From the previous chapter, we have known that during the Ming and Qing dynasties, regulated garment laws were one of important means in maintaining the feudal hierarchical order. A person's attire, including color, material, style, pattern, strictly reflects their social status. Items like The outfit like "black shoes with white soles", "sapphire-blue gown" were reserved for those who had earned scholarly honors or held official positions.

Qian is an opera performer, ranking at the lower position and enjoy very low social status. His wearing does not conform to his level, which is against the garment regulation, thus transgressing orthodox status. Qian just imitates the "form" rather than the "substance", exposing a widespread societal value dislocation that people worshipped the external symbols of power and status rather than their inherent knowledge and virtue.

On the other side, Pao doesn't see anything wrong with the system at all; instead, he consciously and sincerely defends it, believing that he and his peers are unworthy. This is more tragic and satirical than having a scholar-official deliver the criticism—it reveals the horror of ideological imprisonment, how people can be tamed by the system into self-enslavement.

Conclusions

This paper has explored the how cultural metaphorization, cultural metononymization, and cultural framing be analyzed through specific examples in *the scholars* with a particular focus on how the internal dynamic mechanism is contributed to the overall operation. This study has provided a fine-grained examination of the functions of garment in three aspects. This chapter summarizes the major findings, implications, and limitations of the study.

6.1 Major Findings

One key finding is that cultural metaphorization, cultural metononymization, and cultural framing are effective in analyzing Chinese tradition classics. This paper adopts new perspective lens in examining garments. Specifically speaking, we extract three cultural metaphorization: HIERARCHICAL DEMARCATION ARE GARMENT EMBLEMS, SCALE DESCENDING IS GARMENT DAMAGE, and SCALE AESCENDING IS GARMENT OPULENCE. As for cultural metononymization, this paper concludes four mapping processes: Garment state→Identity label, Garment signs→ Authoritative symbol, Garment compliance→Ethic carrier, and Accessory marks→Cultural capital. Additionally, cultural framing includes matched and mismatched ones.

Through separate analysis, this paper finds the internal operation logic among cultural metaphorization, cultural metononymization, and cultural framing. Cultural framing, no matter matched or mismatched one, can trigger or map the happenings of cultural metaphorization or cultural metononymization, or both, which is dependent on the specific context and garment descriptions.

6.2 Implications

Methodologically, this paper encourages future studies to build specific corpus to pay attention to micro levels of the text, instead of focusing on macro narratives. Practically, this thesis this paper advices researchers to adopt cultural cognitive perspectives to analyze Chinese culture classics, which is a new trend for traditional culture text decoding. What's more, it is suggested to explore the inner relationship of specific text like gradual mapping mechanism as this paper has found. Lastly, we expect future studies can conclude the specific pattern or paradigm of cultural metaphorization, cultural metononymization, and cultural framing, which is not universal to some extent.

6.3 Limitations and Prospects for Future Research Development

This study is limited in the following aspects. First, given the complexity of our whole book's data, we only pick the first thirty chapter as the sample to analyze. A full-text analysis enables an examination of the interaction between the framework we have established and can be concluded a comprehensive picture of *the scholars*. Additionally, our corpus has been limited to culture-loaded description of garments, qualitative analysis is required in the cultural classics. Finally, we limit the comparative discussion to English classics to validate the uniqueness of Chinese classics. An extended research of cross-cultural classics dialogue can provide further insights.

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Effects of Evocative Versus Descriptive Game Names On Players' Aesthetic Evaluation

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Abstract: Game names provide a critical first impression, potentially shaping players' aesthetic experiences before gameplay even begins. But how different naming strategies influence player perception remains underexplored. This study investigated the impact of name type, specifically comparing evocative/conceptual names (e.g., 'Stardust Echoes') against descriptive names (e.g., 'Space Shooter'), on players' aesthetic evaluations. Across three experiments using AI-generated game concepts, evocative names consistently yielded higher ratings of liking and interest compared to descriptive or absent names. Furthermore, participants perceived original evocative names as a better fit for the game concepts and were more likely to express an intention to try games bearing such names. These results underscore the importance of a name's conceptual and evocative power, suggesting that names going beyond simple description can significantly boost a game's aesthetic appeal and initial player attraction.

Keywords: Game Name; Evocative Name; Descriptive Name; Conceptual Information; Aesthetic Evaluation; Interest; Liking

1. Introduction

A game's name often acts as the very first point of contact for potential players navigating a crowded digital marketplace. More than just a label, it is a crucial paratextual element that offers initial clues about the game's identity, hinting at its core concept, style, genre, and overall feeling[3]. The linguistic characteristics of a name can affect brand recall[1], and product design elements, including the name, profoundly influence consumer responses[2]. For games, the name functions as a primary framing device, shaping the initial impressions and expectations that directly influence a player's subsequent exploration intent, aesthetic experience, and overall engagement[3].

This study focuses on the differential impact of two primary naming strategies. The first is **Descriptive Names**, which directly state the game's genre, core gameplay, or content (e.g., "Space Shooter," "Turn-Based Strategy"). These names prioritize clarity and informational content about the game's function. The second is **Evocative/Conceptual Names**, which do not directly describe specific content but instead imply the game experience, theme, or emotion through metaphor, association, or atmosphere (e.g., "Stardust Echoes," "Chronicles of Mist"). These names aim to spark imagination and create a particular mood. While the importance of naming is accepted in marketing, the specific aesthetic function of these different name types in the context of video games remains empirically underexplored.

Therefore, this study was designed to systematically investigate the aesthetic function of game names. Drawing on methodologies from empirical aesthetics, we aim to achieve three main objectives:

1. **Determine the basic effect of name presence and type on aesthetic evaluation**, examining whether the type of name (evocative vs. descriptive) significantly alters core aesthetic responses like liking and interest.
2. **Assess the perceived congruence between names and game concepts**, evaluating how well players perceive different name types as fitting or appropriate for the associated game concepts.
3. **Investigate the influence of name type on behavioral intention**, exploring whether the documented effects on aesthetic evaluation translate into a higher likelihood of players expressing an intention to try the game.

Based on findings in art aesthetics that conceptual titles enhance appreciation[9-11], we hypothesize that evocative/conceptual game names, compared to descriptive names, will be more effective at stimulating players' aesthetic interest, positive evaluations, and trial intention.

2. Literature Analysis

This section reviews relevant literature from branding, aesthetics, and game studies to contextualize the current research.

2.1 Branding and Naming Research

Research on the impact of names on products has been extensively explored in brand naming and consumer behavior domains. Effective branding relies heavily on the careful selection of names and associated marks. Studies show that the relationship between a brand name and its brand mark (like a logo) influences the construction of brand meaning[4], establishing a cohesive identity. Furthermore, the phonetic, semantic, and associative characteristics of names are known to significantly affect consumer memory, preference, and purchase intention[5]. For instance, names that are easy to pronounce, carry positive connotations, or align well with product features are more likely to achieve market success. The linguistic structure of names is also important for international brands aiming for cross-cultural appeal[6]. These findings highlight the general importance of name characteristics in shaping consumer perception and behavior.

2.2 Aesthetic Effects of Titles in Art and Photography

While branding literature establishes the functional importance of names, research in empirical aesthetics provides insights into their impact on appreciation. Duran-Barraza et al.[9] found that conceptual titles added by artists to their photographs significantly enhanced viewers' liking and interest. Their work suggests that titles going beyond literal description to provoke thought are more aesthetically appealing. Millis' s[10] research yielded similar conclusions, finding that conceptual titles (explanatory or metaphorical) enhanced aesthetic preference for illustrations compared to descriptive or no titles. This implies that meaning-making, facilitated by conceptual titles, contributes to aesthetic pleasure. Leder et al.[11] also pointed out that title information influences the understanding and appreciation of paintings, acting as a cognitive framework that guides interpretation and evaluation. These studies strongly suggest that non-descriptive, conceptual information accompanying visual stimuli can elevate the aesthetic experience.

2.3 Research Gaps in Game Naming

Despite insights from branding and art aesthetics, empirical research on the aesthetic effects of game product names remains surprisingly scarce. The existing literature in game studies tends to focus on other areas. For instance, some research has analyzed the narrative function of in-game text and titles as literary devices[15] or the social effects of player-chosen avatar names in online environments[7]. Other work has examined game marketing from a broader perspective, such as the impact of cover art[16] or branding strategies on player retention and brand-switching intentions[8].

However, these studies do not directly address the fundamental question of how the game's own title, as a primary marketing and aesthetic signal, influences a potential player's initial evaluation. While some industry-facing analyses discuss naming conventions and trends[17], they often lack the empirical rigor of controlled experimental research. The specific aesthetic comparison between evocative and descriptive naming strategies—a topic well-explored in the study of fine art—has not been systematically applied to video games. This study aims to fill this critical gap by directly adapting experimental paradigms from art aesthetics to investigate whether, like a painting's title, a game's name functions as more than a simple descriptor and plays an active role in shaping aesthetic appreciation and player interest from the very first encounter.

3. Research Methods

This study adopted the experimental design approach from Duran-Barraza et al.[9], exploring the aesthetic impact of game names through three progressive experiments. A key aspect of the methodology was the generation of stimulus materials. All game concepts used in this study (including text descriptions and accompanying images) were generated using artificial intelligence (AI) models, leveraging large language models for text and image generation algorithms for visuals. This approach ensured the novelty and diversity of the stimulus materials, minimizing potential confounding effects from players' prior knowledge of or associations with existing brands or games. The rationale for specific experimental designs was based on standard practices for minimizing bias and maximizing sensitivity. Participants were primarily university students, recruited following institutional ethical guidelines.

Experiment	Design	Participants	Materials	Procedure/Task
Exp. 1	Between-subjects	60 university students	12 AI-generated game concepts, matched with one of three name conditions (evocative/conceptual, descriptive, none)	View concept & name (if any), rate liking and interest (7-point scale)
Exp. 2	Within-subjects	45 university students	12 AI-generated game concepts, matched with one of three name conditions (original evocative, random evocative, descriptive)	View "name-concept" pair, rate the appropriateness of the name to the concept (7-point scale)
Exp. 3	Within-subjects	50 university students	8 AI-generated game concepts, half with evocative names, half without names (counterbalanced across participants)	Browse all concepts, then choose the 2 "most desired to try" from the 8 presented; record choices per condition

4. Research Results

The results from the three experiments consistently indicated that the type of game name significantly affects players' aesthetic evaluations and behavioral intentions. The findings provide empirical support for the hypothesized advantage of evocative naming strategies.

4.1 Evocative/Conceptual Names Significantly Enhance Aesthetic Evaluation: Experiment 1 directly tested the impact of name type on core aesthetic judgments. The analysis showed significant main effects of name type on both liking ($F(2, 57) = 8.72$, $p < .001$) and interest ($F(2, 57) = 9.51$, $p < .001$). As detailed in Table 1, post-hoc comparisons confirmed that ratings in the evocative/conceptual name group were significantly higher than those in both the descriptive name and the no-name groups. Notably, there was no significant difference between the descriptive and no-name conditions, suggesting that simply providing a descriptive label did not significantly enhance aesthetic appeal over no name at all. This pattern strongly suggests that names capable of stimulating imagination and creating atmosphere, rather than just conveying function, receive more positive player evaluations.

Table 1: Liking and Interest Ratings by Name Condition in Experiment 1 (M±SD)

Name Condition	Liking	Interest
Evocative/Conceptual	5.85 ± 0.95	6.05 ± 0.88
Descriptive	4.90 ± 1.10	5.00 ± 1.15
No Name	4.75 ± 1.05	4.80 ± 1.20

Note: Ratings were on a 1-7 scale.

4.2 Perception of Name-Content Appropriateness: Experiment 2 explored whether players perceive evocative names as integral to the game concept. The results revealed a significant effect of name condition on appropriateness ratings ($F(2, 88) = 15.36$, $p < .001$). As shown in Table 2, original evocative names were perceived as the most appropriate match for the game concepts, rated significantly higher than both descriptive names and randomly assigned (non-original) evocative names. Interestingly, descriptive names were still rated as significantly more appropriate than the random evocative names, indicating that semantic relevance is acknowledged, but the original evocative pairing achieved the highest perceived congruence. This supports the view that the name is part of the overall game experience [11], and players can often perceive and appreciate the intended intrinsic connection between a well-crafted evocative name and its underlying content.

Table 2: Appropriateness Ratings by Name Condition in Experiment 2 (M±SD)

Name Condition	Appropriateness
Original Evocative	5.98 ± 1.02
Descriptive	4.80 ± 1.22
Random Evocative	4.15 ± 1.35

Note: Ratings were on a 1-7 scale.

4.3 Evocative Names Increase Choice Intention: Experiment 3 examined whether aesthetic preference translates to behavioral intention using a choice task. The results showed a significant effect of name condition on choice intention ($t(49) = 4.82$, $p < .001$). As detailed in Table 3, games presented with evocative/conceptual names were chosen significantly more often on average (M=1.38 choices out of 2) than games presented without names (M=0.62 choices out of 2). This finding provides behavioral evidence complementing the rating data, indicating that the aesthetic appeal engendered by an evocative name can directly influence players' willingness to engage further and

potentially try the game.

Table 3: Number of Games Chosen by Name Condition in Experiment 3 (M±SD)

Name Condition	Number of Choices
Evocative/Conceptual	1.38 ± 0.65
No Name	0.62 ± 0.65

Note: Participants chose 2 out of 8 games.

Discussion of Potential Mechanisms: These results may relate to established cognitive theories. Evocative names might stimulate curiosity and deeper processing by creating "cognitive disfluency" or an "effort after meaning"[12], which can be hedonically rewarding. This contrasts with effects driven solely by enhanced processing fluency[13], though fluency likely plays a role. Aesthetic experiences are often conceptualized within a dual-process framework involving both immediate pleasure and deeper interest[14] . The semantic richness of evocative names allows them to elicit more complex emotional associations[4] , setting expectations and signaling the uniqueness of the game experience[5]

5. Conclusion

Choosing a game's name is more than a matter of style; this study shows it clearly affects how players judge a game aesthetically and whether they intend to play it. First impressions count heavily in today's crowded game market, and the name is often the first thing a player sees. Across our experiments, evocative names – those hinting at themes or sparking imagination – consistently performed better than purely descriptive ones. Players liked games with evocative names more, found them more interesting, felt the names fit better, and were more willing to try them. What does this mean for game creators? It suggests treating the name as a key creative element. Moving beyond just describing the game, investing in names that use suggestion, emotion, and conceptual depth seems worthwhile. A well-crafted name can make a game stand out and help build a connection with players right from the start.

Limitations and Future Research: Like any study, this one has limitations that open doors for future work. We used AI-generated static images and text, which helped control variables but doesn't fully capture the experience of interacting with a real game. Testing these ideas with actual games or playable demos would be a valuable next step to see if the effects hold in more realistic settings. Also, our participants were mostly university students. To know if these findings apply more broadly, future studies should include players from different age groups, with varied gaming backgrounds, and from diverse cultures. It would also be interesting to explore if the best naming strategy changes depending on the game's genre – do evocative names suit RPGs better than puzzle games, for instance? Or how do cultural preferences shape reactions to different naming styles? Digging into how names work on a deeper level could involve tools like eye-tracking (to see where people look) or EEG (to measure brain responses), potentially revealing more about attention and emotional processing. Finally, looking at the long-term picture – how names influence player engagement, whether they stick with a game, and how communities talk about it over time – would give a fuller understanding of a name's impact beyond that first impression.

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