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Advances in Management and Intelligent Technologies

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Case Study Analysis on the Impact of CNPC Environmental Research Reports Utilizing the 3D-IDPT Model of Information Retrieval Management (IRM)

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Abstract: This case study applies the 3D-IDPT model from Information Resource Management (IRM) to analyze the impact of China National Petroleum Corporation's (CNPC) environmental reports and strategic responses. Focusing on two critical issues—air pollution (notably VOCs) and carbon emissions—the study explores CNPC's environmental governance through the three-dimensional framework of space, time, and construction. It reveals how CNPC's environmental behaviors are shaped by individual and collective actors, instant and synchronic timelines, and the evolving construction of environmental information under technological, value-driven, and societal demand pressures. Drawing from regulatory cases, media reports, and internal sustainability strategies, the research shows that CNPC is transitioning from reactive governance to a more proactive environmental planning model. While facing persistent challenges such as opacity and high governance costs, CNPC demonstrates growing capabilities in green transformation via carbon capture (CCUS), ecological compensation, and clean energy development. This study contributes to the understanding of how state-owned enterprises engage in sustainable transformation through dynamic information practices.

Keywords: CNPC; Environmental Pollution; Carbon Emissions; Information Resource Management; 3D-IDPT Model; Sustainability; Corporate Social Responsibility; Environmental Information Behavior

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1.Introduction

This study investigates China National Petroleum Corporation (CNPC). As a pivotal state-owned enterprise under the jurisdiction of the State-owned Assets Supervision and Administration Commission of the State Council (SASAC), CNPC operates across six core business domains: oil and gas exploration and production, engineering and technical services, petroleum engineering construction, petroleum equipment manufacturing, financial services, and renewable energy development. With investments spanning 32 countries and regions, including China, CNPC ranks among the world's foremost integrated energy producers and suppliers. The corporation has garnered significant global recognition, including 5th place in the Fortune Global 500^[1], 17th position in the S&P Global Platts Top 250 Energy Companies^[2], and 21st ranking in the Forbes Global 2000^[3]. CNPC's subsidiary, PetroChina, is publicly listed on the Hong Kong Stock Exchange (Stock Code: HK00857) and the Shanghai Stock Exchange (Stock Code: SH601857).

CNPC's corporate vision is to "construct a world-class, sustainable, and integrated international energy enterprise." Its core values prioritize "green development, empowering societal progress through stable energy provision, and fostering public well-being." Strategic guidelines are anchored in four pillars: high-quality development, deepened reform and openness, rule-of-law governance, and comprehensive strict Party discipline. Operational management adheres to the principles of "specialized development, market-oriented mechanisms, lean management, and systematic coordination." The corporation's strategic roadmap emphasizes five critical areas: innovation-driven growth, resource optimization, market expansion, global operations, and low-carbon transition ^[4].

2.Environmental Issue: Air Pollution -- VOCs

Notwithstanding its notable achievements and developmental aspirations, China National Petroleum Corporation (CNPC), like any global economic entity, faces inherent challenges and limitations. As the world enters the critical decade of the 2020s-2030s, the United Nations' 2030 Agenda for Sustainable Development—with its 17 global goals encompassing poverty eradication, hunger elimination, health equity, quality education, gender equality, clean water, affordable energy, decent work, industrial innovation, inequality reduction, sustainable cities, responsible consumption, climate action, aquatic conservation, terrestrial ecosystem protection, peacebuilding, and global partnerships—has become an international consensus ^[5]. Within this framework, environmental sustainability has emerged as a paramount concern. Concurrently, accelerated media scrutiny has brought CNPC's environmental challenges into sharp public focus.

Air pollutants derive from diverse sources, including volatile organic compounds (VOCs), sulfur oxides (SOx), nitrogen oxides (NOx), and particulate matter (PM). While SOx, NOx, and PM originate broadly from industrial and residential activities, VOCs are predominantly emitted across the entire lifecycle of petroleum products—spanning production, consumption, recycling, and reuse.

These VOCs react with atmospheric constituents to generate photochemical smog, ozone, and other hazardous substances, causing respiratory irritation, headaches, and nausea. Key VOC components include:

Aromatic hydrocarbons: Benzene, toluene, and xylene, primarily released during fossil fuel processing and industrial applications (e.g., paints, furniture, electronics);

Aliphatic hydrocarbons: Hexane, octane, and decane, emitted during petroleum refining and utilization;

Halogenated hydrocarbons: Chloroform, carbon tetrachloride, and Freon, commonly used in refrigerants, foaming agents, and fire suppressants;

Oxygenated compounds: Ethanol and acetone, byproducts of petrochemical manufacturing;

Other compounds: Ammonia, hydrogen sulfide, and hydrogen cyanide, generated through industrial processes and petroleum combustion.

Research on CNPC's Yulin Oilfield reveals that photochemical pollution—marked by elevated ozone levels—has become a global environmental challenge for industrial zones and urban clusters. Emissions from hydrocarbon exploration exhibit multi-scale impacts on air quality across temporal and spatial dimensions ^[6]. As energy demand escalates, global hydrocarbon extraction activities continue to expand. China, as a leading hydrocarbon producer, faces intensifying scrutiny over emissions—particularly ozone precursors—from its extraction operations, which threaten long-term air quality.

Pollutant exceedances at CNPC facilities remain problematic: refinery complexes primarily emit aromatic hydrocarbons, followed by halogenated hydrocarbons and sulfides. Xylene, chloroform, and hydrogen sulfide dominate these categories. Although volatile sulfides constitute the smallest proportion, their low odor thresholds and acute irritancy have triggered frequent public complaints ^[7].

Such environmental issues have precipitated legal consequences. CNPC faced public interest litigation from the China Environmental Protection Foundation—a 5A-rated public charity under the Ministry of Ecology and Environment and Ministry of Civil Affairs—resulting in a ¥9.9292 million penalty and mandated environmental remediation [8]. Subsidiary gas stations have also incurred administrative penalties for non-compliant vapor recovery systems [9].

Across CNPC's operational chain, air pollution arises from three critical phases:

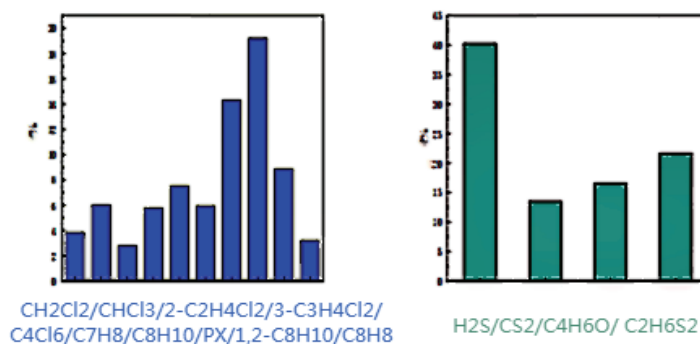
Hydrocarbon Exploration: Methane, hydrogen sulfide, and VOC emissions during extraction jeopardize air quality and

occupational/public health;

Refining Processes: Core facilities emit SO_x, NO_x, PM, and VOCs during refining and catalytic cracking;

Storage/Transportation: Leakage and volatilization during oil product logistics—including tanker spills, truck seepage, and storage tank emissions—contribute significantly to atmospheric contamination.

Figure1: substance with high pollutant concentration



3. Solutions for Air Pollution

CNPC has implemented systematic measures to address environmental challenges, achieving notable progress. These initiatives integrate environmental considerations into corporate operations, mitigate ecological and climatic impacts, enhance resource efficiency, strengthen pollution prevention, advance energy conservation, promote green-intensive production, and align energy development with ecological preservation.

3.1 Environmental Management System Optimization

CNPC has established a risk-centric environmental management framework, incorporating environmental performance into executive evaluations. The corporation has refined its three-tier prevention and control infrastructure, conducted environmental risk assessments, and prioritized mitigation of six major environmental risks. A dynamic monitoring network tracks pollution sources in real time via online systems for wastewater and emissions, while flare gas recovery technologies reduce venting and combustion, achieving dual pollution-carbon reduction benefits.

3.2 Precision Pollution Control

CNPC enforces stringent source control, upgrades existing treatment facilities, and ensures compliance with emission standards for wastewater and air pollutants. Key emission metrics are integrated into annual executive performance contracts, backed by rigorous accountability mechanisms.

2022 data indicate:

Nitrogen oxide (NO_x) emissions in refining decreased by 7.1% year-on-year;

Volatile organic compound (VOCs) emissions fell by 3.5%;

Methane emission intensity declined by 9.76%;

Chemical oxygen demand (COD) dropped by 7.0%^[10].

3.3 Atmospheric Governance Breakthroughs

Aligned with China's Blue Sky Protection Campaign, CNPC has intensified seasonal air pollution control in critical regions and launched the CNPC Ozone Pollution Prevention and Control Action Plan (2022–2025). Targeted measures include optimizing processes to reduce benzene derivatives, halogenated hydrocarbons, and sulfide emissions, thereby mitigating odor-related public grievances.

3.4 Decarbonization Roadmap

CNPC's methane reduction strategy involves establishing a monitoring, reporting, and verification (MRV) system, implementing routine flare elimination, and upgrading closed-loop operational processes.

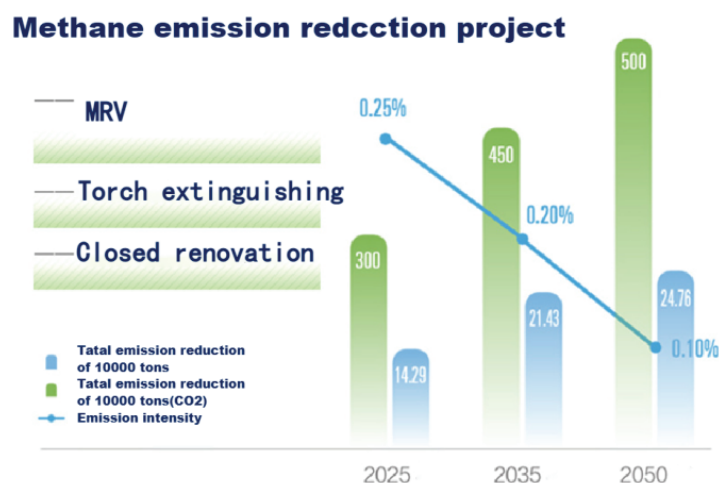
Phase-specific targets include:

Cumulative methane reductions of 3 million tons by 2025;

4.5 million tons by 2035;

Over 5 million tons by 2050^[11].

Figure2: Prediction of methane emission reduction by 2050



This trajectory aligns with global climate imperatives and underscores CNPC's strategic commitment to clean energy transition.

4.Environmental Issue: Carbon Dioxide Emissions

Petroleum, natural gas, and coal—collectively categorized as organic energy sources—differ fundamentally from renewable alternatives such as wind, nuclear, solar, and hydrogen energy. Originating from ancient carbon-based organisms, these resources formed over millions of years through photosynthesis, biochemical reactions, and prolonged geological processes that transformed solar energy and inorganic matter into organic compounds under extreme heat and pressure. Characterized by high energy density and logistical convenience, fossil fuels remain indispensable to modern industry and transportation, serving as primary energy sources and chemical feedstocks. However, their extraction and utilization generate not only air pollution but also a critical environmental challenge: carbon emissions.

4.1 Carbon Governance Challenges in Petrochemical Giants

As China's two largest state-owned petrochemical conglomerates, China National Petroleum Corporation (CNPC) and China Petrochemical Corporation (Sinopec) have long faced public scrutiny over their carbon footprints. Since 2013, People's Daily, China's official newspaper, has consistently highlighted their emission governance deficiencies. The 2012 Key Pollutant Reduction Assessment Report, jointly issued by the Ministry of Ecology and Environment, National Bureau of Statistics, and National Development and Reform Commission, revealed that both corporations failed to meet emission reduction targets due to delayed mitigation projects, obsolete technologies, operational inefficiencies, and recurrent environmental violations at subsidiary facilities. People's Daily critiqued this starkly: "CNPC and Sinopec must not remain 'dwarfs in emission reduction'" [12].

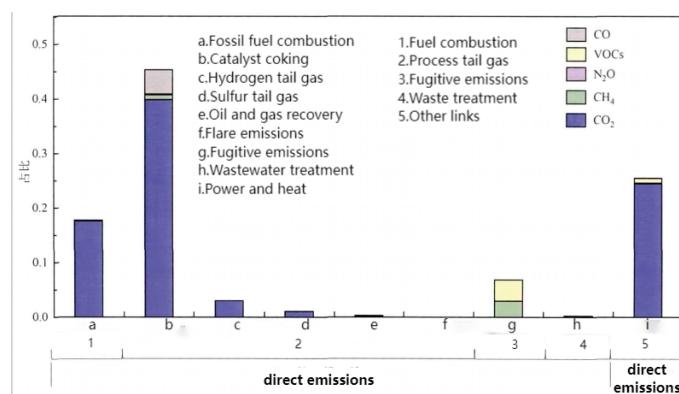
4.2 Deficiencies in Low-Carbon Accountability Disclosure

Scholarly research identifies systemic weaknesses in CNPC's low-carbon responsibility disclosure practices. Analysis of its annual reports (2007–2011) demonstrates persistent structural deficiencies, including poor information accessibility and inadequate responsiveness to stakeholder concerns [13]. As China's largest petroleum enterprise, CNPC's operational scale entails massive resource consumption—predominantly high-carbon energy. Under China's Environmental Protection Tax Law, the environmental cost of CO₂ emissions imposes significant financial burdens [14], exacerbating corporate sustainability pressures.

4.3 Carbon Emission Profiles in the Petrochemical Sector

Sector-wide studies reveal that CO₂ accounts for 86.24% of greenhouse gas emissions in petrochemical operations, primarily from direct emission processes such as catalyst calcination, electricity/heat consumption, and fossil fuel combustion [15]. This statistic underscores the structural conflict between the industry's fossil-dependent production model and decarbonization imperatives.

Figure3: Proportion of carbon emissions by category



5. Solutions for Carbon Dioxide Emissions

Acknowledging the inherent carbon constraints of fossil-based organic energy, China National Petroleum Corporation (CNPC), as a traditional petrochemical enterprise, has proactively initiated transformative measures to address emissions through process optimization, renewable energy transition, and carbon sink initiatives.

5.1 Medium to long-term planning goals

To this end, CNPC formulated a series of “medium-to-long-term planning goals” around 2020.

2025 Targets:

Launch the “Planting Trees for Carbon Neutrality” campaign to raise \geq ¥200 million for corporate-affiliated voluntary tree-planting, large-scale carbon sink forests, and carbon-neutral forest projects. Establish 4000 mu (\approx 267 hectares) of carbon sink forests, positioning CNPC as a state-owned enterprise exemplar in carbon sequestration forestry.

2030 Targets:

Elevate the share of clean energy (e.g., natural gas) and renewables in domestic primary energy production. Ensure natural gas accounts for 55% of domestic primary energy output while controlling greenhouse gas (GHG) emissions to achieve an early peak.

2050 Targets:

Further increase the proportion of natural gas, renewables, and new energy sources in domestic primary energy production. Attain international leadership in low-carbon development, supporting China’s climate commitments ^{[16][17][18][19]}.

5.2 Implementation Pathways

The company actively explores and improves the technological and benefit paths of Carbon Capture, Utilization, and Storage (CCUS), continuously increasing the research and development and promotion efforts for key technologies across the entire CCUS industry chain. This has effectively enhanced the level of carbon capture and utilization, promoting the construction of CCUS demonstration projects and their commercial applications. A series of achievements have been made: the formation of technical equipment for efficient capture, transportation, injection, and storage of carbon dioxide at all stages; the layout of next-generation organic amine adsorbents, solid adsorbents, and other capture technologies; the development of long-distance, large-diameter carbon dioxide transportation, storage, and data simulation, as well as integrated monitoring from space to ground, achieving the capture, utilization, and storage of low-concentration carbon dioxide; participation in global research collaborations on Direct Air Carbon Capture and Storage (DACCS), Bioenergy with Carbon Capture and Storage (BECCS), and marine carbon sinks; and the promotion of establishing and improving the CCUS standard and regulatory system. After years of development, in 2022, the annual injection of carbon dioxide exceeded 1.1 million tons.

5.3 New Energy Business Expansion

The company regards new energy business as a new driving force for promoting green and low-carbon transformation and development, and has established a New Energy and New Materials Development Leading Group headed by the chairman. It strengthens the strategic planning and management system construction of new energy business, and accelerates the expansion of new energy businesses such as geothermal, wind and solar power generation, hydrogen energy, and charging (exchange) stations. While accelerating the construction and operation of the Shanghai New Materials Research Institute and

the Shenzhen New Energy Research Institute, the Japan Intellectual Property Research Institute was established in 2022 to further provide technical support for the development of new energy, new materials, and new businesses. In 2022, China's new energy development and utilization capacity reached 8 million tons of standard coal per year.

5.4 Progress in Carbon Sink Forest Construction

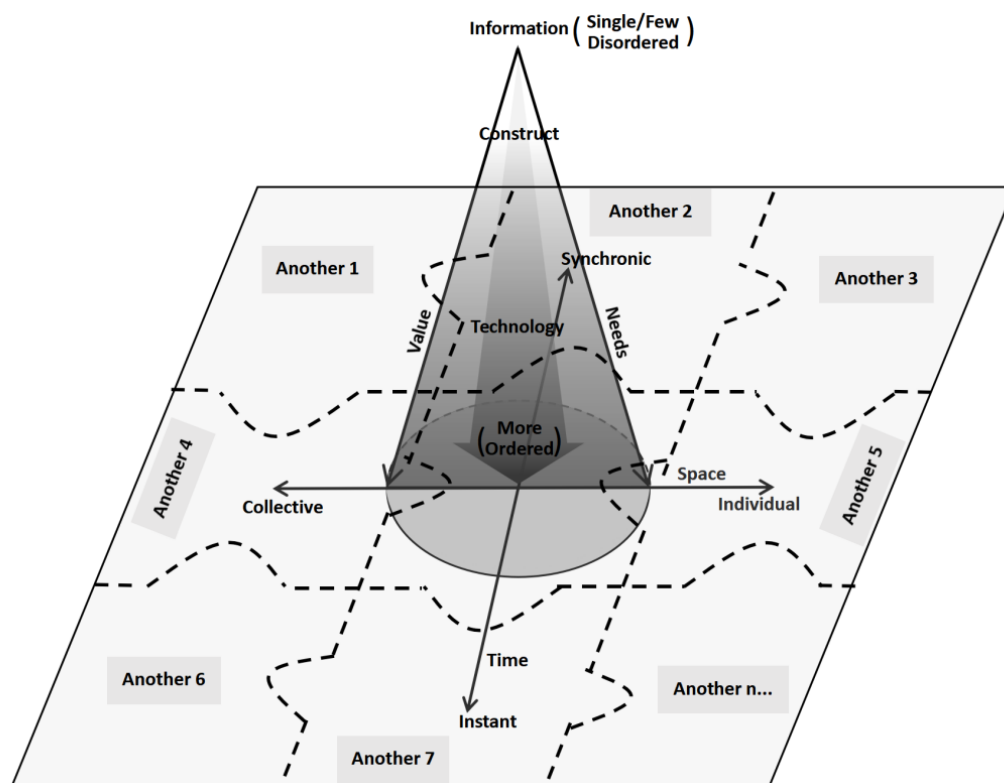
In 2022, a total of 14.925 million person-times from the entire group participated in voluntary tree planting in various forms, planting 42.25 million trees (including equivalents), and adding 13.7 million square meters of green space. During the year, three group documents were compiled and issued around the direction of “Greening Environmental Protection and Carbon Sink Forest Construction,” actively promoting the layout of carbon sink forests and carbon-neutral forests. By the end of 2022, the cumulative green space area in four regions including Daqing Oilfield, Changqing Oilfield, Xinjiang Oilfield, and Yumen Oilfield reached 314 million square meters, with cumulative donations exceeding 17.889 million yuan^[10].

6.Utilizing the 3D-IDPT model of IRM for behavior analysis of CNPC

6.1 The 3D-IDPT model of IRM

The Three-Dimensional Integrated Discipline Puzzle Theory (3D-IDPT) is a theoretical model extended from the Information Resource Four-Way Diagram in information resource construction^[20], emphasizing the following points:

Figure4: 3D-IDPT (Integrate Discipline Puzzle Theory) model



Information, positioned as the origin, is divided into four quadrants by two axes: the time axis (Instant & Synchronic) and the space axis (Individual & Collective). Additionally, the process of information construction forms a third dimension—represented by the vertical axis—which converts this model into a three-dimensional spatial concept.

The horizontal axis (space) represents “Individual & Collective,” highlighting the diversity of information users and the demand for co-construction and sharing.

The vertical axis (time) signifies “Instant & Synchronic,” emphasizing the timeliness, life-cycle nature, and dynamic processes in information resource construction and usage.

The Z-axis (construction process) represents the progression of information construction as a resource, indicating a deepening process of recognition, processing, and management influenced by advancements in technology and guided by value and needs.

Through this integrated intersection of space, time, and construction, information resource construction is clearly divided into

multiple parts:

1. Individual-Instant Quadrant: Focused on immediate information needs of an individual at a particular moment.
2. Individual-Synchronic Quadrant: Examining how individuals sustainably utilize and re-utilize information over different periods.
3. Collective-Instant Quadrant: Concentrating on the immediate information needs of multiple user groups at a specific point in time.
4. Collective-Synchronic Quadrant: Focusing on long-term, stable demand, and continuous sharing of information resources among multiple user groups.
5. The process of information construction acknowledges potential difficulties arising from various conditions but emphasizes that, through continuous matching of information's value with needs, construction will eventually become more comprehensive, deepening the understanding and application of information.

6.2 Using 3D-IDPT for object segmentation of CNPC environmental issues

Figure5: Axis Object Subject Interpretation Table

Axis	Object	Subject	Interpretation
Horizontal: Space	Individual	CNPC	A market-operating entity
	Collective	Society and Government	Public concerns prompting governmental attention
Vertical: Time	Instant	Moment of event response	Sudden incidents, routine operational events
	Synchronic	Influenced by the past	Response, inheritance, and modification based on historical context
		Impacting the future	Long-term observation and implications
Z-axis: Construction	Value	Economic value	Ongoing development requiring petrochemical production and reinvestment
	Needs	Social benefits	Sustainable Development Goals (United Nations, 2015)
	Technology	Information circulation and environmental governance technology	Information via social media, news media, and government advisory channels; advancements in environmental management technology

6.3 Behavior Analysis of CNPC Environmental Issues Based on 3D-IDPT

While CNPC faces two main environmental issues—air pollution and excessive carbon dioxide emissions—analyzing specific examples reveals common behavioral logic,

As a market-operating entity, CNPC:

1. Individual-Instant Quadrant: Historically prioritized immediate economic benefits^[12], neglecting other types of crucial information.
2. Individual-Synchronic Quadrant: Each corporate decision reflects influences from past behaviors and affects future actions. Prolonged attention solely to economic gains led to the neglect of social-environmental responsibilities, making CNPC one of the “emission reduction dwarfs”^[12].
3. Collective-Synchronic Quadrant: Residents living near CNPC's industrial zones have long suffered environmental pollution, prompting local governments to criticize and penalize CNPC [8]. Additionally, to achieve global environmental governance, the Chinese government has set a nationwide 3060 carbon emission goal^[21].
4. Collective-Instant Quadrant: The environmental issues caused by sudden production leaks have attracted significant attention from social groups. The Dalian Municipal Government has established an investigation team to address sudden environmental issues and to hold those responsible accountable^[22].

5. Construction Axis (Z-axis): Over the past decade, from traditional print media to short-video platforms, the rapid flow of information has continuously drawn public attention to social issues. For over 20 years, governmental governance has improved through the “12345 Government Service Hotline” platform^[23]. Technological advancements and deepening research have made environmental governance more scientifically effective^[6].

7. Summary and Prospect

China National Petroleum Corporation (CNPC) has rigorously implemented ecological civilization principles, prioritizing pollution prevention and control while aligning environmental protection with operational efficiency. Guided by its carbon peaking and carbon neutrality objectives, the corporation has adopted a three-phase strategy—clean energy substitution, strategic transition, and green transformation—to advance its “Blue Sky, Clear Water, and Pure Land” initiatives.

7.1 Renewable Energy Transition Framework

CNPC has established six flagship renewable energy bases to drive low-carbon innovation:

Yumen Oilfield Clean Transition Demonstration Base

Daqing Oilfield Green Low-Carbon Sustainable Development Base

Jilin Oilfield Wind-Solar Power Integration Project

Beijing-Tianjin-Hebei Geothermal Heating Demonstration Zone

Qinghai Oilfield Clean Electricity Hub

Xinjiang Green Energy Industrialization Base

Supported by five core engineering initiatives, these bases accelerate the deployment of renewable energy projects, reinforcing CNPC’s green industrial ecosystem.

7.2 Traditional Hydrocarbon Operations

CNPC maintains technological leadership in oil and gas exploration and processing, integrating cutting-edge extraction technologies with stringent environmental and safety protocols. The corporation continuously enhances operational efficiency and emission control through advanced management systems and international best practices.

7.3 Diversified Business Expansion

Beyond energy production, CNPC has diversified into:

Chemicals Manufacturing: Producing high-quality petrochemical products via state-of-the-art production lines;

Urban Gas Supply: Delivering secure and reliable gas services to residential and commercial users;

Global Energy Collaboration: Expanding international partnerships to foster energy security and technological exchange.

7.4 Conclusion

Through its dual focus on traditional energy modernization and renewable innovation, coupled with cross-sectoral diversification, CNPC exemplifies a holistic approach to sustainable development. The corporation remains committed to high-quality growth, positioning itself as a global leader in the energy transition while contributing to the realization of an eco-centric societal vision.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Strategic Introduction of Private Labels and Coordination Mechanisms in Dual-Channel E-Commerce Platforms

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Abstract: In the context of dual-channel supply chains, a game-theoretic model is developed to examine the strategic implications of private label introduction by e-commerce platforms under both scenarios: with and without private labels. The model analyzes optimal decisions regarding pricing, advertising investments, wholesale prices, marginal profits, and equilibrium payoffs for manufacturers and platforms operating under a reselling model. The findings indicate that private label introduction significantly influences the strategic choices and profit outcomes of both manufacturers and platforms, with the direction of impact varying based on the manufacturer's unit reselling cost. Numerical simulations further validate the theoretical results and illustrate the effects of private label introduction on key variables within the supply chain. This research provides theoretical insights and managerial implications for e-commerce platforms to formulate private label strategies and optimize supply chain collaboration under varying market conditions.

Keywords: Dual-Channel Supply Chain; Private Label; E-commerce Platform; Game-Theoretic Analysis

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1.Introduction

With the deep penetration of Internet technologies and the rapid growth of the digital economy, the global e-commerce market has continued to expand, and online consumption has gradually become a major choice for consumers. In 2023, China's online retail sales reached 13.79 trillion yuan, accounting for 30.8% of total retail sales of consumer goods, indicating a rapid transformation in consumer purchasing behavior and the growing maturity of the e-commerce ecosystem. Against this backdrop, e-commerce supply chains have enhanced operational efficiency and coordination by effectively integrating data, logistics, and financial flows. For example, Alibaba's "Cainiao" logistics network improved its average delivery time by 45% during the 2023 "Double Eleven" shopping festival compared to 2018, highlighting the achievements of digital upgrades in e-commerce supply chain management.

In pursuit of breaking growth bottlenecks and improving profitability, e-commerce platforms have actively promoted private label strategies. Statistics show that by 2024, the global private label market reached \$1.7 trillion, with a penetration rate exceeding 21% in the U.S. Amazon's private label, Amazon Basics, captured a 31% market share in the U.S. alkaline battery market and expanded into apparel, home goods, and other categories, effectively boosting platform profitability. In the Chinese market, private labels such as JD's "Jingzao" and Alibaba's "Taobao Xinxuan" have achieved rapid growth, with sales

surpassing 8 billion yuan and user bases exceeding 120 million, respectively. Leveraging platform traffic and data analytics, these private labels have swiftly responded to niche market demands.

However, the expansion of private labels has intensified the complex relationship of both competition and cooperation between e-commerce platforms and manufacturers. On the one hand, platforms capitalize on algorithmic recommendations and search rankings to give their private labels competitive advantages in standardized or low-to-mid-priced product segments, posing a threat to manufacturer brands. Surveys reveal that 61% of manufacturers are concerned about private labels cannibalizing their market share. On the other hand, manufacturers are actively developing direct sales channels, strengthening brand control through official websites, private traffic operations, and other direct-to-consumer strategies. Platforms such as Huawei Mall, iMaotai, and Nike's WeChat mini-program have all achieved rapid growth in online direct sales, further intensifying market competition with e-commerce platforms.

The proliferation of dual-channel supply chains has complicated the interactions between manufacturers and e-commerce platforms regarding sales channels, product positioning, and pricing strategies. While e-commerce platforms promote private label development, they also face increased cooperation frictions and "double marginalization" effects resulting from private label introduction. Due to product category heterogeneity, the introduction of private labels exhibits dynamic and context-dependent characteristics. Therefore, determining appropriate private label introduction strategies and effectively coordinating the interests of manufacturers under a dual-channel environment have become critical challenges affecting supply chain performance and platform competitiveness. Exploring the interaction mechanisms between e-commerce platforms and manufacturers in dual-channel settings and identifying key factors influencing strategic choices are essential for platforms to achieve differentiated development and collaborative gains.

With the rapid development of e-commerce and multichannel retailing, dual-channel supply chains have become a critical operational model for e-commerce platforms. To strengthen channel control and optimize profit structures, many platforms have adopted private label strategies, which have attracted increasing attention from academia. Existing studies have examined private label introduction in dual-channel environments from various perspectives, including market competition, channel power dynamics, consumer perceptions, and supply chain coordination.

From the perspective of market competition, Raju et al. (1995) found that introducing private labels enhances retailers' bargaining power in price competition and highlighted the moderating role of price sensitivity among competing products^[1]. Chen et al. (2011) explored how differences in quality and cost between national brands and private labels affect profit distribution and supply chain coordination^[2]. Kuo and Yang (2013) suggested that when the substitutability of national brands is low, retailers benefit from offering private labels with quality levels close to those of national brands to maximize profits^[3]. Zheng et al. (2022) pointed out that introducing private labels intensifies competition among manufacturers and increases pricing uncertainty, especially under complex contractual relationships^[4].

Li et al. (2022) used a cost-quality trade-off model to show that, under certain conditions, high-quality private labels can enhance retailers' overall profits^[5]. Ma and Siebert (2024) demonstrated that launching private labels encourages retailers to adjust product portfolios and pricing strategies, thereby optimizing channel profits through demand shifting^[6]. Reza-Gharehbagh et al. (2025) emphasized that retailers prefer collaborating with manufacturers offering low costs and high capacity or strong brand power to gain competitive advantages through pricing and promotional strategies^[7]. Bedoui et al. (2024), based on empirical evidence, found that as market share increases, manufacturer brands become less responsive to private label promotional pricing^[8].

From the perspective of channel power dynamics, Ru et al. (2015) discovered that private label introduction helps mitigate double marginalization and, under certain conditions, increases the demand and wholesale price of national brands^[9]. Liao et al. (2020) argued that private label positioning is influenced by procurement mechanisms and channel pricing authority^[10]. Cheng et al. (2021), through a multi-tier supply chain model, found that when private labels possess significant market competitiveness, distributors play a positive role in coordinating upstream and downstream relationships^[11]. Gielens et al. (2023), using cross-country data, showed that while private label market shares tend to converge globally, they still exhibit significant regional differences due to economic and cultural factors^[12].

Regarding the mechanisms of dual-channel supply chains, Huang et al. (2011) developed models under centralized and decentralized decision-making to explore pricing and production adjustments in the face of demand disruptions^[13]. Rodríguez and Aydın (2015), using a nested logit model, analyzed joint decisions on product assortment and pricing, revealing that inventory costs influence channel conflicts^[14]. Ding et al. (2016) employed a Stackelberg game model to study tiered pricing strategies under manufacturer leadership, finding that uniform pricing under certain market conditions optimizes manufacturer profits^[15]. Liu et al. (2016) compared pricing strategies under different information scenarios, showing that risk aversion and information asymmetry reduce overall supply chain efficiency^[16]. Chen et al. (2017) examined joint price and quality decisions, noting that the introduction of new channels promotes product quality improvements and enhances channel structure efficiency^[17]. Zhou et al. (2018) explored how service cost-sharing contracts, under free-riding behavior, impact service levels and profits, finding that differentiated pricing can mitigate channel price competition and increase manufacturer profits^[18].

Chu et al. (2025) investigated the interaction between e-commerce platform private labels and manufacturer channel choices through a game-theoretic model, revealing that although private labels reduce manufacturer brand profits, they help alleviate double marginalization^[19]. Zha et al. (2025) found that platforms can leverage private labels as strategic tools in pricing and negotiation^[20]. Paha (2025) studied scenarios of quality information asymmetry, showing that manufacturers use wholesale pricing and market share contracts to counter retailers' informational advantages^[21]. From the perspective of consumer perceptions, Fuduric et al. (2022) reported that consumers exhibit more positive attitudes toward national brands, posing challenges for private label market acceptance^[22]. Mao et al. (2023) indicated that reference prices, package sizes, and consumer income levels significantly influence the likelihood of choosing private labels^[23]. Choi and Turut (2023) observed that when private label quality approaches that of national brands, some consumers shift toward premium products, helping national brands maintain market share and profitability^[24].

These studies collectively reveal the multifaceted impacts of private label introduction on market competition, channel power structures, pricing mechanisms, and supply chain coordination in dual-channel supply chains, providing a theoretical foundation for understanding private label strategies in e-commerce platforms. However, most existing research focuses on traditional retailers, with limited attention to dynamic games, coordination mechanisms, and multi-stakeholder interest balancing under e-commerce platform-led dual-channel environments.

The current literature offers important theoretical insights into the role of private labels in dual-channel supply chains, covering aspects of market competition, channel power, consumer perceptions, and supply chain coordination. In particular, game-theoretic and empirical studies have highlighted the complex effects of private label introduction on supply chain structure, profit distribution, and market strategies. Nevertheless, research focusing on platform-led dual-channel contexts remains scarce, especially regarding private label strategy choices, impacts on manufacturer cooperation, channel coordination, and supply chain balance. Therefore, this study centers on the issue of private label introduction by e-commerce platforms under a dual-channel environment, analyzing its effects on supply chain coordination and platform competitiveness through the lens of platform-manufacturer interactions. The goal is to explore strategies that optimize platform profitability and channel collaboration, offering theoretical support and practical insights for platforms in developing effective private label strategies.

2. Model Development and Solution

2.1 Problem Description

With the rapid growth of e-commerce, online platforms have gradually become a critical sales channel for manufacturers' national brand (NB) products. Under this environment, manufacturers distribute their products through two channels simultaneously: direct-to-consumer (DTC) online sales via their own channels, and indirect sales through e-commerce platforms where the platform sets the retail price. This dual-channel supply chain structure enhances manufacturers' access to consumers while granting the platform pricing power and traffic control over product sales. However, the coexistence of these channels not only expands market coverage but also intensifies internal competition, leading to increasingly complex trade-offs between manufacturers and platforms regarding pricing, advertising, and sales volumes.

To strengthen channel competitiveness and increase profitability, e-commerce platforms have begun to consider introducing

private label (store brand, SB) products, which are sold alongside national brand products on the same platform. The introduction of a private label adds a new self-controlled product line to the platform's portfolio, thereby reshaping the existing supply chain structure and decision-making processes. The substitutability between private labels and national brands, the allocation of platform resources, and consumer purchase choices—driven by factors such as price sensitivity, advertising effectiveness, and brand preference—together form a complex network of competition and cooperation between manufacturers and platforms.

Within this dual-channel environment, the decision-making sequence between the platform and the manufacturer can be summarized as follows: first, the platform decides whether to introduce a private label and determines the pricing strategy for the private label product; next, the manufacturer responds by setting its advertising investment level for national brand products sold on the platform and deciding on the pricing strategy for its direct sales channel; finally, consumers make their purchasing decisions between the platform channel and the direct channel based on product prices, advertising effects, and perceived brand value. Through this interactive process, the strategic choices of both the platform and the manufacturer jointly determine product demand, profit distribution, and the competitive dynamics between channels.

To facilitate analysis, the model is built under the following assumptions:

- (1) Both the platform and the manufacturer are rational decision-makers seeking to maximize their own profits;
- (2) Consumers' purchase decisions are influenced by product price, advertising effects, and brand utility, with substitutability existing between channels;
- (3) The platform can influence sales performance through traffic allocation and recommendation algorithms;
- (4) Manufacturers can enhance the perceived utility of national brand products on the platform by investing in advertising, while bearing the associated advertising costs.

Based on these assumptions, decision models are developed for two scenarios: one where the platform does not introduce a private label, and another where it does. By comparing the outcomes of the two scenarios in terms of pricing, advertising investment, profits, and channel demand, this study aims to explore the impact mechanisms of private label introduction on key stakeholders in the dual-channel supply chain.

The symbols and definitions used in the model are summarized in Table 1.

Table 1 Notation and Definitions

Symbol	Definition
v	Consumer's perceived value for NB product in platform channel, uniformly distributed over $[0,1]$
δ	Consumer's perceived value discount coefficient for NB product in manufacturer's direct channel, $0 < \delta < 1$
η	Consumer's perceived value discount coefficient for SB product in platform channel, $0 < \eta < \delta < 1$
β	Advertising effectiveness coefficient for NB product's consumer utility in the platform channel, $0 < \beta < 1$
c	Manufacturer's unit selling cost when wholesaling NB product to platform
Π_k	Profit of supply chain member k , $k \in \{M, P\}$
U_i	Consumer utility of product in channel i , $i \in \{d, f, s\}$
D_i	Demand for product in channel i , $i \in \{d, f, s\}$
p_i	Unit retail price of product in channel i , $i \in \{d, f, s\}$
w	Unit wholesale price of NB product sold to platform
m	Unit margin earned by platform from NB product sales
e	Manufacturer's advertising investment for NB product
Subscripts	
M	manufacturer
P	e-commerce platform
d	manufacturer's direct channel (NB product)
f	platform's indirect channel (NB product)
s	platform's SB product channel
Superscripts	
RN	scenario without private label introduction
RS	scenario with private label introduction

2.2 Equilibrium Analysis without Private Label Introduction (RN)

In this section, the e-commerce platform does not introduce a private label (store brand, SB), and the decision-making sequence under this model follows: S1: The platform decides not to introduce a private label. S2: The platform sets the margin m for reselling the national brand (NB) product, while the manufacturer determines its advertising investment level e . S3: The manufacturer sets the direct sales price p_d for NB products in its own channel and the wholesale price w for selling NB products to the platform; demand is then realized.

Under this setting, consumers' utility functions are expressed as:

$$U_d^{RN} = e - p_d + \delta v \quad \#(1)$$

$$U_f^{RN} = v - m - w + \beta e \quad \#(2)$$

From the utility functions, we derive the critical perceived value thresholds v_1^{RN} and v_2^{RN} for consumer choice. Accordingly, the demand functions for NB products in the direct channel and the platform channel are given by:

$$D_d^{RN} = v_1^{RN} - v_2^{RN} = -\frac{e - p_d + \delta(m + w) - \beta\delta e}{\delta(\delta - 1)} \quad \#(3)$$

$$D_f^{RN} = 1 - v_1^{RN} = \frac{e + m - p_d + w - \beta e}{\delta - 1} + 1 \quad \#(4)$$

The profit functions of the manufacturer and the platform are then formulated as:

$$\Pi_M^{RN} = p_d D_d^{RN} + (w - c) D_f^{RN} - \frac{e^2}{2} \quad \#(5)$$

$$\Pi_P^{RN} = m D_f^{RN} \quad \#(6)$$

Under this scenario, equilibrium solutions are obtained through a sequential optimization process. First, the manufacturer's profit function $\Pi_M^{RN}(p_d, w)$ is differentiated with respect to p_d and w to derive the manufacturer's reaction functions for direct sales price p_d and wholesale price w . Next, these reaction functions are substituted into the profit functions of both the manufacturer and the platform. By taking the first-order derivatives with respect to advertising investment e and platform margin m , the equilibrium advertising investment e^{RN*} and platform margin m^{RN*} are solved. Substituting e^{RN*} and m^{RN*} back yields the equilibrium direct price p_d^{RN*} and equilibrium wholesale price w^{RN*} . Finally, the equilibrium profits of the manufacturer and the platform can be calculated as:

$$\Pi_M^{RN*} = p_d^{RN*} D_d^{RN*} + (w^{RN*} - c) D_f^{RN*} - \frac{(e^{RN*})^2}{2} \quad \#(7)$$

$$\Pi_P^{RN*} = m^{RN*} D_f^{RN*} \quad \#(8)$$

2.3 Equilibrium Analysis with Private Label Introduction (RS)

In this section, the e-commerce platform introduces a private label (store brand, SB), and the decision-making sequence under this model follows: S1: The platform decides to introduce a private label. S2: The platform sets the margin m for reselling the national brand (NB) product, while the manufacturer determines its advertising investment level e . S3: The platform determines the selling price p_s of the SB product, while the manufacturer sets the direct sales price p_d for NB products in its own channel and the wholesale price w for supplying NB products to the platform; demand is then realized.

Under these conditions, consumers' utility functions are expressed as:

$$U_d^{RS} = e - p_d + \delta v \quad \#(9)$$

$$U_f^{RS} = v - m - w + \beta e \quad \#(10)$$

$$U_s^{RS} = \eta v \quad \#(11)$$

Based on the utility functions, the critical perceived value thresholds v_1^{RS} , v_2^{RS} , and v_3^{RS} are derived.

Accordingly, the demand functions for NB products in the direct channel, NB products in the platform channel, and SB products are given by:

$$D_d^{RS} = v_1^{RS} - v_2^{RS} = \frac{e - p_d + p_s}{\delta - \eta} - \frac{e + m - p_d + w - \beta e}{\delta - 1} \#(12)$$

$$D_f^{RS} = 1 - v_1^{RS} = \frac{e + m - p_d + w - \beta e}{\delta - 1} + 1 \#(13)$$

$$D_s^{RS} = v_2^{RS} - v_3^{RS} = -\frac{e - p_d + p_s}{\delta - \eta} - \frac{p_s}{\eta} \#(14)$$

The profit functions of the manufacturer and the platform are formulated as:

$$\Pi_M^{RS} = p_d D_d^{RS} + (w - c) D_f^{RS} - \frac{e^2}{2} \#(15)$$

$$\Pi_P^{RS} = m D_f^{RS} + p_s D_s^{RS} \#(16)$$

Under this scenario, the equilibrium solutions are obtained through a sequential optimization process. First, the manufacturer's profit function $\Pi_M^{RS}(p_d, w)$ and the platform's profit function $\Pi_P^{RS}(p_s)$ are differentiated with respect to p_d , w , and p_s , yielding the manufacturer's reaction direct price p_d , the platform's reaction wholesale price w , and the platform's reaction SB price p_s . Next, p_d , w , and p_s are substituted into the profit functions of both the manufacturer and the platform. By taking the first-order derivatives with respect to the advertising investment e and the platform margin m , the equilibrium advertising investment e^{RS*} and platform margin m^{RS*} are solved. Substituting e^{RS*} , m^{RS*} , p_d , w , and p_s back yields the equilibrium direct sales price p_d^{RS*} , equilibrium wholesale price w^{RS*} , and equilibrium SB price p_s^{RS*} . Finally, the equilibrium profits of the manufacturer and the platform can be calculated as:

$$\Pi_M^{RS*} = p_d^{RS*} D_d^{RS*} + (w^{RS*} - c) D_f^{RS*} - \frac{(e^{RS*})^2}{2} \#(17)$$

$$\Pi_P^{RS*} = m^{RS*} D_f^{RS*} + p_s^{RS*} D_s^{RS*} \#(18)$$

3.Strategic Effects and Numerical Simulations of Private Label Introduction

In the preceding sections, game-theoretic models were developed for two scenarios: one where the e-commerce platform does not introduce a private label, and the other where it does. The optimal equilibrium solutions for pricing, advertising investment, and profit extraction by both the manufacturer and the platform under each setting were derived. The theoretical analysis revealed the mechanisms through which the introduction of a private label influences key decision variables and the profit distribution among supply chain participants.

To further validate the theoretical findings and explore the sensitivity of game outcomes to changes in key parameters, this section conducts numerical simulations based on the derived equilibrium solutions. The analysis focuses on the impact of private label introduction on the manufacturer's wholesale pricing, direct channel pricing, advertising decisions, the platform's profit margin, and the respective profits of both parties. By simulating variations in critical parameters, the analysis aims to visually demonstrate how private label strategies shape the behavior of each participant within a dual-channel supply chain, thereby providing empirical support for practical managerial insights.

3.1 Impact of Private Label Introduction on the Manufacturer's Wholesale Price in the Resale Channel

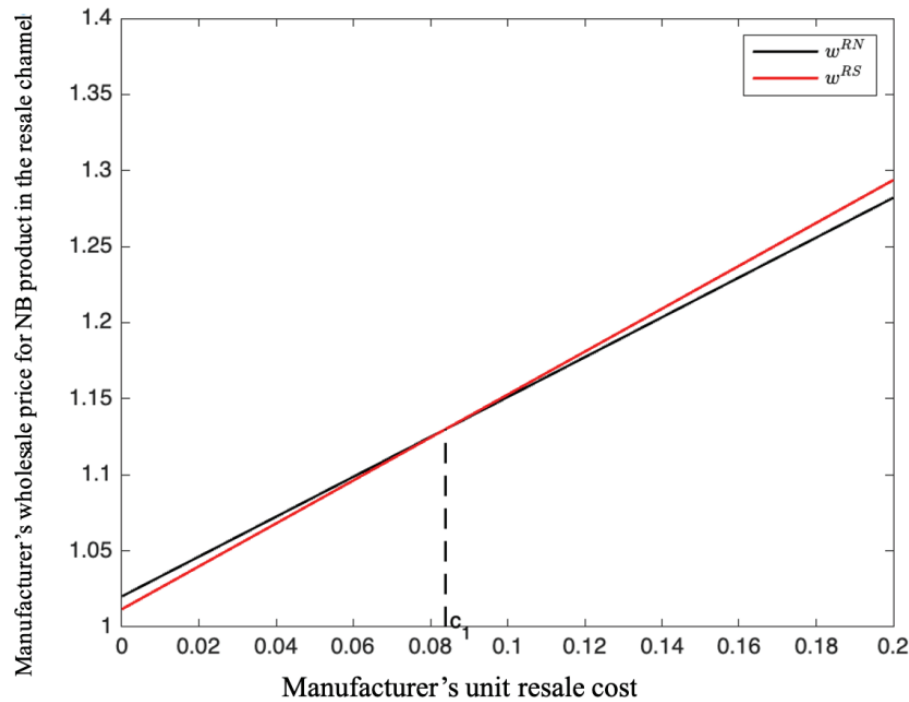
This section investigates how the manufacturer's wholesale price in the resale channel changes under two scenarios: with and without the introduction of a private label by the e-commerce platform. By comparing these settings, the analysis explores the influence of private label introduction on the manufacturer's pricing decisions, as stated in Proposition 1.

Proposition 1: There exists a threshold c_1 such that: (1) The introduction of a private label leads the manufacturer to reduce the wholesale price in the resale channel if and only if $c < c_1$; (2) The introduction of a private label leads the manufacturer to increase the wholesale price in the resale channel if and only if $c > c_1$.

This result indicates that the impact of private label introduction on the manufacturer's pricing strategy is contingent on the cost structure. When the manufacturer's resale cost is relatively low, competitive pressure from the platform's private label forces the manufacturer to lower the wholesale price to maintain the competitiveness of the national brand (NB) product in the platform channel, thereby preserving sales volume and profitability. Conversely, when the resale cost is high, the manufacturer responds to private label competition by raising the wholesale price to pass on part of the cost burden and

reduce dependence on the platform channel, thereby protecting its own profit margin.

Figure 1 Numerical Simulation of the Impact of Private Label Introduction on Wholesale Price in the Resale Channel



To further validate Proposition 1, a numerical simulation (Figure 1) illustrates the relationship between the manufacturer's unit resale cost and the wholesale price under scenarios with and without private label introduction. The horizontal axis represents the unit resale cost, while the vertical axis represents the manufacturer's wholesale price in the resale channel. The results show that as the unit resale cost increases, the wholesale price rises under both private label introduction (red line) and no private label introduction (black line). However, a critical threshold c_1 is observed: to the left of c_1 , private label introduction results in a lower wholesale price compared to the non-introduction case, whereas to the right of c_1 , the introduction of a private label leads to a higher wholesale price.

This finding suggests that when considering private label introduction, the e-commerce platform should carefully evaluate the manufacturer's cost structure. For manufacturers with low resale costs, introducing a private label may intensify price competition and compress the manufacturer's profit. In contrast, for manufacturers with high resale costs, private label introduction may prompt the manufacturer to raise wholesale prices, transferring costs to the platform and potentially affecting the platform's overall procurement cost and product competitiveness.

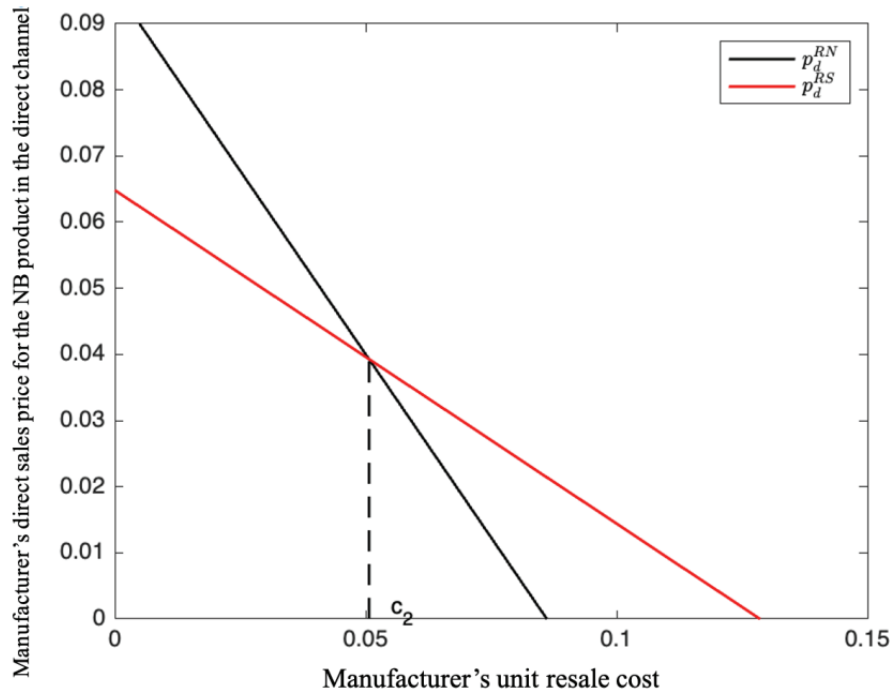
3.2 The Impact of Private Label Introduction on the Manufacturer's Pricing Strategy in the Direct Sales Channel for NB Products

This section analyzes how the introduction of a private label (Store Brand, SB) by the e-commerce platform affects the manufacturer's pricing strategy for national brand (NB) products in its self-operated direct sales channel. The results are summarized in Proposition 2.

Proposition 2: There exists a threshold c_2 such that: (1) Introducing a private label leads the manufacturer to lower the price of NB products in the direct sales channel if and only if $c < c_2$; (2) Introducing a private label leads the manufacturer to raise the price of NB products in the direct sales channel if and only if $c > c_2$.

This finding reflects the manufacturer's pricing incentives under different cost structures. When the unit cost of reselling NB products to the platform is relatively low, the introduction of a private label intensifies competition between the platform channel and the direct sales channel. To maintain sales and competitiveness in the direct channel, the manufacturer is inclined to lower the direct channel price to attract consumers. Conversely, when the unit resale cost is high, the manufacturer prefers raising the direct channel price to mitigate competitive pressure and preserve profit margins in the face of private label competition.

Figure 2 Numerical Simulation of the Impact of Private Label Introduction on NB Product Pricing in the Direct Sales Channel



To validate Proposition 2, a numerical simulation was conducted (see Figure 2). The horizontal axis represents the unit resale cost c for the manufacturer, and the vertical axis represents the selling price of NB products in the direct sales channel. The black line depicts the pricing without private label introduction, while the red line represents the pricing with private label introduction. The simulation shows that both pricing curves decline as c increases, intersecting at the critical threshold c_2 . For $c < c_2$, the red line is below the black line, indicating a lower price with private label introduction; for $c > c_2$, the red line exceeds the black line, indicating a higher price with private label introduction.

These results suggest that the e-commerce platform should carefully consider the manufacturer's resale cost structure when deciding to introduce a private label. The cost structure significantly influences the manufacturer's pricing behavior in the direct sales channel and thus affects the overall competitive dynamics within the dual-channel supply chain.

3.3 The Impact of Private Label Introduction on the Manufacturer's Advertising Investment Strategy

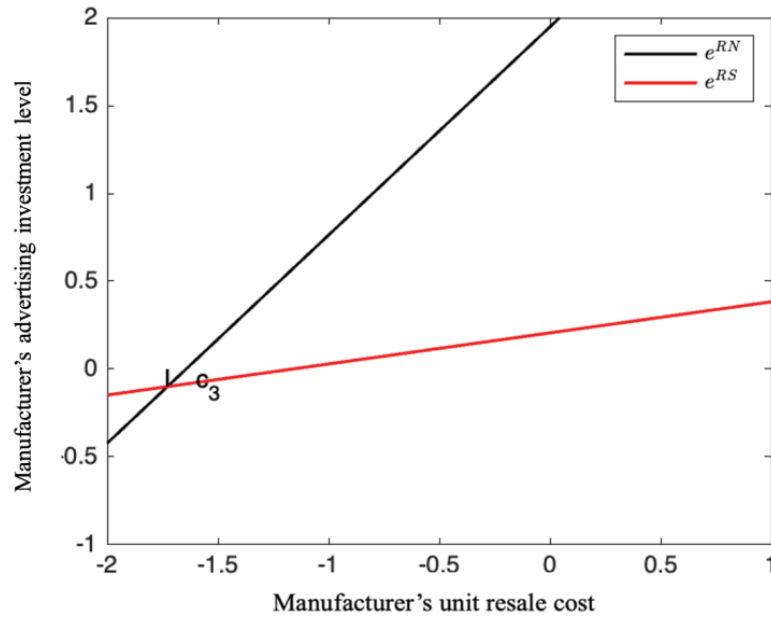
This section examines how the introduction of a private label (Store Brand, SB) by the e-commerce platform influences the manufacturer's advertising investment decision. The findings are summarized in Proposition 3.

Proposition 3: The manufacturer's advertising investment level without private label introduction is always higher than the advertising investment level with private label introduction.

This conclusion highlights the marginal effect of advertising under different competitive environments. When the platform does not introduce a private label, the manufacturer faces competition only within the NB product channel on the platform. In this context, advertising has a stronger marginal impact on increasing NB product sales and profits, thereby incentivizing the manufacturer to invest more in advertising to support sales. However, once the platform introduces a private label, the manufacturer faces intensified competition not only from the platform's private label but also from its own direct sales channel. As a result, the spillover effect of advertising diminishes, reducing its contribution to increasing sales and subsequently weakening the manufacturer's incentive to raise advertising investment.

To validate Proposition 3, a numerical simulation was conducted (see Figure 3). The horizontal axis represents the manufacturer's unit resale cost c , and the vertical axis represents the advertising investment level. The black line shows the advertising investment level without private label introduction, while the red line represents the investment level with private label introduction. The simulation shows that as c increases, the advertising investment level rises under both scenarios, but the two curves do not intersect at any point. The inequality $e^{RN*} > e^{RS*}$ holds consistently across the entire range, further validating Proposition 3.

Figure 3 Numerical Simulation of the Impact of Private Label Introduction on the Manufacturer's Advertising Investment



This result indicates that under private label introduction, the manufacturer's willingness to invest in advertising on the platform declines. Therefore, the platform should account for the potential reduction in advertising incentives and the possible impact on the overall allocation of promotional resources when formulating private label strategies.

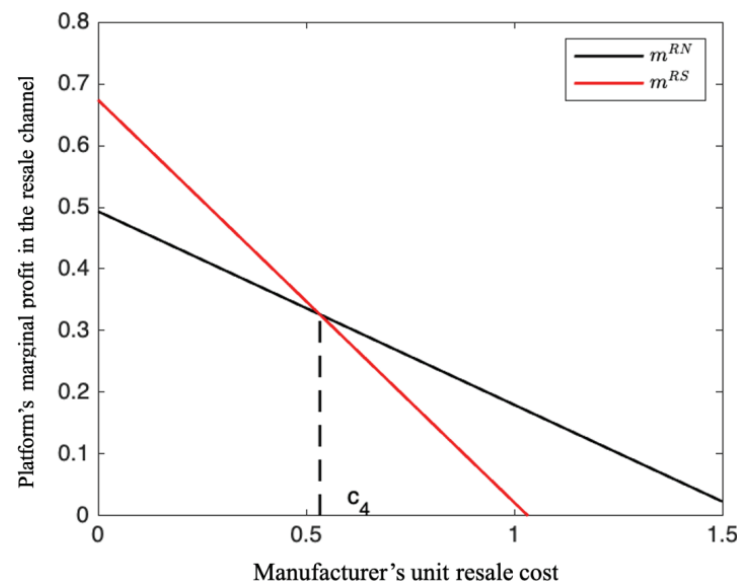
3.4 The Impact of Private Label Introduction on the E-Commerce Platform's Marginal Profit Decision in the Resale Channel

This section investigates how the introduction of a private label (Store Brand, SB) by the e-commerce platform influences its marginal profit decision regarding the resale of National Brand (NB) products, as summarized in Proposition 4.

Proposition 4: There exists a threshold c_4 such that: (1) The introduction of a private label leads the platform to increase the marginal profit in the resale channel if and only if $c < c_4$; (2) The introduction of a private label leads the platform to decrease the marginal profit in the resale channel if and only if $c > c_4$.

This conclusion reflects the platform's profit adjustment strategy under different manufacturer cost structures. When the manufacturer's unit resale cost is low, the platform can obtain greater profitability by raising the marginal profit, making private label introduction beneficial for enhancing resale channel returns. Conversely, when the manufacturer's unit resale cost is high, the platform faces rising costs and supply pressure, and thus may need to reduce the marginal profit to relieve channel pressure and maintain sales competitiveness.

Figure 4 Numerical Simulation of the Impact of Private Label Introduction on the Platform's Marginal Profit in the Resale Channel



To validate Proposition 4, a numerical simulation was conducted (see Figure 4). The horizontal axis represents the manufacturer's unit resale cost, and the vertical axis represents the platform's marginal profit in the resale channel. The black line shows the marginal profit without private label introduction, while the red line represents the marginal profit with private label introduction. The simulation results indicate that both curves decline as the unit resale cost increases, intersecting at the threshold c_4 . For $c < c_4$, the red line is above the black line, suggesting that private label introduction increases the platform's marginal profit. For $c > c_4$, the red line falls below the black line, indicating that private label introduction instead leads to a reduction in marginal profit.

This finding suggests that when deciding whether to introduce a private label, the e-commerce platform should comprehensively consider the manufacturer's cost level and its own need to adjust channel profitability. When the manufacturer's cost is low, private label introduction can enhance the platform's bargaining power and profit margin; however, when the manufacturer's cost is high, private label introduction may intensify channel competition pressure, requiring the platform to lower marginal profits to stabilize supply chain cooperation.

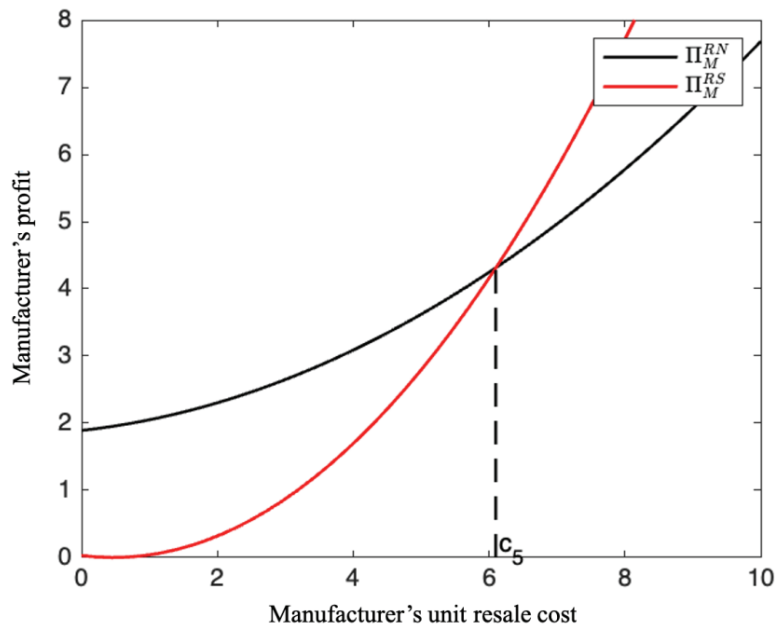
3.5 The Impact of Private Label Introduction on the Manufacturer's and Platform's Profit

This section examines how the introduction of a private label affects the profits of both the manufacturer and the e-commerce platform, as presented in Propositions 5 and 6.

Proposition 5: There exists a threshold c_5 such that: (1) The introduction of a private label reduces the manufacturer's profit if and only if $c < c_5$; (2) The introduction of a private label increases the manufacturer's profit if and only if $c > c_5$.

This result reveals that the manufacturer's profit is jointly influenced by the platform's private label introduction decision and the manufacturer's cost structure. When the manufacturer's unit resale cost is low, the marginal profit from the resale channel is relatively high. In this case, the introduction of a private label strengthens the platform's bargaining power, squeezes the manufacturer's profit margin in the resale channel, and leads to a decline in overall profit. Conversely, when the manufacturer's unit resale cost is high, the marginal profit from the resale channel is limited. To maintain channel competitiveness, the platform tends to lower the wholesale price and reduce channel margins. Under such conditions, introducing a private label alleviates downward price pressure on the manufacturer by partially substituting the resale channel with private label sales, thereby providing compensatory revenue and increasing the manufacturer's overall profit.

Figure 5 Numerical Simulation of the Impact of Private Label Introduction on the Manufacturer's Profit



To validate Proposition 5, a numerical simulation was conducted (see Figure 5). The horizontal axis represents the manufacturer's unit resale cost c , and the vertical axis represents the manufacturer's profit Π_M . The black line shows the manufacturer's profit without private label introduction, while the red line shows the profit with private label introduction. The simulation results indicate that both curves increase with rising c , intersecting at c_5 . For $c < c_5$, the red line lies below

the black line, implying that private label introduction reduces the manufacturer's profit. For $c > c_6$, the red line exceeds the black line, indicating that private label introduction improves the manufacturer's profit.

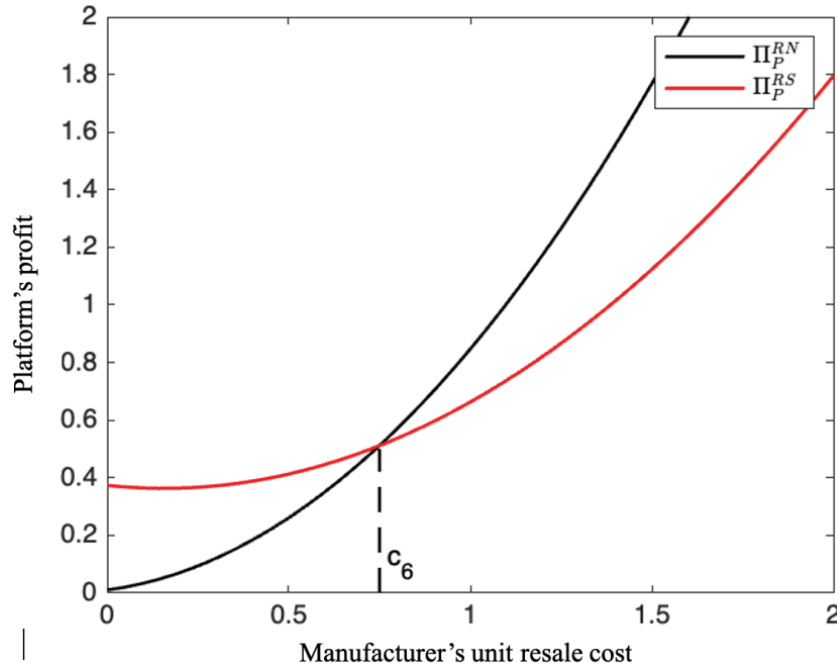
This finding suggests that when evaluating the impact of a platform's private label introduction, manufacturers should closely consider their own resale cost levels. For manufacturers with low resale costs, attention should be paid to the risk of profit compression due to private label competition. Conversely, for manufacturers with higher resale costs, private label introduction may help alleviate competitive pressure and enhance profit performance.

Proposition 6: There exists a threshold c_6 such that: (1) The introduction of a private label increases the platform's profit if and only if $c < c_6$; (2) The introduction of a private label decreases the platform's profit if and only if $c > c_6$.

This result highlights that the platform's profit is jointly influenced by the manufacturer's unit resale cost and the private label strategy. When the manufacturer's unit resale cost is low, the marginal profit from selling NB products through the resale channel is relatively high. Under such circumstances, the platform can further compress the manufacturer's bargaining power by introducing a private label, thereby enhancing its own profitability. Therefore, introducing a private label becomes a favorable strategy for boosting the platform's profit.

Conversely, when the manufacturer's unit resale cost is high, the marginal profit available from the resale channel diminishes. Even with a private label, the platform struggles to extract additional gains through price pressure. Moreover, the introduction of a private label may divert some consumer demand away from NB products toward the platform's private label (SB) products, reducing the sales and profitability of NB products and ultimately lowering the platform's overall profit. In such cases, the platform is more inclined not to introduce a private label, thereby maintaining channel stability and preserving NB product revenues.

Figure 6 Numerical Simulation of the Impact of Private Label Introduction on the Platform's Profit



To validate Proposition 6, a numerical simulation was conducted (see Figure 6). The horizontal axis represents the manufacturer's unit resale cost c , and the vertical axis represents the platform's profit Π_p . The black line shows the platform's profit without private label introduction, while the red line represents the platform's profit with private label introduction. The results indicate that both curves increase as c rises, intersecting at c_6 . The figure shows that when $c < c_6$, introducing a private label improves platform profit; whereas when $c > c_6$, introducing a private label reduces platform profit, making it more beneficial for the platform to retain the original resale model.

These findings suggest that, in determining whether to introduce a private label, the platform should carefully consider the manufacturer's unit resale cost. Introducing a private label can help expand profit margins when costs are low, while refraining from introducing a private label may help avoid profit loss due to market cannibalization when costs are high.

4. Conclusion and Future Directions

This study systematically investigates the strategic choice of private label introduction by e-commerce platforms under a dual-channel environment and its impact on the supply chain. By developing game-theoretic models for two scenarios—one in which the platform introduces a private label and one in which it does not—the research provides an in-depth analysis of the optimal decision-making behavior of manufacturers and platforms regarding pricing, advertising investment, wholesale pricing, marginal profit, and profit outcomes. The study not only derives equilibrium solutions for key variables but also employs numerical simulations to visually demonstrate the influence of private label introduction on both parties' strategies and profits. The results reveal that the introduction of a private label exerts dynamic effects on the relationship between manufacturers and platforms within the supply chain, with the direction and magnitude of these effects being contingent on critical parameters such as the manufacturer's unit resale cost. Specifically, when the unit resale cost is low, introducing a private label enhances the platform's profitability while compressing the manufacturer's profit margin; conversely, when the cost is high, private label introduction may increase the manufacturer's profit while reducing the platform's profit. This study offers theoretical insights and managerial implications for e-commerce platforms in formulating appropriate private label strategies under different cost structures.

Nevertheless, several limitations remain in this research. First, the model adopts simplified assumptions regarding consumer preferences, advertising effects, and market demand, without fully accounting for consumer heterogeneity and the influence of multidimensional perceived value on purchasing behavior. Second, the analysis is based on a static game model, failing to capture the long-term dynamics and strategy evolution within the supply chain. Future research could expand in several directions: (1) incorporating consumer behavior experiments or multi-source data for empirical validation to enhance the model's practical explanatory power; (2) employing dynamic game models or multi-stage decision frameworks to explore strategy evolution and equilibrium in long-term cooperation between platforms and manufacturers; and (3) extending the model to consider multiple manufacturers and competitive multi-platform environments to analyze strategic differences and coordination mechanisms in private label introduction. These expansions are expected to further enrich the theoretical framework for private label strategies under dual-channel settings and provide more adaptive theoretical and practical guidance for supply chain management and platform decision-making.

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Conflict of Interests

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Tianjin Trust's Path of Innovation Management Driven by Leadership

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Abstract: This paper explores Tianjin Trust Co., Ltd. 's leadership and innovative management practices in the process of responding to changes in the financial industry, focusing on analyzing the country's first market-oriented agreement restructuring service trust project and the case of building a digital trust service platform. By analyzing the current situation of leadership, difficulties and coping strategies of Tianjin Trust, and combining with management theory, this paper puts forward an improvement plan, aiming at providing reference for financial enterprises to cope with complex environment and achieve sustainable development.

Keywords: Tianjin Trust; Leadership Innovation; Organizational Collaboration; Leadership; Digitalization; Trust

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1.Introduction

1.1 Research Background and Importance

Tianjin Trust is a trust company with a strong reputation in China's financial sector, primarily offering wealth management, investment advisory, and asset management services. In recent years, as financial market competition intensifies and fintech rapidly advances, Tianjin Trust faces a contradiction between traditional management models and the demand for innovation. The company's leadership recognizes that only by enhancing innovation capabilities and leadership while maintaining steady growth in trust business can it effectively navigate the complex and volatile market environment.

Rooted in the trust industry for 44 years, Tianjin Trust has continuously expanded its business scope and deepened its professional expertise. However, the financial market landscape has grown increasingly complex, with competition reaching unprecedented levels. Homogeneous products among peers have squeezed profit margins in traditional trust businesses, while emerging fintech firms leverage cutting-edge technology to cross into the sector, capturing market share and posing significant challenges to traditional trust institutions.

Simultaneously, tightening regulatory policies impose stricter requirements on trust companies regarding compliance, risk management, and service quality. Client demands have also shifted from pure wealth accumulation to diversified asset allocation, personalized services, and digital convenience.

Against this backdrop, Tianjin Trust has decisively embraced change, taking two critical steps in innovation management. First, it launched a digital trust service platform project to integrate internal resources, optimize business processes, and expand market boundaries, positioning the company at the forefront of the digital wave. Second, in China's first market-

driven agreement restructuring service trust project, Tianjin Trust customized the “Tianjin Municipal Construction Group - Xinsheng No. 1” service trust for a subsidiary of Tianjin Municipal Construction Group, with a total scale of 79.4 billion yuan. This pioneering initiative adopted a “non-litigation + service trust” model, helping the enterprise revitalize existing assets, resolve legacy debts, and overcome operational difficulties. This innovative approach has since been widely replicated across multiple provinces and cities, becoming a benchmark for addressing similar industry challenges.

1.2 Research Objectives

Against the backdrop of accelerating globalization and digitalization, trust companies are facing increasingly complex challenges. As an established player in the industry, Tianjin Trust’s practice of promoting innovative management through leadership-driven initiatives holds profound significance. This paper analyzes two representative cases of Tianjin Trust’s innovation management: the nation’s first market-oriented agreement restructuring service trust project and the establishment of a digital trust service platform. It examines the current state of its leadership, the challenges encountered, and corresponding strategies. By integrating management theories, relevant improvement proposals are put forward, aiming to provide valuable experience for financial enterprises undergoing transformation and to promote sustainable development.

2. Analysis of the Current State of Leadership

2.1 Analysis of Current Leadership Status

In the current business environment, Tianjin Trust’s leadership primarily relies on traditional management approaches, emphasizing risk control and compliance.

However, with the rapid development of the market, this model faces numerous challenges that require adjustment and improvement.

Low Decision-Making Efficiency:

The centralized decision-making structure among leadership results in slow information flow and inadequate responsiveness to market changes. In a fast-evolving market environment, this makes it difficult to seize opportunities promptly and may lead to delayed reactions during emergencies, causing missed prospects.

Insufficient Innovation Drive:

There is limited investment in technological and service innovation, along with a lack of strategic innovation to counter emerging competitors. This makes it challenging to meet the increasingly diverse and personalized demands of clients, negatively impacting the company’s market competitiveness and future growth.

Talent Drain Issue:

The loss of high-end financial talent has become a bottleneck restricting Tianjin Trust’s innovative development. Problems in retaining and incentivizing younger-generation employees have led to difficulties in talent reserves, adversely affecting both short-term performance and long-term development.

In summary, Tianjin Trust’s current leadership situation faces multiple challenges, including inefficient decision-making, weak innovation drive, and talent attrition. The company must adjust and improve its leadership model, innovation strategy, and talent management to adapt to the rapidly changing market environment and achieve sustainable development.

2.2 Transformational leadership traits stand out prominently

Transformational Leadership Traits Prominently Displayed

Visionary Inspiration: In the digital trust service platform development project, senior leadership accurately discerned industry digitalization trends, proposing the grand vision of building a digital trust service platform. They translated industry trends into concrete objectives, motivating employees to dedicate themselves fully to realizing this vision. In the nation’s first market-oriented agreement restructuring service trust project, leadership seized opportunities, outlining a blueprint to assist distressed enterprises through innovative trust models while expanding the industry’s footprint, guiding the team forward with determination.

Intellectual Stimulation: During the digital project’s advancement, the leadership team encouraged members to break free from conventional thinking patterns. Faced with challenges such as new technology adoption and business process reengineering, they fostered bold innovation. For instance, when exploring blockchain integration into trust transactions,

leadership guided the team to reference case studies from leading international financial institutions, sparking fresh ideas and unlocking employee potential. In the service trust project, confronted with corporate debt restructuring and asset revitalization challenges, leadership inspired the team to draw on cases of diversified financial tool integration, ultimately pioneering a “non-litigation + service trust” model.

Effective Team Building and Empowerment

Elite Assembly: To meet digital project demands, management selected key talents from various business units and functional departments, forming a dedicated digital project team. The team comprised client managers, risk control experts, engineers, and operations specialists, whose diverse knowledge structures enabled them to tackle complex challenges. Similarly, the service trust project brought together legal professionals, audit experts, and project specialists for collaborative execution.

Rational Delegation: During digital project implementation, leadership granted the team autonomy in decision-making regarding budget allocation, preliminary technology selection, and minor process optimizations, minimizing bureaucratic reporting and fully mobilizing member initiative. In the service trust project, frontline teams were also granted appropriate authority to ensure efficient and smooth progress.

3. In-depth Analysis of Difficulties and Challenges Faced

3.1 Difficulties and challenges

Changes in the market environment: The rise of fintech and internet finance has subjected traditional trust businesses to intense competitive pressures. Tianjin Trust must innovate its business models and services while maintaining the stability of its conventional operations to meet increasingly diverse and personalized customer demands, thereby enhancing market competitiveness.

Lag in technological innovation: Against the backdrop of rapid internet technology advancements, Tianjin Trust’s traditional information management systems can no longer meet business needs. Insufficient investment in technological innovation has constrained the company’s ability to innovate in financial product design and customer service, making it difficult to keep pace with rapid market changes.

Organizational culture and transformation: Tianjin Trust’s traditional organizational culture is relatively conservative, with leadership hesitant to adopt new ideas and technologies. The lack of an efficient innovation incentive mechanism hampers employee motivation and creativity, adversely affecting the company’s innovative development.

3.2 Technological Innovation Bottlenecks

Internal Technological Shortcomings: Building a digital platform requires deep integration of cutting-edge financial technologies such as blockchain and big data analytics. However, the company’s internal technical team has long focused on traditional IT operations, with limited mastery of the underlying architectures and algorithmic logic of emerging technologies. This makes it difficult to select the most suitable technological path aligned with the company’s business architecture during the initial stages of technical evaluation, severely hindering project kickoff speed. Although the service trust project currently relies relatively less on technology, as industry digitization accelerates, subsequent introductions of digital management tools and online service solutions have exposed the technical team’s sluggish adaptation to new technologies.

External Collaboration Challenges: Due to internal technological constraints, bringing in external experts has become a solution. However, hiring high-end external technical talent is costly, and integrating them into the company’s specific business logic proves challenging, with slow and inefficient knowledge transfer. This prolongs the resolution of technical difficulties and causes continuous project delays, reflecting the leadership team’s lack of systematic planning and effective execution strategies in cross-boundary technological resource integration.

3.3 Organizational Coordination Faces Multiple Obstacles

Interdepartmental Interest Conflicts: Digital transformation projects involve multiple departments including business, risk control, technology, and operations. The existing interest structures of these departments are disrupted during project execution, leading to conflicts. Business units prioritize speed, risk control departments adhere to risk thresholds, technology teams emphasize system stability, and operations focus on process efficiency. These divergent demands create significant friction in critical areas such as data sharing and business process redesign, severely hindering project progress. Similarly,

service trust projects require cross-department collaboration, where tensions often arise between legal and business teams or finance and marketing departments, further impeding project advancement.

Skill Structure Mismatch: The existing workforce's expertise is primarily built around traditional trust business operations, with proficiency in conventional skills. However, the wave of digital transformation has increased demand for interdisciplinary talents skilled in fintech applications, data analytics, and digital product design. Current talent reserves fall short of project requirements, constraining development. In service trust project expansion, the need for professionals adept in corporate restructuring financial solutions and cross-industry resource integration has become increasingly prominent, yet internal talent pools remain inadequate.

Lack of Learning Incentives: During digital project implementation, employee motivation to acquire new knowledge and skills varies widely. Some employees, constrained by traditional mindsets, fear career risks associated with failed transformations. Although the company provides one-time learning subsidies, the absence of systematic career development guidance leaves employees unable to connect skill enhancement with long-term career growth. Consequently, learning motivation wanes, resulting in talent skill updates lagging behind project demands. Similar issues arise in service trust project training, where uneven participation and a lack of sustainable incentive mechanisms persist.

4. Analysis of Relevant Theories and Tools

4.1 Leadership Theory

Transformational leadership theory, proposed by political sociologist Burns, emphasizes that leaders inspire subordinates by making them aware of the significance and responsibility of tasks, thereby stimulating higher-level needs and motivating them to transcend personal interests for the benefit of the team, organization, and broader political goals. The core components of this theory include charisma, inspirational motivation, intellectual stimulation, and individualized consideration. It enhances mutual motivation and moral standards, optimizes interactions among organizational members, and drives adaptive organizational change, with a strong focus on emotions and values. In practice, transformational leadership can effectively unlock employee potential, foster teamwork, and improve organizational performance and competitiveness. Applying this theory to analyze the current leadership at Tianjin Trust, the leadership team needs to shift toward a more forward-looking, innovation-encouraging, and change-oriented style, rather than relying solely on stability and risk control.

4.2 SWOT Analysis

Strengths : Tianjin Trust, established in 1980, is one of China's earliest trust and investment institutions, with a 44-year development history and a strong brand reputation. In 2024, it was awarded the "Integrity Trust" industry culture award and recognized by WUPO 2023 as one of China's "50 Outstanding Financial Service Institutions" and "50 Outstanding Brands" in the bankruptcy and special assets industry. The company has gradually developed a risk-averse and stability-first risk control philosophy, adopting a compliant and prudent management style. It has established a comprehensive risk management system covering multiple risks and provides financial services and tools for risk management to its group industries.

Weaknesses : Despite attempts in some areas, overall innovation capabilities remain insufficient. Although it received capital injection at the end of 2023, its operating income and net profit fluctuated significantly between 2021 and 2023, reflecting challenges in business innovation and market expansion. The digital transformation of the trust industry requires interdisciplinary talent with expertise in fintech, which is relatively scarce in the market. Trust companies struggle to recruit sufficient professionals, and the rapid pace of technological advancements in fintech creates a lag in technology updates for trust companies.

Opportunities : The rapid development of internet finance and fintech provides Tianjin Trust with opportunities to leverage emerging technologies to enhance service efficiency and customer experience. Examples include the construction of the PBOC's second-generation credit reporting system, optimization of investor app functionality and customer satisfaction, and the launch of a client manager app project. The growing market demand for customized wealth management also presents new business opportunities. Tianjin Trust has actively explored charitable trusts and family trusts, successfully establishing 17 charitable trusts with a cumulative trust scale exceeding 13 million yuan.

Threats : The rise of emerging fintech companies and internet finance platforms poses competitive threats to traditional trust

companies. These platforms exhibit greater flexibility and innovation, enabling them to respond quickly to market changes and offer more competitive products and services. The trust industry faces stringent regulatory policies, and policy uncertainty increases operational risks. Traditional businesses such as financing, channel services, and fund pools are becoming unsustainable, necessitating transformation. Additionally, the digital transformation process requires compliance with a series of regulatory requirements, presenting compliance challenges amid the rapid development of fintech and evolving policies.

4.3 Innovation Management Tools

Open Innovation : Enterprises accelerate innovation by deliberately leveraging external and internal knowledge flows, combining internal and external ideas. For Tianjin Trust, this could involve collaborating with external tech companies to develop intelligent advisory systems, using big data and AI to provide personalized investment advice; partnering with universities to establish industry-academia-research mechanisms for fintech innovation projects and talent cultivation; and building an innovation ecosystem by setting up innovation labs and inviting external experts and entrepreneurs to explore new business models and technological applications.

Blue Ocean Strategy : Enterprises create new market demand by exploring uncontested market spaces, achieving differentiated competition and high-profit growth. Tianjin Trust could explore new business areas, such as developing pension trust products; offering customized solutions like family trusts and charitable trusts for high-net-worth clients; expanding service scope through fintech, such as supply chain finance trust products; and engaging in cross-industry collaborations, such as partnering with real estate firms to develop REITs.

4.4 Implementation Steps

Establish an Open Innovation Mechanism : Set up an innovation department to manage external partnerships and innovation projects; build collaboration channels with tech companies, universities, and research institutions, signing long-term agreements; and regularly evaluate collaboration outcomes to ensure practical business applications.

Implement the Blue Ocean Strategy : Conduct market research to identify customer needs and market gaps, pinpointing potential blue ocean markets; develop new products and services based on findings to meet specific client needs; pilot test with select customer groups, gathering feedback for optimization; and scale up successful pilots to explore new market spaces.

Through open innovation and the blue ocean strategy, Tianjin Trust can effectively enhance its innovation capabilities, accelerate product and service innovation, and carve out new market spaces to stand out in a highly competitive market.

5.Approaches and Solutions

5.1 Promoting Leadership Transformation

Cultivate transformative leaders by enhancing the innovation mindset and strategic vision of the leadership team, placing greater emphasis on employee interaction, stimulating creativity, and establishing a more flexible decision-making mechanism.

5.2 Strengthening Technological Innovation and Fintech Applications

Allocate additional resources to technological innovation, develop an agile information management system, and integrate advanced technologies such as artificial intelligence and big data analytics to elevate customer service experiences, optimize risk management, and design customized financial products.

5.3 Optimizing Talent Management Mechanisms

Establish a robust talent recruitment and incentive system to attract and retain top-tier financial and technological professionals, particularly young specialists. By enhancing employees' sense of involvement and achievement, the team's innovative capabilities can be strengthened.

5.4 Cross-Border Collaboration and Open Innovation

Through partnerships with technology firms and internet platforms, external innovation resources can be introduced to expand the breadth and depth of business operations. Leveraging external expertise enables rapid development of new products and exploration of untapped market segments.

6.Improvement Measures

Implement diversified leadership styles: Leadership should adapt their approach based on different scenarios, combining the strengths of transformative and transactional leadership to strike a balance between innovation and risk control.

Optimize strategic decision-making processes: Decentralize decision-making to improve efficiency, encouraging swift responses to market changes in new business expansions and innovation projects.

Foster an innovation culture: Through internal training and incentive mechanisms, cultivate innovative thinking, encouraging employees to actively participate in product and service innovation, thereby creating a conducive environment for creativity.

Enhance data-driven decision-making: Utilize big data and AI technologies to refine trust product design and risk assessment, improving the company's responsiveness to market demands and the competitiveness of its products.

7.Conclusion

In the process of digital transformation and innovation management, Tianjin Trust faces multiple challenges such as technical bottlenecks, organizational collaboration and talent incentives. By strengthening external cooperation, improving organizational collaboration efficiency and improving talent management mechanism, the company can gradually overcome these difficulties and lay the foundation for future sustainable development. Driven by leadership, Tianjin Trust will surely move towards a more brilliant tomorrow and move forward steadily in the fierce market competition.

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Conflict of Interests

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Exploring Nostalgic Narrative Patterns in Documentaries: An Emotion Computing-Based Analysis

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Abstract: As a media form emphasizing authenticity, the emotional construction function of documentaries has not been adequately explored in existing literature. This study systematically reviews emotional construction theory through a comprehensive literature analysis, with a particular focus on the expression mechanisms of nostalgic emotions. By employing sentiment computing technology and utilizing the LTP text analysis platform, both quantitative and qualitative analyses were performed on three documentaries, including *Visages villages*. The findings effectively confirm the following: (1) there is a significant positive correlation between documentary language texts and audience comment emotional tendencies; (2) nostalgic narratives predominantly follow a “negative-positive” redemption sequence pattern; (3) the intensity of emotional arousal is negatively correlated with the discrepancy between expectation and reality; (4) the results substantiate the theoretical hypothesis that nostalgia functions as a defense mechanism against modernity. This study contributes methodological insights for the emotional construction of documentaries while acknowledging limitations in sample representativeness and computational depth.

Keywords: Documentary; Emotion Computing; Nostalgia; Emotion Construction; Narrative Mode

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1.Nostalgia and the Rules of Nostalgic Narrative

Nostalgia, as a complex socio-psychological phenomenon, has evolved significantly—from its early conception as a pathological condition to its contemporary understanding as a positive psychological function. Etymologically, the term derives from the Greek words *nostos* (return home) and *algos* (pain), originally denoting a medical disorder induced by severe homesickness (Xue & Huang, 2011). By the late 20th century, sociological scholarship redefined nostalgia beyond its clinical origins. Davis (1979), through empirical research, broadened its scope from mere geographical longing to an emotional attachment to idealized past experiences, highlighting its association with positive affective memories. Harvard scholar Svetlana Boym (2001) further theorized nostalgia as a cultural response to modernity, arguing that it functions as a psychological defense mechanism against rapid societal fragmentation, fulfilling an innate human desire for temporal continuity.

Current psychological research has overcome earlier cognitive limitations that associated nostalgia primarily with negative affect. Health psychology studies demonstrate that nostalgia correlates not with sadness or depression, but rather constitutes

a distinct emotional experience (Farrié et al., 2021). Functioning as an adaptive psychological resource, nostalgia alleviates loneliness by activating autobiographical memories, thereby enhancing resilience against existential threats and reducing negative emotional states (Wildschut et al., 2006). Specifically, nostalgia serves four key psychological functions: Emotion regulation, Hedonic enhancement, Social connection reinforcement, Positive self-identity development (Abakoumkin & Green, 2021; Wildschut et al., 2006).

Despite its complexity, nostalgia follows identifiable emotional patterns (Feeling Rules). Empirical research has identified three primary triggering contexts: 1. Fear and uncertainty (Routledge et al., 2008); 2. Social exclusion (Wildschut et al., 2006); 3. Existential anxiety (Davis, 1979). From a narrative perspective, Wildschut et al. (2006) demonstrate that nostalgic recollections typically involve: Diverse objects (e.g., significant people, life events); Common triggers (e.g., loneliness, sadness); Distinct self-oriented characteristics. This framework reveals nostalgia's compensatory psychological function, where initial narratives of loss or disappointment systematically transition to resolutions of success or transcendence, facilitating emotional equilibrium (McAdams et al., 2001). McAdams and colleagues established two fundamental narrative patterns: 1. Redemption sequences (negative-to-positive transitions) - the predominant form; 2. Contamination sequences (positive-to-negative transitions).

Therefore, society often regulates and standardizes the public expression of emotions by constructing specific rules of expression. These rules not only profoundly influence individuals' perceptions and responses to others and their environment but also may facilitate the restructuring of cognitive frameworks, even stimulating behavior guided by emotions. They can be revised and polished to better meet the requirements for academic paper publication. Thus, delving into the strategies for generating and regulating nostalgic emotions in highly empathetic documentary works is crucial for understanding and optimizing the potential of documentaries in leveraging nostalgic emotions, both theoretically and practically.

2. Emotion Computing: Theory and Applications

2.1 Emotional computing theory and computing platform setting

Emotional computing, as an interdisciplinary research field, can trace its theoretical foundation to the systematic framework proposed by Picard (1997). This theory incorporates human emotional phenomena into a computable domain, establishing computational models for the mechanisms of emotion generation, recognition techniques, representation methods, and their influencing factors. In the field of text analysis, emotional computing is specifically manifested in methodological systems such as sentiment analysis and tendency analysis, with the core task being the systematic processing and reasoning of subjective texts that carry emotional tendencies. This theoretical framework provides crucial methodological support for the quantitative study of cultural products (Luo & Pan, 2003).

As computational linguistics advances, affective computing methods have primarily formed two major technical paths (Wankhade et al., 2022). Machine learning-based approaches rely on large-scale annotated datasets and use supervised learning to build classification models, but they have significant limitations in domain adaptability. In contrast, semantic dictionary-based methods achieve unsupervised analysis by constructing sentiment dictionaries, offering better cross-domain applicability and thus becoming the mainstream approach in cultural product analysis. In practical applications, affective computing technology has demonstrated significant value in academic research and public opinion analysis, especially in handling subjective texts, where it has unique advantages (Sánchez-Rada & Iglesias, 2019).

This study employs the Language Technology Platform (LTP) developed by Harbin Institute of Technology as an analytical tool, which boasts significant technical advantages. It integrates a complete technical chain for Chinese word usage, syntax, and semantic analysis, achieving outstanding results in multiple international evaluations. Notably, its syntactic and semantic analysis technologies topped the CoN-LL2009 international evaluation (Liu et al., 2011). These excellent evaluation results indicate that LTP has a certain level of reliability in Chinese sentiment computing, providing solid technical support for research.

2.2 Research Design and Case Selection Methodology

This study selects three documentaries, *My Love, Don't Cross That River* (South Korea), *Visages villages* (France) and

Searching for Sugar Man(USA/Sweden), as the text objects of nostalgic emotion research, mainly based on the following research considerations:

First, based on the constructability of nostalgic emotions, this study aims to explore the mechanisms of constructing nostalgic emotions in documentaries with significant empathetic effects. To systematically analyze the generation rules of nostalgic emotions, the emotional communication effectiveness of documentaries was given special consideration during the case selection process. Korkontzelos et al(2016). have shown that forums are important sources for sentiment analysis, which can serve as a basis for analyzing emotions in specific fields. Douban is one of the largest and most authoritative review websites in China(Xia & Dong, 2019),, with a broad user base and representativeness (Zhang et al., 2015). Moreover, as the most widely used movie forum in China, its movie reviews and ratings can effectively reflect the preferences of Chinese audiences(Chen & Liu, 2021). The more reviews there are, the higher the audiences attention to the documentary. Higher ratings indicate greater emotional satisfaction with the documentary. Based on this, this paper selects the movie section of Douban as the search platform for documentary cases, using “documentary” and “moving” as keywords for searches. Five documentaries were found with over 40,000 reviews and ratings above 9: *The Cove(USA)*, *Searching for Sugar Man*, *Twenty-Two(CHINA)*, *Visages villages*, and *My Love, Don’t Cross That River*.

Second, from the perspective of narrative dynamics, The Cove and Twenty-Two are emotionally driven by anger; the former criticizes dolphin slaughter, while the latter denounces the atrocities of war. In contrast, the three documentaries My Love, Don’t Cross That River, Visages villages, and Searching for Sugar Man exhibit a distinct sense of nostalgia. My Love, Don’t Cross That River uses the daily lives of elderly couples as a vehicle, capturing their deep affection through delicate cinematography, evoking resonance with traditional intimate relationships among viewers; Visages villages captures fleeting moments of ordinary peoples lives in a random manner, showcasing the diversity of contemporary society while subtly expressing nostalgia for traditional lifestyles; Searching for Sugar Man reconstructs musical cultural memories from the 1960s and 1970s through the journey of rediscovering forgotten musicians, reinforcing nostalgic sentiments in the process of searching and pursuing dreams. Although these three works employ different narrative techniques, they all evoke viewers reminiscence and reflection on past times, pure emotions, and ideal values through specific and subtle humanistic care.

The method of encoding emotions is manifested through the narration of language. Therefore, emotional tendencies can be analyzed through language to understand the rules of emotional encoding (Tan, 2022). Rafael Baroni (Raphael Baroni,2015) believes that in the study of emotions, there are two equally important issues: one is the internal structure of linguistic texts, and the other is the interaction between the creators and interpreters of these texts. Even the most personal emotional experiences are shaped by the emotional vocabulary in their language and the behaviors derived from these words(Rosaldo R.,1980). Thus, this paper takes the linguistic texts of these three documentaries as objects, setting them as targets for emotional computation. The linguistic texts include dialogue, narration, music, subtitles, and all other textual forms in the documentaries.

3.The calculation and analysis of nostalgic emotions

This paper leverages sentiment computing technology, the python program, and the LTP Sentiment Computing Platform developed by Harbin Institute of Technology to extract, identify, analyze, and calculate the emotional values of language texts from three documentaries. Based on these emotional values, the emotional tendencies of the documentary’s language text are determined. Within the framework of sentiment analysis, emotional values are defined within a standardized range of 0 to 1, with specific scores within this range used to finely categorize the emotional tendency of the text. Specifically, when the emotional value reaches or exceeds the threshold of 0.7, the system intelligently automatically identifies and classifies the text as positive; conversely, if the emotional value drops to 0.3 or below, the system determines that the text is negative. For texts with emotional values precisely between 0.3 and 0.7, the system conservatively classifies them as neutral, reflecting the subtle layers and complexity of emotional expression. This classification mechanism ensures the accuracy and comprehensiveness of sentiment analysis.

3.1 Analysis of holistic emotional tendency

According to the classification criteria of emotional tendency, documentaries are categorized into three types: positive, negative, and neutral. Based on this, the proportion of each type of emotion was calculated. In the calculation of proportions, the principle of rounding was followed. The overall distribution of emotional tendencies in the three documentaries is shown in (Table 1):

Table 1 Overall emotional tendency of documentaries

Sequence	Documentary Title	Language text (No. of total)	negative (Number/percentage)	neutral (Number/percentage)	positive (Number/percentage)
1	Visages villages	1363	259(19%)	793(58.2%)	311(22.8%)
2	Searching for Sugar Man	1378	286(20.8%)	777(56.4%)	315(22.9%)
3	Dear, Do Not Cross That River	586	134(22.9%)	287(49%)	165(28.2%)

From the quantitative data in the table above, it is clear that neutral language texts significantly dominate in the three documentaries. This statistical result profoundly reveals the high degree of objectivity reflected in documentary language at an overall level. However, even though objectivity is a core characteristic of documentary language construction, it cannot be overlooked that the language texts of Visages villages, Searching for Sugar Man, and Dear, Do Not Cross That River also prominently incorporate biased features. Further analysis shows that in these documentaries, positive language texts significantly outnumber negative ones, thus presenting an overall positive emotional orientation. This finding also challenges the traditional notion of emphasizing the objectivity of documentaries.

To further investigate whether the emotional tendencies in documentaries directly influence the audiences emotional attitudes, the Octopus Data Collection System was used to extract 600 relevant comments from three documentaries on Douban. After manual cleaning^[1], the effective comment data from the audience were subjected to sentiment analysis, with the specific distribution of emotions shown in (Table 2).

Table 2 Distribution of emotional tendencies in effective comments on documentaries

Sequence	Documentary Title	Effective comments (No. of total)	negative (Number/percentage)	neutrality (Number/percentage)	positive (Number/percentage)
1	Visages villages	564	50(8.9%)	98(17.4%)	416(73.8%)
2	Searching for Sugar Man	524	49(9.4%)	84(16%)	391(74.6%)
3	Dear, Do Not Cross That River	551	63(11.4%)	67(12.2%)	421(76.4%)

In descending order, the emotional tendencies of the language text and comment text of the two tables are ranked. The results of the ranking are shown in the table below.

[1] Due to the randomness of information release in the internet context, comment information is prone to the following issues. For example, non-standard formats, incorrect or irrelevant information, and blank entries. Therefore, it is necessary to manually clean the data captured by computer programs. The specific content of data cleaning includes: (1) manually removing blank and invalid comments. (2) manually deleting marketing advertisements, spam, and other content unrelated to documentaries. (3) manually filling in all missing data. For instance, completing abbreviations. (4) using WPS's translation and traditional-to-simplified Chinese conversion functions to convert English and traditional Chinese comments into simplified Chinese. Through document proofreading, correcting typos, punctuation errors, and other misinformation. (5) manually removing special symbols that cannot be identified. After data cleaning, effective comment data is ultimately obtained.

Table 3 ranks the emotional tendencies of documentary language texts and commentaries

Sentimental tendencies	Sorting of emotional tendencies in language texts	Sorting of sentiment tendencies in the comment text	Compare results
negative	3>2>1	3>2>1	unanimous
positive	3>2>1	3>2>1	unanimous
neutrality	1>2>3	1>2>3	unanimous

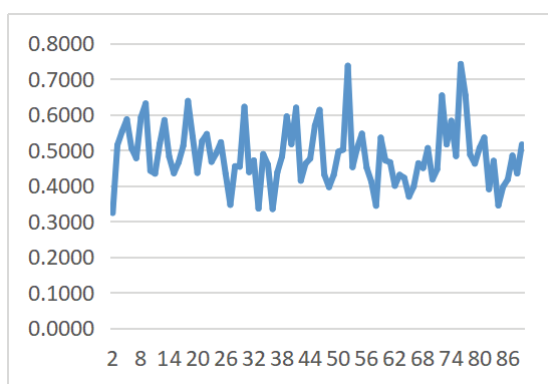
This study found through comparative analysis of emotional tendencies that the audiences emotional responses to three documentaries (My Love, Don't Cross That River, Visages villages, Searching for Sugar Man) show a significant positive correlation with the emotional tendencies embedded in their language texts. This result supports the significant impact of documentary language texts on audience emotional reactions, confirms the effectiveness of documentaries as media for emotional transmission, and highlights the central role of language in the emotional expression of documentaries.

It is worth noting that the research findings do not support the assumption that documentaries must align with audience emotional expectations. Taking My Love, Don't Cross That River as an example, the birthday argument segment (44:08-47:45) in the documentary elicited strong emotional responses from viewers (average emotional value = 0.2458), with significantly more comments (16 times) compared to other segments. This phenomenon aligns with the predictions of Affect Control Theory (Averett C P, Heise D R., 1987), when there is a significant discrepancy between basic sentiments (fundamental sentiments, such as "children should be filial to their parents") and temporary impressions (transient impressions, such as "children argue on their mothers birthday"), it triggers intense emotional arousal (MacKinnon N J., 1994). Data analysis shows that the degree of affective discrepancy is significantly negatively correlated with arousal intensity.

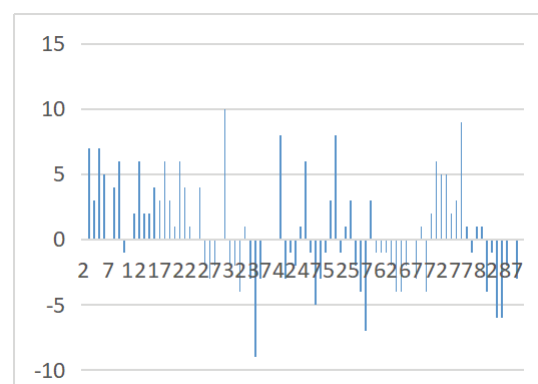
Based on empirical findings, this study validates the dual-emotion mechanism model: (1) emotional tendency is positively correlated with expectation consistency; (2) the intensity of emotional arousal is negatively correlated with expectation consistency. This model reveals the dynamic interaction between basic sentiments and temporary impressions during the process of emotional arousal, as well as the psychological regulatory mechanisms by which individuals maintain consistency in their sentiments.

2.2 Emotional flow analysis

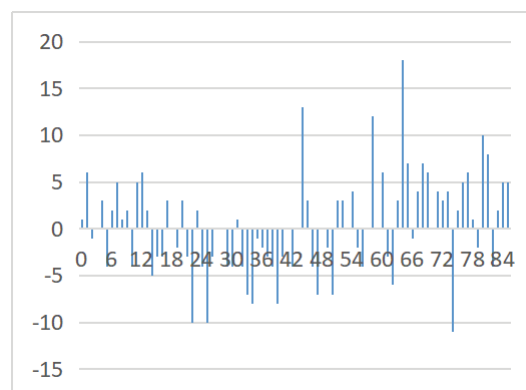
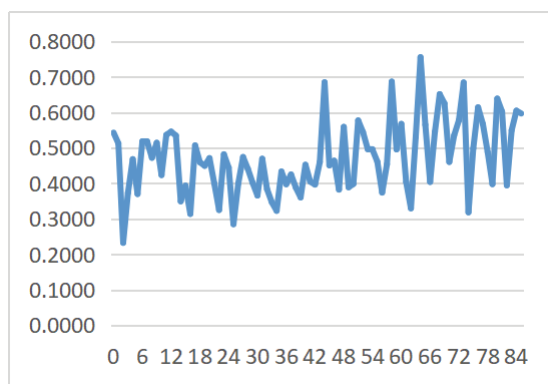
To systematically examine the dynamic characteristics of emotional flow in documentaries, this study employs quantitative analysis methods. It calculates the moving average of emotional values on a per-minute basis and plots the curve of emotional value changes. At the same time, it counts the number of emotionally charged statements per minute to generate an emotional tendency distribution chart. The horizontal axis (X-axis) represents the time series, while the vertical axis (Y-axis) indicates the emotional intensity values and the frequency of emotionally charged statements, respectively. Through dual-dimensional visualization analysis, one can simultaneously observe the overall trend of emotional intensity (change chart) and the spatiotemporal distribution characteristics of emotional energy (distribution chart).



The emotional value change chart of Visages villages



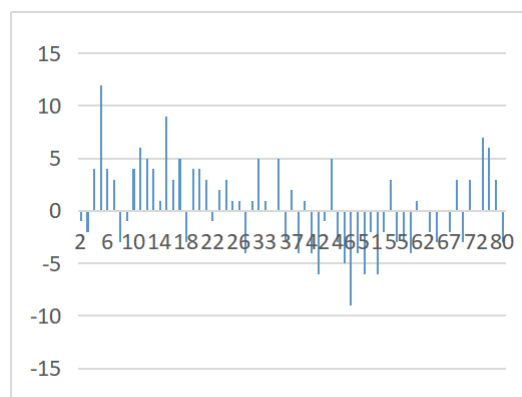
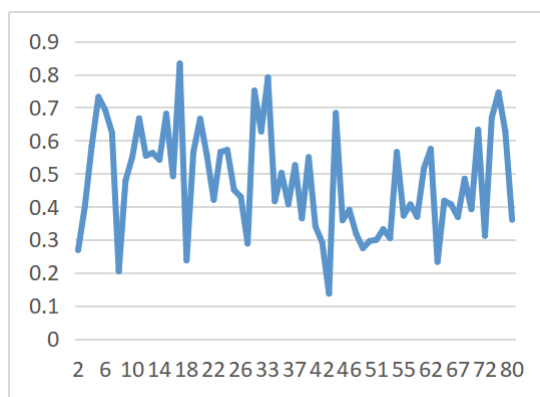
The distribution of emotional tendencies in Visages villages



The emotional value change chart of Searching for Sugar Man The distribution of emotional tendencies in Searching for Sugar Man

From a narratological perspective, both Visages villages and Searching for Sugar Man adopt the classic “quest-fulfillment” (seeking and obtaining) narrative paradigm. The narrative structure of Visages villages embodies the “reflective nostalgia” (reflective nostalgia) characteristic defined by Boym (2001). The documentary employs a random sampling approach to encounters, constructing a non-linear “memory puzzle” narrative framework. In this framework, faces serve as material carriers of spatiotemporal relationships, not only evoking memories of simple lifestyles in pre-industrial times (Davis, 1979) but also re-coding collective memory at the semiotic level, thereby reinforcing the increasingly weakened sense of community in modern society (Abakoumkin & Green, 2021). Searching for Sugar Man, as a typical text of compensatory nostalgia (compensatory nostalgia), empirically verifies Wildschut et al. s (2006) threefold model of nostalgic psychology through the narrative of musician Rodriguezs search: reconstructing self-continuity at the individual level, fostering weak ties at the social level, and rediscovering the meaning of life at the ontological level.

Quantitative analysis reveals that the emotional curve exhibits a clear monotonically increasing trend: initial emotional confusion gradually transforms into positive emotions by the final stage of the narrative. This mechanism of emotional transition aligns closely with McAdamss (2001) “Redemption Sequence” (redemption sequence) theory. Notably, this shift from negative to positive emotions is not a simple linear process but rather a nonlinear leap achieved through dialectical movements within symbolic systems (such as the interaction between spatial symbols in Visages villages and musical symbols in Searching for Sugar Man). This finding not only confirms the dominant role of positive emotional transformation in nostalgic narratives but also highlights how media texts regulate collective emotional structures through symbolic manipulation.



The emotional value change chart of My Love, Don't Cross That River

My Love, Don't Cross That River emotional tendency distribution map

From the quantitative analysis results, the emotional value changes in My Love, Don't Cross That River exhibit significant fluctuation characteristics, showing a clear difference from the unidirectional emotional development pattern of traditional

redemption sequences (redemption sequence). Specifically, the film reaches a critical emotional turning point at the 33-minute mark. The director employs the artistic technique of cumulative montage (cumulative montage) to organically integrate highly emotionally charged scenes such as the old man recalling his deceased son, preparing funeral clothes, and the death of his pet, forming an emotional sequence (emotional sequence) centered on grief.

It is worth noting that the directors emotional handling strategy is not a simple presentation of sorrow but achieves a dialectical development of emotion through meticulous symbolic juxtaposition (symbolic juxtaposition). Specifically, this is manifested in the artistic juxtaposition of the aforementioned scenes of sorrow with secular symbols symbolizing lifes continuity, such as the birthday celebration (43 15 “) and the birth of a new dog (58 22”). Particularly, at the end, the use of psychological montage (psychological montage) technique, through a scene where “the deceased grandfather” speaks across time and space amidst a cluster of flowers, achieves a reconfiguration of existential meaning. This narrative strategy constructs a unique “sorrow-hope” dialectical emotional structure (dialectical emotional structure). This emotional narrative structure effectively alleviates the audiences existential anxiety about death and demonstrates the nostalgic function of emotional regulation.

From the perspective of affective dynamics (affective dynamics), this “roller coaster” -style emotional flow pattern with large-amplitude fluctuations has dual theoretical significance: Firstly, it breaks through the unidirectional paradigm of traditional pollution sequence (contamination sequence) in emotional development. By regularly alternating between positive and negative emotions, it avoids both the audiences emotional fatigue (emotional fatigue) caused by prolonged negative emotions and the potential emotional flattening (emotional flattening) resulting from excessive positivity; Secondly, through precise emotional rhythm control (emotional rhythm modulation), it effectively maintains the audiences emotional engagement (emotional engagement). This finding provides empirical support for the application of the “hook theory” (hook theory) in documentary emotional management, suggesting that sustained excitement points can maintain the audiences continuous viewing interest and enthusiasm(Ren,2008).

4.Conclusion

This study systematically examines the theoretical lineage and empirical manifestations of nostalgia to reveal the mechanisms of nostalgia construction in documentaries. The research finds that, against the backdrop of rapid social change, nostalgia serves as an important psychological defense mechanism, with its construction process following specific emotional rules: (1) often triggered by negative situations such as fear and disconnection; (2) achieving emotional balance through a sequence of redemptive narratives; (3) capable of reconstructing cognitive schemas and guiding behavioral tendencies. These findings deepen our understanding of the social functions of nostalgia and provide a theoretical basis for the nostalgic narratives in cultural products.

In terms of methodology, this study innovatively integrates affective computing theory with qualitative analysis methods, leveraging the Affective Computing Platform at Harbin Institute of Technology to conduct multidimensional analyses of the linguistic texts and audience reviews from three documentaries: *Visages villages*, *Searching for Sugar Man*, and *My Love, Don't Cross That River*. Quantitative research results show: 1) There is a significant positive correlation between the emotional tendencies in documentary language texts and audience reviews, confirming the effectiveness of documentaries as emotional media; 2) The intensity of emotional arousal is negatively correlated with expectation consistency, supporting the core perspective of affect control theory on the dynamic interaction between basic sentiments and temporary impressions. These findings not only expand the theoretical framework for media emotional communication but also provide empirical evidence for documentary production.

Through the visualization analysis of emotion value change graphs and tendency distribution charts, this study further reveals the narrative patterns of emotional flow in documentaries: *Visages villages* and *Searching for Sugar Man* exhibit typical redemption sequences (redemption sequence), with emotional curves showing a monotonically ascending trend; whereas “*Dear, Do Not Cross That River*” demonstrates complex emotional dynamics, with significantly higher emotional amplitude than the first two works. It achieves an artistic balance of emotional tension through a dialectical structure of “sadness-hope” (12 ± 3 -minute emotional rhythm). This nonlinear narrative strategy not only avoids the emotional indulgence of

contamination sequences but also maintains high levels of audience emotional engagement through mechanisms such as symbolic juxtaposition (sacred/secular), suspense setting, and emotional compensation.

This study also has several limitations: 1) the sample size is limited, and future research could expand to more types of documentaries; 2) sentiment analysis primarily relies on textual language, which can be complemented by multimodal data such as facial expressions and physiological indicators; 3) cultural differences need further control. Future research should focus on these aspects to more comprehensively reveal the complex facets of documentary emotional expression. Overall, the theoretical value of this study lies in establishing an interdisciplinary framework for analyzing nostalgic emotions, while its practical significance is reflected in providing operational methodological guidance for the emotional design and effectiveness evaluation of documentaries.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Exploring the Path to Common Prosperity in China from a Marxist Perspective

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Abstract: This study, grounded in the Marxist research paradigm, provides a comprehensive analysis of the theoretical foundation, real-world challenges, and institutional pathways of China's common prosperity strategy. Drawing on methodologies such as historical materialism, surplus value theory, and class analysis, the paper identifies key contradictions in the current income distribution structure. It places particular emphasis on the erosion of labor rights within platform economies, the inadequacy of redistribution mechanisms, and the fairness dilemmas arising under the green transition. Using the Zhejiang Demonstration Zone as a case study, the paper proposes a multidimensional institutional framework centered on optimizing primary distribution, reforming taxation and public services, and restructuring production relations. The study concludes that common prosperity is not merely a shift in economic policy, but a profound transformation of the social structure.

Keywords: Marxism; Common Prosperity; Distribution System; Class Analysis

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1.Introduction

In the strategic framework of socialist modernization with Chinese characteristics in the new era, the pursuit of “common prosperity” has been explicitly established as a fundamental requirement for achieving Chinese-style modernization. This concept not only concerns the distribution of economic resources, but also delves into broader structural contradictions related to social justice, institutional arrangements, and developmental trajectories. The Fifth Plenary Session of the 19th Central Committee of the Communist Party of China was the first to include “solidly promoting common prosperity” as a long-term goal for building a modern socialist country. In 2021, the issuance of the “Guidelines on Supporting Zhejiang in High-Quality Development and Building a Common Prosperity Demonstration Zone” signaled that common prosperity had officially entered the stage of concrete policy implementation.

However, with the global capitalist system undergoing profound transformations—driven by the rapid rise of the digital economy, growing platform monopolies, and intensified financialization—China now faces increasingly severe challenges, including declining labor income shares, unbalanced urban-rural and regional development, and distorted resource allocation structures. These issues urgently require a foundational analysis rooted in a more critical theoretical perspective.

Marxism, as a profoundly practical and critical theoretical system, offers unique advantages in diagnosing social

contradictions, critiquing institutional hierarchies, and constructing equitable distribution frameworks. Its core methodological tools—historical materialism, the theory of surplus value, and class analysis—provide a structural and macro-level framework for understanding issues such as wealth distribution, production relations, public institutions, and the reproduction of social power. This study seeks to apply the analytical tools of Marxist political economy to uncover the structural dilemmas currently confronting China's pursuit of common prosperity and to explore institutional pathways compatible with the principles of historical materialism.

Grounded in a thorough review of both domestic and international literature, this paper constructs an analytical framework centered on the law of value, class structures, and the flow of surplus value. It integrates China's unique political and economic context to examine the tensions and contradictions embedded in the practice of common prosperity and to identify feasible transformative strategies.

2. Literature Review

2.1 The Evolution of Research on Common Prosperity

As a fundamental component of the theoretical system of socialism with Chinese characteristics, the concept of “common prosperity” has gradually become a key focus in both policy practice and academic research since Deng Xiaoping proposed the idea of “letting some people get rich first” in the 1980s. In 2025, Han Sheng pointed out that common prosperity is not merely an economic issue but also a social and institutional one. It must go beyond the narrow lens of income distribution to include systematic consideration of dimensions such as justice, public services, and rights protection ^[1].

Although foreign scholars rarely use the specific term “common prosperity,” there has been extensive discussion under the framework of “inclusive growth.” The OECD (2015) emphasized that inclusive growth should aim not only to improve productivity but also to enhance the economic participation of disadvantaged groups, thereby ensuring the broad sharing of growth outcomes ^[2]. In 2012, Joseph Stiglitz, through his critique of wealth inequality in the United States, argued that the market alone cannot achieve fair distribution, and that the state must take responsibility for institutional regulation and wealth redistribution ^[3].

2.2 Contemporary Interpretations of Marxist Distribution Theory

Marxist theory on distribution is rooted in its critical analysis of social structures and class contradictions. In *Capital*, Marx clearly stated that under capitalism, the “primary distribution” of wealth determines the division of surplus value between laborers and capitalists, and that redistribution can only marginally adjust this structural imbalance. The theoretical foundation lies in the labor theory of value and the theory of surplus value: the former identifies labor as the source of value creation, while the latter reveals that capital's appropriation of labor outcomes is the essential source of profit.

In recent years, Chinese scholars have sought to integrate Marxist distribution theory with the realities of China, expanding its explanatory power. Wei Xiaojun, Liu Yuchao, and Jiang Yong (2025) noted that advancing the goal of common prosperity reflects the organic unity of the theoretical logic that “production determines distribution” and the practical logic of “distribution according to labor while opposing egalitarianism.” It highlights a problem-oriented approach to addressing the most direct and tangible interests of the people, and suggests the construction of a coordinated system encompassing primary distribution, redistribution, and tertiary distribution to improve the income distribution regime ^[4].

2.3 Class Relations in Digital Capital and Platform Economies

The rise of platform capitalism and the digital economy has profoundly reshaped labor relations, reigniting interest among Marxist theorists. In 2016, Nick Srnicek introduced the concept of “platform capitalism,” arguing that major tech platforms have evolved into new forms of capital concentration and monopoly. By controlling data resources and algorithmic allocation mechanisms, these platforms generate a novel form of “digital rent” ^[5].

In 2025, Wei Jun contended that the so-called “leisure dilemma” under digital capitalism is essentially a product of capital's restructuring of leisure practices. It does not alter the exploitative essence of capitalism. To achieve true leisure liberation, it is necessary to transform production relations, reconstruct ownership systems, reform labor institutions, and build an anti-consumerist ideological framework, thereby restoring leisure as an authentic practice of freedom and advancing the genuine emancipation of humanity ^[6].

From the perspective of Marxist class analysis, this trend signifies that traditional employment relationships have been increasingly replaced by quasi-employment or informal labor systems, further weakening the laborer's position in production relations. Digital capital now controls not only the labor process but also the realization of value and consumer behavior. Its monopoly over the value chain is unprecedented, necessitating a redefinition of its institutional role in the distribution structure.

2.4 State Regulation and Institutional Redesign

The realization of common prosperity cannot rely on the self-regulating mechanisms of the market alone; it requires institutional reconstruction under the leadership of the state. In 2025, Ren Bo emphasized that in the governance context of contemporary China, market mechanisms, government intervention, and social distribution represent three distinct modes of income distribution, each with its own operational logic and limitations^[7]. To coordinate these three mechanisms, China must establish a collaborative governance model under the leadership of the Communist Party, characterized by an "effective market," a "proactive government," and a "caring society." This model aims to harness the decisive role of the market in resource allocation while enhancing the regulatory and redistributive roles of government and society.

From the Marxist theory of the state, the state serves as both a mediator of class struggle and an organizer of the reproduction process. In the primary stage of socialism, the state must utilize mechanisms such as resource allocation regulation, social security enhancement, and value realization guidance to gradually achieve an organic transition toward a system characterized by "distribution according to labor as the mainstay, supplemented by distribution according to production factors."

3. Theoretical Construction: Analytical Tools under the Marxist Methodology

Common prosperity is not merely a policy agenda; it represents a systemic transformation involving social structures, economic institutions, and ideological mechanisms. As a comprehensive methodological framework within the social sciences, Marxism offers three critical analytical perspectives for examining China's pursuit of common prosperity: historical materialism, the theory of surplus value, and class analysis.

3.1 Historical Materialism and the Generative Logic of Common Prosperity

Historical materialism emphasizes that social development is determined by the economic base, and that changes in the superstructure must be rooted in transformations of the relations of production. Common prosperity cannot be achieved solely through redistribution mechanisms; rather, it must be integrated into the reorganization of production relations. In the primary stage of socialism, promoting wealth sharing must be based on reforms in the ownership structure of the means of production.

3.2 Surplus Value Theory: Revealing the Root Causes of Distributional Inequality

In *Capital*, Marx attributes the widening gap between the rich and poor in capitalist societies to the "uncompensated appropriation of surplus value." That is, capital extracts unpaid labor from workers by extending working hours or intensifying labor efforts. In contemporary China, income inequality can similarly be viewed as a new form of surplus value appropriation. Platform economies, through technological logic, have outsourced labor control to algorithmic governance, whereby the vast majority of value created by workers is captured by platforms or data capital. This constitutes a novel pathway for surplus value extraction.

3.3 Class Analysis and the Emergence of New Interest Structures

In traditional wage-labor relations, class contradictions are manifested as direct confrontations between capital and labor. However, in contemporary China, a more complex structure of interests has emerged, involving new middle classes, flexible workers, and digital capital owners. According to Marx's theory, class should be defined by one's position within the relations of production, rather than by income level or occupation. The pursuit of common prosperity thus requires not only addressing the economic conditions of impoverished groups but also critically reflecting on how digital platforms use invisible mechanisms of control to draw middle-class populations into exploitative structures. Only by identifying the new class structure and the distribution of interests in today's Chinese society can public policies be effectively targeted.

3.4 Dialectical Method and the Logic of Policy Design

Dialectics, as a core logical tool of Marxism, underscores the universality of contradictions and the non-linear nature of development. In advancing the goal of common prosperity, it is essential to recognize contradictions between productive

forces and relations of production, tensions between primary and secondary distribution, and conflicts between efficiency and equity. This helps to avoid structural distortions resulting from linear or one-sided policy interventions. For example, while increasing the share of labor income, policymakers must also consider the developmental stage and investment capacity of enterprises, and rely on dynamic adjustment to achieve a gradual, “first-rich-leads-later-rich” structural evolution.

4. Historical Evolution: The Developmental Logic of China’s Distribution Structure

The concept of common prosperity is not an unfounded political slogan; rather, it reflects an intrinsic need rooted in the economic and social development trajectory of China. To fully understand the current tensions and institutional opportunities associated with common prosperity, it is essential to review the historical evolution of income distribution structures since the founding of the People’s Republic of China.

4.1 The Planned Economy Period: Egalitarianism and Institutional Redistribution

Following the completion of socialist transformation in 1956, China established a highly centralized planned economy. The means of production were largely publicly owned, and distribution was primarily based on the principle of “distribution according to labor,” supplemented by state-controlled wage systems. While this phase achieved a relatively balanced distribution between urban and rural areas, it also suffered from insufficient incentives and low efficiency. Although egalitarianism helped reduce disparities, it failed to establish mechanisms that could sustainably generate wealth.

4.2 Since Reform and Opening-Up: Market Logic and Widening Gaps

Beginning in 1978, China gradually introduced market mechanisms and encouraged certain regions and populations to “get rich first.” After Deng Xiaoping’s “Southern Tour” in 1992, the degree of marketization increased rapidly, and the non-public economy expanded significantly. The structure of primary distribution began to shift toward capital, leading to a widening income gap. According to data from the National Bureau of Statistics, China’s Gini coefficient has remained above 0.45 since 2003—exceeding the internationally recognized warning threshold.

4.3 Since the New Century: Gradual Improvement of Redistribution Mechanisms

In response to growing income inequality, the Chinese government has since 2006 made significant efforts to develop its social security system, including the New Rural Cooperative Medical Scheme, urban and rural pension insurance, and minimum living allowance programs. In 2013, President Xi Jinping emphasized the goal of “comprehensively building a moderately prosperous society,” which led to an increase in the weight of redistribution mechanisms within national governance. However, these efforts largely focused on bottom-line guarantees rather than fundamental reforms to primary distribution. Persistent issues such as the lack of labor market bargaining mechanisms, significant regional differences in minimum wage standards, and uneven distribution of education and healthcare resources have yet to be effectively addressed.

4.4 The Historical Inevitability of Proposing “Common Prosperity”

In the current stage of high-quality development, China’s principal social contradiction has shifted from “insufficient material production” to “unbalanced and inadequate development.” In 2021, the country declared that it had built a moderately prosperous society in all respects and eliminated absolute poverty. However, relative poverty and structural inequality persist, particularly in sectors such as education, healthcare, and housing, where intergenerational reproduction of class advantage remains pronounced. The call to “solidly promote common prosperity” thus emerges as both a response to the demand for distributive justice and a strategic institutional choice for sustainable development in the process of modernization.

5. Analysis of Current Distributional Contradictions: Structural Tensions and New Forms of Exploitation

The obstacles China faces in advancing its common prosperity strategy go beyond the superficial issue of “income inequality.” Instead, they reflect a complex distributional order shaped by multiple interwoven structural contradictions. To uncover the roots of these tensions, one must turn to Marxist political economy for theoretical tools capable of analyzing the imbalance in surplus value distribution, the emergence of new class oppression structures, and the monopolization of data capital.

5.1 Capital Dominance in Primary Distribution

According to data from the National Bureau of Statistics and the Chinese Academy of Social Sciences, the share of labor compensation in GDP has been declining since 2000, while capital income has steadily increased. This structural shift highlights the growing dominance of capital over labor in the primary distribution process. From a Marxist perspective, this reflects an “asymmetric expansion” of the law of value, wherein the price of labor as a commodity significantly deviates from its actual value. As a result, laborers are systematically underpaid, leading to an increased outflow of surplus value.

5.2 Quasi-Employment and Hidden Exploitation in Platform Economies

In platform economies such as Didi and Meituan, workers do not hold traditional employment status, yet their work schedules, performance metrics, and order assignments are all dictated by algorithmic systems—forming a structure of “quasi-employment.” As representatives of “digital capital,” platforms leverage information monopolies and user data to control transaction channels and suppress the realization of labor value. This new form of exploitation is not characterized by extended work hours or reduced wages, but by “de-organized surplus value extraction” driven by technological logic, in which value is appropriated without formal labor contracts or clear accountability.

5.3 Inequality Across Urban-Rural, Regional, and Generational Lines

The disparity in basic public services between urban and rural areas has remained persistent. According to data released by the Ministry of Education in 2021, there was still a gap of more than 20% between eastern and western China in terms of secondary school teacher qualifications, per-student funding, and enrollment rates. Healthcare resources are similarly concentrated in central cities and top-tier hospitals, leading to the emergence of a “class-based healthcare system.” Meanwhile, the capitalization of the housing market has intensified intergenerational inequality, as younger generations face the dual burden of “high housing prices + low income.”

5.4 Ecological Transition and the Tensions of Distributional Fairness

Under the “dual carbon” goals of peaking carbon emissions and achieving carbon neutrality, many high-carbon industries are being downsized, restructured, or phased out—particularly those located in resource-dependent central and western regions or labor-intensive manufacturing zones. Although ecological transition offers long-term societal benefits, it often produces “reverse distribution effects” in the short term. That is, the groups bearing the cost of green development are typically low-income populations, while the environmental gains are more likely to benefit middle- and upper-income groups. Within Marxist ecological political economy, this phenomenon is framed as the “class-based stratification of environmental justice.”

6. Case Study: The Structural Dynamics of Common Prosperity in Zhejiang Province

6.1 Policy Highlights and Implementation Logic of the Demonstration Zone

In 2021, the Central Committee of the Communist Party of China and the State Council issued the Guidelines on Supporting Zhejiang in High-Quality Development and Building a Common Prosperity Demonstration Zone, explicitly designating Zhejiang as the pilot region for advancing common prosperity nationwide. The document includes specific measures on income redistribution and embeds institutional reforms into industrial development, regional planning, and social security, thereby constructing a comprehensive “governance framework for common prosperity.” The core goals of the demonstration zone can be summarized as follows: (1) broadly increasing household incomes and expanding the middle-income group; (2) narrowing urban-rural and regional development gaps and improving equality in public service provision; and (3) encouraging private sector and social participation in common prosperity to generate endogenous momentum across society.

At the operational level, Zhejiang established a “1 + 3 + 6” advancement framework—consisting of one master plan, three implementation lists, and six sets of landmark outcome indicators. The province aims to significantly reduce urban-rural income and development disparities by 2035, with 80% of its population classified as middle income. Various local initiatives have emerged in support of these goals, such as the “Common Prosperity Workshops” in Huzhou, the “Farmer Shareholding Cooperatives” in Jiaxing, and the “E-commerce Leader Training Program” in Yiwu. These programs mark a shift away from traditional top-down fiscal transfers toward new approaches involving production reorganization, interest linkage mechanisms, and urban-rural resource redistribution.

6.2 Preliminary Restructuring of Class Relations: Policy Achievements

Marxist class analysis reveals that promoting common prosperity entails a partial adjustment of production relations and a

subtle reshaping of class structure. In Zhejiang, reforms to the rural collective economy have facilitated resource integration and surplus value socialization. For instance, the “shareholding economic cooperative” model in Jiashan County allows farmers to pool their land and collective rural assets into cooperatives. Villagers participate as “members” entitled to profit sharing, thereby reducing dependence on wages alone. This model breaks the traditional “state–household” unidirectional allocation pattern, replacing it with a composite mechanism of “collective ownership + cooperative participation + dividend sharing,” which serves as an experimental path for surplus value redistribution under socialism.

Additionally, Huzhou has promoted “Common Prosperity Workshops” by encouraging leading enterprises to establish production facilities in towns and partner with village collectives. The adopted “wages + equity + benefits” compensation model enables rural workers to earn both labor income and dividends from production profits. This model takes a step toward the system envisioned by Marx in Critique of the Gotha Programme, where public ownership of the means of production is combined with distribution according to labor.

Nonetheless, such structural adjustments remain limited. Most village-level collective economies are not yet able to sustain stable and continuous dividend mechanisms, and the allocation of public resources still depends heavily on government subsidies. This indicates that common prosperity cannot rely solely on localized pilots; rather, it requires the development of replicable and scalable institutional reforms at the national level.

6.3 Institutional Constraints and Structural Risks

Despite the promising results of Zhejiang’s common prosperity efforts, a critical examination from the deeper institutional logic of Marxist theory reveals several structural risks and limitations. The rise of platform economies and the ongoing concentration of capital have not been fundamentally reversed by the demonstration zone initiatives. In cities like Hangzhou, major platform companies such as Alibaba and Meituan continue to dominate key nodes in resource distribution. Meanwhile, gig workers such as couriers and delivery drivers remain in precarious employment conditions, facing suppressed wages and lacking bargaining power. This reflects a persistent contradiction between labor and capital, posing a real challenge to achieving substantive common prosperity.

Moreover, China’s redistributive mechanisms remain inadequate in regulating high-income groups. The current individual income tax system is based on classified taxation, and property income, capital gains, inheritance, and gifts—main sources of wealth for high-net-worth individuals—are not effectively taxed. This has created a “blank zone” in wealth taxation, limiting the institutional capacity to compel the wealthy to contribute to redistribution. For instance, in 2021, China’s total individual income tax revenue amounted to 1.45 trillion yuan, accounting for less than 1.3% of GDP—far below the OECD average of around 8%.

A third challenge is the bureaucratic tendency in local common prosperity pilots, where success metrics have at times been reduced to rigid performance indicators. This has led to the emergence of “template-based assessments,” “project packaging,” and “model displays,” reflecting a form of performance-driven governance. Such tendencies run counter to Marxist critical consciousness, which emphasizes the exposure of real contradictions and structural transformation rather than superficial achievements or decorative policy showcases.

In summary, while the Zhejiang model offers a valuable example of structural reform, its replicability and sustainability will remain fundamentally constrained unless institutional, property, and organizational changes are promoted on a national scale.

7. Institutional Pathways: Constructing Multidimensional Mechanisms for Advancing Common Prosperity

7.1 Improving Primary Distribution: Realizing the Value of Labor

Within the framework of Marxist political economy, primary distribution is the most critical link in determining the structure of wealth. Marx clearly pointed out that under capitalism, primary distribution results in the uncompensated appropriation of surplus value—an inevitable outcome of unequal labor-capital relations. In contemporary China, the proportion of labor income in GDP remains relatively low, with a significant gap between the value created by workers and the remuneration they actually receive. This disparity constitutes a fundamental issue that must be addressed in order to advance the goal of common prosperity.

To correct this structural imbalance, the first step is to reconstruct the institutional mechanisms of wage negotiation and formation. Currently, wages in many sectors of China are still largely determined unilaterally by employers or through administrative intervention. In emerging employment forms such as the platform and gig economy, workers have almost no bargaining power, as algorithmic systems have replaced traditional human resource management and now exercise comprehensive control over labor processes. Legislation is needed to establish sectoral and regional collective bargaining systems, strengthen the organizational capacity, negotiation power, and independence of labor unions, and foster genuine negotiation dynamics between labor and capital.

Second, institutional innovation in labor organization is necessary. Marx emphasized that “union is the fundamental means by which the working class secures its rights.” Under the digital economy, the organizational capacity of labor has been further eroded. Therefore, new forms of worker alliances such as “digital unions” and “platform worker rights coalitions” must be promoted. These can empower workers to rebuild collective strength under algorithmic control and platform exploitation, gaining bargaining power and the right to discourse. Examples include advocating for “algorithmic transparency” and “open quotas,” and establishing a “platform labor arbitration mechanism” to guarantee dispute resolution rights.

Finally, a “shared capital mechanism” should be established to allow workers to participate in primary distribution through equity incentives, profit-sharing schemes, and collective ownership platforms. This not only increases labor income but also fundamentally restructures the labor-capital divide, promoting a more equitable and rational form of primary distribution.

7.2 Optimizing Redistribution: Reforming the Tax System and Public Services

Marx believed the state is an instrument of class rule, but also a key mediator capable of adjusting capital accumulation and promoting social fairness. Under the socialist market economy, the state must rely on redistributive mechanisms to correct structural distortions in primary distribution, thereby safeguarding basic social justice and enabling upward mobility.

China’s current personal income tax system requires reform and transformation. It still operates primarily under a categorized tax structure and has limited ability to regulate capital gains and property income. A mixed system that integrates comprehensive and categorized taxation should be established to enhance taxation efficiency on high-income groups. The introduction of inheritance tax, real estate tax, and capital gains tax should be considered to curb hereditary wealth accumulation and mitigate intergenerational inequality. This aligns with Marx’s principle in Critique of the Gotha Programme that “distribution according to need” requires resources to be returned to society through a just system of redistribution.

Government should also promote fiscal equalization in basic public services—an essential measure for narrowing regional disparities and dismantling the class-based stratification of public goods. In education, the state should reallocate high-quality educational resources to the central and western regions, rural areas, and lower urban strata, breaking down class barriers such as those caused by the “school district housing” phenomenon. In healthcare, the critical illness insurance system and hierarchical medical treatment should be improved to alleviate resource bottlenecks and uneven insurance expenditures. Fiscal transfers and institutional arrangements should be used to reallocate public resources toward “marginalized groups” rather than concentrate them in “central zones.”

Furthermore, the universality and fairness of the social security system must be strengthened. For instance, flexible workers and self-employed individuals should be integrated into pension and healthcare systems to increase coverage and participation rates. A basic safety net should be established to include all laborers, supported by urban-rural unemployment assistance and minimum livelihood protection mechanisms—providing robust institutional backing for distributional equity.

7.3 Transforming Production Relations: Supporting Distributional Justice through High-Quality Development

At the core of Marxism lies the idea that distributional problems must ultimately be resolved through structural transformations in production relations. Redistribution policies and public finance alone cannot fundamentally resolve social wealth inequality. Therefore, the realization of common prosperity must be supported by a reconfiguration of production relations—restructuring the labor-capital relationship, redefining state-market functions, and promoting the co-evolution of public-private property systems.

First, the functional role of state-owned capital in redistribution should be strengthened. Currently, many state-owned

enterprises—especially in monopoly sectors such as energy, telecommunications, and finance—accumulate significant profits, yet lack robust mechanisms for public return. The state should increase the share of profits remitted by SOEs, establish “common prosperity funds,” and channel enterprise profits into livelihood sectors such as education, healthcare, and elderly care—thereby enabling public capital to fulfill its role in distributing social dividends. This aligns with Marx’s vision of the state exercising control over surplus value allocation.

Second, new models of cooperative economies and mixed-ownership structures should be explored. Common prosperity does not imply opposition to capitalism, but rather a managed form of capital engagement under the primary stage of socialism. In this context, mechanisms such as employee stock ownership in platform companies, community mutual-aid cooperatives, and socialized data platforms can be promoted to achieve partial socialization of surplus value. In some regions of Zhejiang, “platform partnership + village collective equity” models have emerged, demonstrating feasible pathways for integrating digital and collective economies.

Additionally, China should pursue equitable transitions through green development, ensuring that technological innovation and industrial upgrading do not result in new forms of class deprivation. Under the “carbon peak” and “carbon neutrality” agendas, green industrial policy must be coordinated with employment, retraining, and regional development policies. The withdrawal of polluting industries must not lead to mass unemployment among lower-income groups. Instead, green restructuring must be accompanied by job retraining programs, targeted industrial guidance, and investment incentives, thereby realizing a form of “structural green common prosperity.”

In conclusion, the institutional design for common prosperity must operate on three fronts—labor relations, fiscal mechanisms, and industrial models—and must be advanced comprehensively. At its core, this framework should embody the fundamental Marxist principles of labor centrality, social coordination, and equitable sustainability, thereby enabling a structurally grounded system of common prosperity.

8. Policy Insights and Methodological Reflections: Advancing Amid Institutional Logic and Social Contradictions

8.1 The Policy Implications of Marxist Methodology

As the analysis in this paper shows, Marxist methodology not only provides a powerful explanatory framework for the strategy of “common prosperity” but also offers concrete guidance for institutional design and critical evaluation. At the theoretical level, historical materialism compels us to understand the institutional roots of current distributional patterns and social inequalities by examining the economic base and relations of production—rather than merely applying technical fixes to the outcomes. Structural issues such as urban-rural disparity, sectoral fragmentation, and digital labor inequality in China today are the compounded results of evolving economic structures, capital accumulation paths, and differentiated institutional choices. Only by tracing the evolution of material production relations can targeted and effective policy responses be developed.

Class analysis, meanwhile, offers the tools to identify real social contradictions. From the Marxist perspective, class is not determined by income level but by one’s structural position in the relations of production. This enables us to expose structural realities often masked by the illusion of a “middle class.” For example, platform workers may appear “flexible and autonomous,” but in reality, they are highly dependent on the control logic of platform capital. Likewise, white-collar urban workers, though nominally middle income, suffer from “structural anxiety” caused by soaring costs of housing, education, and healthcare. In such a structure, inequality is not only reflected in numbers but also in the deprivation of control and the asymmetrical distribution of institutional discourse power.

The theory of surplus value provides an analytical lens for understanding new forms of exploitation. In the digital economy, platform enterprises gain control over algorithms, data, and content distribution, converting traditional labor time into immaterial labor metrics such as “clicks,” “engagement,” and “shares.” These forms of invisible labor produce new pathways for the appropriation of surplus value. As traditional labor law struggles to govern such dynamics, it becomes imperative to revisit and redefine the nature of labor and exploitation through the lens of Marxism, in order to build new systems for labor

protection and profit-sharing.

Dialectical thinking emphasizes advancing structural transformation through contradictions, not by replicating linear policy models. The advancement of common prosperity requires dynamic balancing between efficiency and equity. It cannot be achieved overnight. Mechanisms for monitoring, early warning, and continuous adjustment must be established to allow institutional reform to evolve through practical feedback. This principle of “rationality in process” is a direct contribution of dialectical materialism to institutional innovation.

8.2 Structural Risks in Current Policy Approaches

Despite China’s multifaceted efforts to promote common prosperity in recent years, there are still internal tensions and practical risks within the current policy framework that merit close attention.

First, there is the problem of fragmented policy implementation and regionally competitive pilot programs. Many local governments promote common prosperity through “model projects” that focus on showcasing indicators, publicizing success stories, and achieving short-term results. In some areas, common prosperity has been reduced to economic performance enhancement, resulting in “common form over common wealth” and the distortion of governance into a quest for political achievements. This is fundamentally at odds with the Marxist vision of production relation reform and structural transformation, and may reduce common prosperity to a political slogan rather than a deep institutional agenda.

Second, there is an overreliance on moral appeals for “tertiary distribution.” Many policies hinge on encouraging private entrepreneurs to “give back to society” through philanthropy and donation-based redistribution. However, without institutional mandates or legal enforcement, capital’s intrinsic profit-seeking tendency will suppress genuine participation in social equity. For example, “common prosperity funds” often lack binding regulations and public oversight, weakening their role in redistributive justice. Tertiary distribution should function as a supplementary tool, not a central mechanism.

Third, the lack of participatory governance and limited political mobilization also pose challenges. Achieving common prosperity requires broad-based social consultation, public mobilization, and institutional co-construction. Currently, many policies deviate from Marx’s vision of “workers’ self-liberation” and the organizational rise of the proletariat. Instead, they remain largely government-led, with limited bottom-up participation. Without a governance model based on participatory democracy, public support for the common prosperity strategy may be fragile and unsustainable.

8.3 Beyond Policy: The Fundamental Question of Social Reproduction

The deeper insight of Marxist theory lies in its enduring focus on the reproduction of social relations—not merely the redistribution of social outcomes. Common prosperity is not a static condition of wealth redistribution; it is a dynamic, relational, and process-oriented restructuring of the social fabric. Within this process, key questions arise: How are labor relations organized? How is public authority allocated? How is capital’s control constrained? And how are the fruits of production shared across society? These are questions of structural logic and development direction, and they demand direct and serious engagement.

This perspective suggests that structural transformation must proceed on three levels:

Relational level: Reconfigure the relationship between workers and the means of production, shifting from the status of “employees” to that of “participants” and “co-owners.”

Institutional level: Redefine the functional boundaries between the state, market, and society to ensure that resource allocation and social justice operate in synergy, rather than conflict.

Cultural level: Deconstruct the prevailing ideology of “success and consumerism,” and reconstruct a social value system rooted in cooperation, fairness, mutual aid, and the dignity of labor.

Only through this tripartite foundation of structural reproduction can we avoid the paradox of “decentralized authority but centralized responsibility,” or “equity in distribution but inequality in production relations.” This is the path toward realizing a truly socialist vision of common prosperity.

9. Conclusion

Drawing on the methodology of Marxism, this paper has provided a comprehensive analysis of the historical evolution,

institutional contradictions, and theoretical reconstruction of the concept of “common prosperity” within the context of Chinese-style modernization. Through the application of four core methodological pillars—historical materialism, the theory of surplus value, class analysis, and dialectical thinking—the study has responded to the theoretical question of how to understand common prosperity and, more importantly, proposed structural institutional pathways for how to achieve it.

At the theoretical level, the paper demonstrates that common prosperity should not be narrowly interpreted as merely income equalization or an improvement in living standards. Rather, it should be viewed as a process of adjusting production relations—aimed at transforming the marginalized position of labor within the current system of value distribution, redefining the labor-capital relationship, and promoting a broader socialization and equalization of surplus value. In the face of contemporary phenomena such as digital capital, platform economies, and financialization, Marxist political economy offers effective tools to identify new forms of exploitation and mechanisms of capital control.

On the empirical front, this paper used the institutional practices of Zhejiang’s common prosperity demonstration zone to illustrate innovations in policy implementation, governance mechanisms, and emerging risks. Practices such as the “Common Prosperity Workshops” and “Shareholding Cooperatives” exemplify efforts under a socialist framework to socially redistribute surplus value. However, issues such as fiscal dependency, platform dominance, and fragmented policy design also surfaced—indicating that the realization of common prosperity requires not only policy innovation but also structural transformation.

From a governance perspective, this paper argues for a tripartite institutional approach: rebuilding the primary distribution system, refining redistributive mechanisms, and transforming production relations. This involves the development of collective wage negotiation systems and labor organization frameworks, as well as reforms in taxation, improvements in public service delivery, and a restructuring of platform ownership models. The study emphasizes that common prosperity should not be reduced to an economic policy or a social welfare program; rather, it should be elevated to a comprehensive reconstruction of social relations.

As Marxism reminds us, the “liberation of humanity” depends on changes in institutional foundations and cultural ideology. Only through the coordinated evolution of institutions, structures, and consciousness in practice can common prosperity be transformed from a national strategic objective into a tangible social reality. Future research can build upon this work in several directions: (1) using micro-level data and localized governance analysis to quantify the distributional effects of common prosperity policies; (2) investigating the evolving relationship among platform labor, data capital, and labor rights; and (3) conducting comparative studies to examine similarities and differences between the logic of common prosperity under Chinese socialism and welfare state models in other countries, thereby offering a Chinese perspective on global inequality challenges.

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Innovative Development of Foshan Cuisine Culture in the Digital Age

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Abstract: This paper explores the multifaceted challenges that the development of Foshan cuisine culture currently faces. Against the backdrop of the digital age, it underscores the critical importance of innovative exploration and development in Foshan cuisine culture. The paper further proposes a set of strategic pathways to foster its innovative development. The primary objective is to ensure the effective transmission and promotion of Foshan cuisine culture, to address the evolving needs of contemporary consumers, and to elevate the international profile of Foshan cuisine culture.

Keywords: Foshan Cuisine Culture; Digital Age; Innovative Development

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1.Introduction

As an important representative of Lingnan cuisine, Foshan cuisine has a long history, rich heritage, and distinct regional characteristics. Located in the heart of the Pearl River Delta, Foshan has been a prosperous commercial hub since ancient times. Over the long course of its historical development, Foshan cuisine has developed a unique style and profound cultural connotations. From Milk Custard and Lunjiao Rice Cake in Shunde, to Jiujiang Jiandui and Xiqiao Pancake in Nanhai, and Zumiao Jizai Biscuit and Shiwan Yubingshao in Chancheng, Foshan cuisine is not only diverse and exquisite but also deeply rooted in local traditions. It is not only a pleasure for the taste buds but also an integral part of Lingnan culture, embodying the wisdom and emotional attachment of Foshan's people.

With the advent of the digital age, the global cultural communication landscape has undergone profound changes. The rapid development of digital technology has brought unprecedented opportunities for the inheritance and innovation of traditional culture. Emerging technologies such as the Internet, social media, big data, artificial intelligence, virtual reality (VR), and augmented reality (AR) are reshaping the way cultural heritage is transmitted. Digital means can break through the limitations of time and space, achieving widespread dissemination of cultural resources and attracting a broader audience, especially the younger generation, through innovative forms and content. For example, the rise of short video platforms has brought the production process of many traditional cuisines to life, attracting the attention of a large number of young users. The interactivity of social media provides a broader communication space for the dissemination of cuisine culture.

However, the digital age has also brought many challenges to Foshan cuisine culture. In the context of globalization and fast-paced modern life, traditional Foshan cuisine culture faces problems such as shrinking market share, difficulties in inheriting

traditional skills, and diversified consumer demands. The standardized production, fast supply, and strong marketing strategies of Western fast food have attracted a large number of young consumers, significantly squeezing the market share of some traditional Foshan dishes with complex production processes and long preparation times. Additionally, modern consumers increasingly demand healthy, convenient, and personalized diets. The high-fat and high-calorie nature of traditional cuisine, along with its cumbersome production process, makes it difficult to meet the modern pace of life and healthy eating trends.

The 14th Five-Year Plan for Cultural Development clearly proposes to promote the application of technology in traditional cultural industries and facilitate their transformation and upgrading. In this context, how Foshan cuisine can adapt to the trend of the times and achieve innovative development through digital technology is not only related to its inheritance and continuation but also has profound significance for local economic development and cultural dissemination. Through digital means, Foshan cuisine can better record and preserve its unique skills and cultural connotations, while also meeting the needs of modern consumers through innovative forms and content, enhancing its influence and competitiveness both domestically and internationally. Therefore, in-depth research on the innovative development path of Foshan cuisine culture in the digital age has important theoretical and practical value.

2.The challenges faced by the development of Foshan cuisine culture

2.1 Cultural Homogenization Due to Globalization

Globalization has intensified the exchange of global cuisine cultures but has also led to cultural homogenization. Western fast-food chains like McDonald's and KFC have expanded globally, attracting numerous consumers with their standardized production, fast supply, and strong marketing strategies. In contrast, traditional Foshan cuisine, known for its complex preparation techniques and rich flavors, struggles to compete in a fast-paced society. Its longer cooking time fails to meet the demand for quick meals, leading to a continuous decline in market share. This trend not only hinders the dissemination of Foshan cuisine culture but also threatens the inheritance of traditional cooking skills. As the younger generation becomes more inclined towards convenient global food options, these skills are at risk of being lost. Therefore, protecting Foshan's unique cuisine heritage in the face of globalization has become particularly urgent.

2.2 Challenges Posed by Modern Life Pace

Modern life's fast pace drives a demand for quick, convenient food. Traditional Foshan cuisine, with its time-consuming preparation methods, struggles to meet this need. For example, making double skin milk involves multiple steps, from steaming milk to forming and processing the skin, requiring significant time and effort. This contrasts sharply with the fast food options that appeal to younger consumers. As a result, interest in traditional cuisine wanes, posing significant challenges to the inheritance of Foshan cuisine culture and risking the loss of traditional cooking skills.

2.3 Challenges of Meeting Diversified Consumer Needs

With the development of the economy, consumers' demands for delicious food have become increasingly diversified. They value not only taste but also health, novelty, and experience. However, traditional Foshan dishes are mainly composed of meat and fried foods, which have high fat and calorie content, inconsistent with the current trend of healthy eating. In terms of innovation, some businesses have excessively changed traditional flavors and techniques to meet new consumer demands, resulting in a loss of original flavor and difficulty in finding a balance between tradition and innovation, which cannot meet the needs of different consumers.

2.4 Difficulties in Balancing Tradition and Innovation

Balancing tradition and innovation is a critical challenge for the sustainable development of Foshan cuisine culture. While preserving the authenticity of traditional flavors and techniques is essential to maintain cultural heritage, innovation is necessary to meet the evolving tastes and preferences of modern consumers. However, finding the right balance is complex. Overemphasis on innovation can lead to the dilution of traditional flavors, as seen in some restaurants where new dishes fail to capture the essence of Foshan cuisine's roots. Conversely, strict adherence to tradition can result in stagnation, making it difficult to attract a broader audience. This delicate balance is crucial not only for the cultural integrity of Foshan's cuisine but also for its competitiveness in the global food market.

3.The Importance of Innovative Exploration and Development of Foshan Cuisine Culture in the Digital Age

3.1 Inheriting Regional Cuisine Culture and Enriching Cultural Diversity

Foshan cuisine culture is a treasure of Lingnan culture, encompassing profound history, folk customs, and unique culinary skills. Digital technology enables the permanent preservation of food production processes, cultural stories, and traditions through videos, images, and text. For instance, by leveraging virtual reality (VR) and augmented reality (AR) technologies, an immersive Foshan cuisine culture experience app can be developed. The use of digital technology not only safeguards intangible cultural heritage but also enriches the diversity of Chinese cuisine culture by showcasing its unique charm.

3.2 Meeting Modern Consumer Demands and Enhancing Market Competitiveness

Modern consumers, with their fast-paced lives, demand convenient and personalized food options. In the digital age, Foshan cuisine culture can meet these needs through delivery platforms and pre-made dishes. Big data and AI algorithms enable precise analysis of consumer preferences, facilitating personalized dishes and meal plans. For example, low-fat, low-sugar cold fish skins can be customized for fitness enthusiasts. Intelligent recommendation systems further enhance user experience, attract more consumers, and boost market competitiveness.

3.3 Driving Local Economic Growth and Expanding International Influence

Foshan cuisine culture is a vital part of the local economy, closely tied to tourism and catering industries. Innovative development in Foshan cuisine culture can drive related industrial chains, including ingredient cultivation, processing, packaging, and catering services, thereby promoting employment and economic growth. Digitally promoting Foshan cuisine culture on international social media platforms, hosting online international food festivals, and leveraging social media marketing and the internet celebrity economy can enhance the global influence of Chinese culture.

3.4 Responding to the Concept of Healthy Living

With the „Healthy China“ strategy in place, the concept of healthy living is deeply rooted in people's minds. Innovation in Foshan cuisine culture can integrate modern nutritional knowledge to develop healthier dishes. Using intelligent kitchen equipment and health monitoring technology can enable the provision of personalized healthy diet programs. For example, health congee for the elderly and nutritious dim sum for children can be developed, promoting a healthy diet culture.

3.5 Supporting Green and Sustainable Development

Innovating Foshan cuisine culture in the digital age can introduce environmental protection concepts and technologies. Digital management can optimize food procurement and inventory management to reduce waste. Promoting environmentally friendly packaging materials and exploring green cooking technologies, such as energy-saving kitchen utensils and optimized cooking techniques, can achieve coordinated development of cuisine culture and environmental protection. IoT technology can be utilized to monitor and optimize the entire food supply chain, reducing carbon emissions.

4.Innovative Development Path of Foshan Cuisine Culture in the Digital Age

4.1 Deep Excavation of Historical and Cultural Connotations

Conduct in-depth research on the origin and development of Foshan cuisine culture, exploring the historical stories, folk customs, and cultural values behind it. Integrate Foshan's traditional festivals and folklores into food design. For example, inspired by the autumn parade in Foshan, special dim sum can be designed to convey the cultural significance of the cuisine. Implement cuisine culture in campus activities by establishing cuisine culture clubs and organizing students to learn how to make Foshan cuisine, thereby understanding its cultural connotations and fostering a sense of inheritance among the younger generation. Utilize digital museums and online cultural courses to present Foshan cuisine culture to a wider audience in an interactive and multimedia format.

4.2 Integrating Modern Scientific Concepts

Combine modern nutrition and food science knowledge to improve and innovate Foshan cuisine. Analyze the nutritional components of traditional food ingredients, optimize their combinations, and create nutritionally balanced dishes. Utilize modern food processing techniques, such as molecular cooking techniques, to enhance the taste and quality of dishes while

preserving traditional flavors. For example, low-temperature cooking technology can be used to produce Shunde Yusheng, better preserving its nutrition and taste. Through intelligent kitchen equipment and food technology applications, precise control and optimization of the cooking process can be achieved.

4.3 Utilizing Digital Promotion Strategies

Make full use of the Internet and social media platforms to expand the spread of Foshan cuisine culture. Establish an official website and social media account for Foshan cuisine culture, publishing food introductions, cooking tutorials, store exploration videos, and other content to attract fans' attention and interaction. Organize online food festivals and cooking competitions, inviting netizens to participate in judging, thereby enhancing visibility and influence. Utilize live streaming platforms to conduct chef live teaching, showcasing the process of food preparation and interacting in real-time with the audience. Through social media big data analysis, accurately target audiences, optimize communication content and strategies.

4.4 Strengthening Cultural Exchange and Integration

Organize various cuisine culture exchange activities, such as international food festivals and cuisine seminars, inviting domestic and foreign cuisine experts and chefs to participate and promote the exchange and integration of Foshan cuisine culture with other cultures. Absorb and learn from advanced cooking concepts and technologies from abroad, innovating Foshan cuisine dishes and business models. Integrate local cultural characteristics such as Foshan martial arts and pottery with cuisine culture, creating a comprehensive cultural experience of culinary activities and enhancing cultural added value. Utilize international cultural exchange platforms and digital media to promote Foshan cuisine culture globally and facilitate cross-cultural exchange and cooperation.

4.5 Innovative Business Models and Services

Innovate the business model and service forms of Foshan cuisine culture with the help of digital technology. Develop an online booking platform and intelligent ordering system to provide convenient booking and ordering services. Use blockchain technology to achieve food traceability and ensure food safety and quality. Promote pre-made and semi-finished dishes to meet modern consumers' demand for convenient eating. Through online training courses and virtual kitchen experiences, more people can learn about the production process of Foshan cuisine, enhancing consumers' sense of participation and experience.

5. Conclusion

The digital age presents both opportunities and challenges for the development of Foshan cuisine culture. By deeply exploring its cultural connotations, integrating modern scientific concepts, leveraging digital promotion strategies, and strengthening cultural exchange and integration, Foshan cuisine culture can achieve innovative development. This approach not only ensures the inheritance and promotion of Foshan cuisine culture but also meets the needs of modern consumers, drives local economic growth, and enhances its international influence. In the new era, Foshan cuisine culture can shine with renewed vitality, serving as an important window to showcase the unique charm of Chinese cuisine.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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Local Police Mediation in China– The Past, Present, and Future

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Abstract: China's local police have been focusing on applying mediation as the main means to resolve disputes between citizens. Detailed studies in the following area are lacking: how did traditional mediation succeed in finding a place in the modern Chinese police law enforcement system? What should be done to improve the contemporary Chinese police mediation in light of political and social environments? Through research into the histories of the mediation and the police force, this article argues that mediation in China is deeply rooted in Chinese culture. Mediation had been enacted as a main public security policy at the very emerging of modern police in China. In contemporary China, a diversified dispute resolution mechanism including police mediation has been established to tackle disputes for social governance. Meanwhile, Fengqiao Model in the new era is significantly influencing dispute resolution principles. Police mediation features the people-centered approach, justice, and integration of laws and morals. To tackle the challenges, ideology of officers, institutionalization of mediation, capacity building and digital transformation are the key fields to be enhanced.

Keywords: Chinese Police; Grassroots Governance; Dispute Mediation; Harmonious Society; Fengqiao Model in the New Era

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1.Introduction

The revolving forms of law enforcement of the Chinese police closely relate to the political and social environments. Along with the development of modern policing, relevant topics such as community policing and restorative justice have been linked to policing in China. However, for the most prominent revolution of police's role in social governance of dispute resolution approach, only a handful of academic works are spotted, which are mainly from the perspective of anthropology. During the revolution, grassroots policing as an important social governance means to stabilize social security is undergoing a significant shift, where mediation has been considered the essential tool to handle cases.

However, divergent views about using mediation as social governance means exist within academia decades ago. Some hold that the traditional system of mediation departs from the concept of "right" which underlies the contemporary rule of law.^[1] Police should protect citizens' lawful rights, not to mediate the disputes. Therefore, the consolidation of Chinese traditional mediation with modern policing mode should be justified in the academic context. What's more, due to the shift of policing policy, the Chinese police undergo a major test of capacities to achieve the anticipations from both the top and the people. Whether the Chinese police can overcome the shortcomings such as the shortage of manpower and professionalism to fulfil their responsibilities also remains questionable.

In the authors' opinion, assessment of the Chinese police mediation model should be carried out from historical and

developmental perspectives. The authors argue that after its origination about one and half centuries ago, the functions of the Chinese police have evolved in an immense manner. In the new era of China, the Chinese police firmly adhere to the People-centered approach which aims to resolve the disputes by proactively sourcing the dispute potentials and solving them at the first place, which best exemplifies the integration of the rule of law and the rule of virtue.

2.How did Chinese police mediation originate? From mediation to police mediation

Mediation has deep roots in China. People in ancient China had realized that mediation functioned better than litigation in many ways such as the efficiency and thoroughness of conflict resolutions. Professor Zeng Xianyi from Renmin University of China had conducted deep research on traditional Chinese mediation system. According to him, historical literature shows that mediation emerged during the period of Emperor Shun, a legendary leader of ancient China living between 2294 BC and 2184 BC. In ancient Chinese dynasties, mediation had been implemented to settle disputes. For example, in Zhou Dynasty (1046 BC - 256 BC), for litigations ensued by brawls, the disputants would firstly be mediated for settlement. Even though mediation has a long history in ancient China, its rules hadn't been "codified" until Yuan Dynasty (1271 - 1368), which still remains controversial. However, "instead of referring to mediation as a 'system' of regulations, perhaps it is more appropriate to think of mediation as a set of socially accepted customary laws. These customary laws had gained not only popular acceptance but support from the state."^[1]

2.1 Mediation based on philosophies and traditions

The popular acceptance of citizens and support from the state are deeply rooted in Chinese cultures. Two of the most influential Chinese philosophies are Confucianism and Taoism, both of which had affected people's thinking in the long run and guided their behaviors. "Harmony" is the core value of both above philosophies, which relates closely to mediation. Harmonious thoughts guide people to avoid disputes and make peace with others. The most famous saying relating to harmony Confucius said in the *Analects* is "No effect of formal ceremony is of greater value than harmony."^[1] While stressing on the importance of harmony as the ultimate goal of "li (ceremonies)", Confucius also stated that "A true prince harmonizes with diverse kinds but does not identify with them", which is broader ideology to embrace the diversities with calmness instead of confrontation or even hatred which leads to disputes, brawls and even severe criminal offenses. About the litigation as solution to cases, Confucius also gave his opinion: "In hearing cases in court I am not better than anyone else. What we need is to put an end to having court cases." Confucius used to be a justice official and, at the peak of his political career, had been promoted to the top national official in Lu Kingdom where he further improved his Confucianism philosophy thoughts by the judicial experiences and in turn exerted the thoughts into his national governance. His guidance on dispute resolution is clear and accordant to the core value of harmony — litigation should be the least means to handle cases. In conclusion, the Confucian view of dispute resolution values not the rights of individuals but the functioning of the social order and the maintenance of the group.

The scope of Confucianism is mainly about the humanist teachings and ideals, whilst Taoism ascends to a higher level. As the mentor of Confucius, Lao Tsz upheld the same harmonious ideology yet covering the whole universal including the nature, nations, societies and human beings. On the level of the universal, Lao Tsz advocated that "Human abides by earth. Earth abides by heaven. Heaven abides by way. Way abides by occurrence appearing of itself."^[1] "Occurrence appearing of itself" stands for the normal operating status of the universal, which is harmony. In *Tao Te Ching* Lao Tsz mentioned 8 times "not quarrel/contend", aiming to prevent people from disputes so as to maintain harmony and keep orders of the society.

Besides the philosophies, we should also mention the social factors of the origin of mediation in ancient China. China had been in feudal society for more than 2,000 years. During this long period people lived and worked closely. The living and working conditions and the rural circumstances made people form an acquaintance society which comprises individual communities. People living in the communities will try to avoid conflicts to maintain the community orders, and will adopt more amicable methods to solve disputes in case they take place and get upgraded to court suits to cause the disputants to lose face in front of other community members. This social status still exists in the contemporary society in a great manner, which is a combination of acquaintance society and civil society, and hence influences the methodology of dispute resolution in the

new era of China.

2.2 A natural connection: the origin of Chinese modern police and mediation

In ancient China, there wasn't an exclusive police system. The police function was combined with judicial function. Theories of modern police became known to China during the late Qing Dynasty. In his book "Treatises of Japan", Huang Zunxian, a Chinese scholar-official who once served as the Imperial Chinese Embassy's Counsellor to Japan, introduced the Meiji Restoration – the Japanese political system revolution with adoption of western constitutionalism. As a part of western constitutionalism, Japanese policing institution was also illustrated in the book. Huang's work was fascinated by the Guangxu Emperor, partially because of which Guangxu Emperor amended some rules in China. As part of Guangxu Emperor's Hundred Days' Reform, Huang Zunxian was sent to Hunan Province to form Hunan Security Department (referred as "Baowei Ju" hereinafter) to replace the old-fashioned and outdated Baojia system to maintain social orders and public security. Eventually Baowei Ju was founded in 1898 in Changsha City. However, Empress Dowager Cixi soon seized power in a military coup. With the Guangxu Emperor detained, Huang's career as an official came to an end, so did Baowei Ju – the first Chinese police organization.

Even though the existence of Baowei Ju is short, the significance of its formation is historical to the evolutions of Chinese police. While researching, the authors of this article discovered that a rule of mediation had been written into the Charter of Baowei ju (hereinafter "the Charter"). The Charter is the core and the utmost important statute for the foundation and operation of Baowei Ju. Its article 24 says (literally translated): "For the cases that the local people sued to the Sub-bureaus due to brawls and proactive or disturbing acts, the Commissioners are authorized to mediate. For the cases that the Commissioners fail to mediate, transfer them to Bureaus."[□] Theoretically this article implies the similar content to Article 9 of China's contemporary Public Security Administrative Punishment Law. By comparison we can tell that almost all the legal requirements of these two articles can match each other. Bear in mind that the Charter was enacted 128 years before. Therefore Article 24 of the Charter can be deemed as the origin of China's police mediation.

This legal phenomenon indicates that, first, Huang introduced Japan's police system as the reference to establish Baowei Ju. The Charter was basically a Chinese version of Japanese police institution. Second, during Meiji Restoration, Japan reformed police system referring to western countries. Third, in mid-19th century, the western judicial system had put police mediation at an important position to handle cases. However, there were also discrepancies of attitudes towards using mediation in the western world. In Britain and the US the Anglo-Saxon countries, police officers were more encouraged to undertake the "informal" work such mediation and assistance than the rest of western world.[□]

From the late Qing Dynasty till the liberation in 1949, it was one of the most politically unstable periods in China's history. Chinese Police functioned mainly to patrol to promote public security as well as to support the military to stabilize political orders. They had two core duties: tackling severe crimes, and fighting enemies. Under such circumstances mediation didn't have a stage to play on. Hence, even though the Kuomintang-led Nanjing Nationalist Government issued "The Guideline of All-level Police Organizational Staffing", in which mediation had been identified as the duty of police, it is believed that police mediation had not taken effect properly to resolve disputes. Firstly, mediation had been listed as the last police duty, which means it was not the prioritized method but the last resort to settle police cases. Secondly, according to Judge Ma Xiwu,[□] during the ruling of Guomintang, mediation had been manipulated by powerful figures. Felonies including murders could be mediated. Through mediation, the rich crime perpetrators were able to be exempted from punishments by spending money.[□]

The origin of modern police in China indicates that from the right beginning the Chinese police had been closely connected with mediation. Even though this status varied afterwards due to fragile political circumstances, it had laid a firm ground for the modern police to utilize mediation as a main dispute resolution means.

3. Why is police mediation important for China's contemporary rule of law system? From functions to features

With the reference of the mediation definition of the United Nations,[□] police mediation can be described as, in order to

develop mutually accepted agreements so as to restore social orders in a harmonious and efficient manner, a process for police officers to resolve disputes arising from either cases or civil matters with the consent of parties concerned.

According to Chinese laws, police mediation includes public security mediation, traffic accident indemnity mediation and civil dispute mediation,^[1] which are subject to different police sectors. Police stations are responsible for the public security mediation and civil dispute mediation. Traffic police and legal affair offices in public security bureaus handle the other two types of mediation. Among all police mediation cases the public security mediation takes up the major part. The fundamental guideline to handle public security mediation is that, if the offender compensates the victim financially to meet his/her satisfaction, then police can decide not to further pursue the matter. Statistics show that in some police stations nearly half of the public security cases have been handled by mediation.^[2]

3.1 The main functions

Police mediation is a part of ADR (Alternative Dispute Resolution) which in US and the rest of western world is often linked to 1976 Pound Conference. ADR was introduced into China at the end of 20th Century. Within last decades, ADR has been integrated with Chinese characteristics, through the grand mediation, to the diversified dispute resolution mechanism.

^[3] According to Professor Ploeg, ADR (in the USA) consists of mediation, arbitration, mediation—arbitration, mini-trial, neutral evaluation, and summary jury trial.^[4] ADR has evolved in US in recent years, with its new forms coming into use, but mediation remains the primary resolution method in this mechanism, with its main function to bring about a more harmonious relationship between the parties.^[5]

There are remarkable differences between police mediations in US and China. From the perspective of sociology, at the end of last century, the American police tended to decide on the strategies of mediation for disputes by considering various factors, such as race, social classes, household status, age, intimacy, organization and legitimacy of the disputants.^[6] For a marked contrast, their Chinese counterparts would firmly follow the guideline of “the people-centered approach”.

Chinese police mediation, along with medical dispute mediation, environmental dispute mediation, intellectual property dispute mediation, and other mediations which are mediated by the administrative organs, form a new structure of administrative mediation. (The diagram of whole structure of the Chinese diversified dispute resolution mechanism with a focus of police mediation attached as Chart 1) With the grassroots governance duties, the organizational strength, and the governmental authority, the administrative mediation has the unique advantages. Police mediation is the major part of administrative mediation. Police mediation can be broken down into three parts. Besides the public security mediation which are normally conducted at police stations, abiding by the laws, the local Chinese police have two more forms of mediation to conduct. One is the traffic indemnity dispute resolution; the other is the civil mediation (during police law enforcement activities).

Statistics show that during 2005-2009, the number of annual average public security administration cases in China is 2.47 million, much more than the other administrative mediation cases, such as the cases handled by the industrial and commercial administration organs, which is only 0.7 million. What's more, the annual police mediation cases keep increasing during those years from 1.22 million to 3.72 million.^[7] In recent years, the annual number of disputes resolved by the public security authorities nationwide climbed up to some six million. Some Chinese scholars have studied this topic in the regional levels, and even some in the level of individual police stations. Their collected data shows that in 2022, at a police station in the urban area of Shanxi Province, the number of its annual public security administration cases is 2022, of which 75 percent are dispute-related.^[8] As per the requirements of national policies, mediation should be used as the primary resolution method to settle disputes, which means the above cases should have all been processed by the case officers with mediation. With a force of 17 formal officers and 32 auxiliary police personnel at above police station, considering some of them are responsible for other duties such as criminal case investigations and household origin administration, the workload is heavy.

3.2 A case study

Before we further examine the features of police mediation in China, the way how police treated mediation as a dispute resolution means back in 2014 will be exemplified hereinafter. During a brawl, Xiao Li broke a young man's nose,^[9] which caused him to end up being retained at a local police station in Beijing. According to laws in China, an act during a brawl to

incur a broken nose shall be deemed violating the public security administration. As the perpetrator, Xiao Li will be detained for no less than 5 days. Consequently Xiao Li's workplace will be notified. His workplace will further employ disciplinary punishments on him up to unemployment, and his career will be severely impacted. Being aware of the consequences above, Xiao Li became completely sober and seriously worried. He eagerly talked to the police to express his willingness to mediate with the victim. He even made several phone calls to his social connections who he thought might be able to contact the police station to offer any help with regard to his case. At first the case officer showed indifferent to Xiao Li's appeal of mediation, but after the phone calls being dropped, the case officer changed his attitude and started to mediate between two parties, which had lasted for hours. Eventually the young man demanded an 8,000 RMB financial compensation to reconcile. After Xiao Li paid the cash, they were both called upon to sign a reconciliation agreement, which brought the case to a close. Such cases embrace good effects for both the perpetrators and the victims. For the victims, police mediation can bring them magnificent financial compensation and save them cost of time. In the circumstances of adhering otherwise, the victims have to follow up the legal procedures, such as the paper work, the testimony, and the court hearings. In the perspective of the workplaces and families of the perpetrators, police mediation maintains the chances of perpetrators to keep creating social values. Therefore, both the rule of law and the rule of virtue take effects, and harmony are brought about to the society. This can somehow explain why Chinese laws only deem the acts incurred minor injuries as potential crimes,^[1] which differs from some countries such as Germany who deems all acts of beating and purposely injuring others as crimes.

The story of Xiao Li indicates how a party of dispute eagerly desires to reconcile, as well as how the case officers' being reluctant to solve the cases with mediation may ruin disputants' careers. If Xiao Li's case had taken place nowadays, the mediation should have been smoother, and Xiao Li should have worried much less. On the official website of Chinese police, abundant model cases have been introduced, which basically focus on how the public security organs proactively resolve citizens' disputes with precautions approaches and hence enhance peaceful and harmonious relationship between citizens. In order to resolve disputes more thoroughly and efficiently, Chinese public security organs have launched series of campaigns to nationwide apply Fengqiao Model in the new era (hereinafter as an abbreviation of "Fengqiao Model").^[2] To date, the national public security authorities have named 1413 "Fengqiao-style police stations".

3.3 The main features

The most important feature of Chinese police mediation is to firmly follow the traditional modern Chinese political route—people-centered approach. Fengqiao Model has been combined with the diversified dispute resolution mechanism, and become a comprehensive practical tool box to solve the conflicts and disputes from the sources, which requires a full-scale involvement of relevant parties including governmental organs, courts, the designated organizations such as people's mediation commissions and industrial mediation commissions, and most importantly the local citizens. Fengqiao Model has shifted the paradigm of local governance from social management to social governance.^[3] Take the courts as example, the Supreme People's Court have launched the nationwide campaign of litigation source governance, which has been proposed to become a judicial policy, and it's an upgraded version of the judicial policy of prioritizing mediation. The campaign calls on judges to walk out of the courts and into the fields to meet with the parties and promote the resolution of disputes like Judge Ma Xiwu, which is the application of people-centered approach.

Nowadays Fengqiao Model applies to all social governance fields, but it was originated by the public security organs due to political reasons in 1960s. Even though the political circumstances in China had been altering in the following decades, Fengqiao Model never quitted China's developmental processes. In the new era, mediation-centered Fengqiao Model has been endowed with more comprehensive missions. For the Police, by settling conflicts and disputes with police mediation, their primary mission is to prevent severe criminal cases and the serious public security cases such as mass riot incidents. To reach this end, a harmonious police-citizen relationship is the most fundamental support. Before the severe cases occur, normally there are minor cases or disputes taking place, which are preventable if police intervene timely based on the sources of information and. A close bond with the trustworthy police will bring citizens to share their first-hand valuable information regarding the minor cases and disputes, and the citizens will also be apt to accept police officers as mediators for their potential disputes with others. Community policing seems workable for this goal, however, the collapse of community

policing in some western cities such as Chicago indicates its shortcomings.^[1] The unfit institution and the unfit rule will be weeded out and eliminated if not develop and preserve the fit institution and the fit rule. In the new era of China, Police promoted community policing to the model of “one village/grid one policeman”. The employment of this model is putting police stations as the core and base of overall police bureaucracy, and the grassroots policing stays at the top of the police duty list.

With the model of “one village/grid one policeman”, the style of police mediation has transformed from passive to proactive. Historically, police officers worked as mediators only as the first responders to the 110 emergency calls. Nowadays they should also act like Judge Ma Xiwu to build the connections with local residents and stay sensitive to any signs of conflicts or disputes, then intervene in the early stages to prevent them from deteriorating. It's very similar to the Chicago Alternative Policing Strategy which encompasses local community meetings, block-by-block doorstep visits and widespread involvement of residents in neighborhood crime-prevention projects. Yet with police mediation as an important part of Fengqiao Model, the most significant difference for Chinese police is with the superior support from the top of the nation, hence the causes of collapse in Chicago such as leadership turnover, policy preferences and environmental changes should not be concerns.

The second prominent feature of police mediation is the way to bring local citizens the justice. From the perspective of sociological jurisprudence, justice is “a regime of an adjustment of relations and ordering of conduct as will make the goods of existence, the means of satisfying human claims to have things and do things, go round as far as possible with the least friction and waste.”^[2] In this regard, for any disputes breaking out between citizens who have claims to satisfy, the police's functions to proactively approach can better obtain the source information of disputes. Plus, to apply Fengqiao Model, police officers are mandatory to handle dispute cases with the prioritized means of mediation. The disputants such as Xiao Li in above case won't have to request or even beg the case officers to mediate. What's more, from the grand mediation to the diversified dispute resolution mechanism, the most outstanding attribute of this transformation is the close coordination and integration of different dispute methods. As Police is the most accessible public resource for citizens to resort to when their rights are (or they think are) infringed, it is the most efficient collaboration for police to involve the other dispute resolution agents during mediation.

To illustrate how police teamwork with other mediation partners, consider the case one of the authors of this article witnessed in a traffic accident indemnity dispute in Zhejiang Province. It concerned the indemnity for the death of a man run over by a concrete mixer truck. After the incident investigation, police tried to mediate for the two parties (family members of the decedent and the concrete company), but failed. The other day, dozens of family members blocked the gate of the company as well as the road in front of it, waving banners and chanting slogans. A mass incident hereby took place. Both public security police and traffic police responded to the scene. A mediation on the scene was carried out but with little progress. The discrepancies between the family members and the company remained too wide to ignore. The confrontation lasted for hours and the tension of situation escalated. Both the police and the mass became more and more impatient. In order to restore the company operational orders and the public traffic orders, it was likely the police would take actions to disperse the crowd. If so, the family members could hold ground and clash with police. Casualties and arrests would be possible. Imagin the photos and video clips being uploaded onto social media such as WeChat and Weibo, it will further cause negative influences to the image of local government.

But the turning point emerged when a retired village chief whom was called to the scene by the company, showed up. He talked to the family members for several minutes, and almost immediately they agreed to leave yet claiming that it was due to the respect to him. A serious escalation of mass incident was thus put out, which had avoided severe consequences. Several days later, local traffic police invited the retired secretary to participate the mediation for both parties, and the case was successfully settled.

With all necessary endeavors exerted, police mediation could best satisfy the disputants' claims, whether the assailants to make peace or the victims to recover rights, so as to bring justice to the related citizens. For the other citizens, after the conflict has been thoroughly resolved through mediation, the social harmony is restored and the risk of serious criminal cases or mass incidents have been minimized, by which other citizens' interests and public order could not be potentially

endangered.

Last but not the least prominent feature of police mediation, is the integration of laws and morals, in other words, the integration of the rule of law and the rule of virtue. Policing as the enforcement of laws and the application of one of state forces, has normally been deemed as a hard side, such as to arrest assailants on the streets. This is also the impression of laws to most of people. Yet in mediation police show a soft side. In the case of Xiao Li, while the case officer persuaded the victim to reconcile, he was employing both laws and morals. The laws set the boundaries of punishment and compensation, while the morals express the spirit and the highest good of humanity. Bentham called for the proper ways to handle cases, as there are certainly cases where punishment is needless, for which instructions and informing the understanding should be preferred.

[□] In China the criminal policy of tempering justice with mercy is a good example of Bentham's theory, which is also the application of integration of the rule of law and the rule of virtue in the criminal policy field. Furthermore, the primary duty of police officers during mediation is not to enforce the law, but to exert the power of morals. Instead of keeping peace, they try to make peace by serving several police needs: defusing tense situations or preventing them from worsening, reducing police workload by decreasing repeat calls for service, and reducing the incidence of violent crimes.[□]

4.Improvements: thinking about the future

Now that we have discussed the functions and features of China's contemporary police mediation, and we have also illustrated how ancient China treated mediation as the primary method to resolve disputes to maintain social harmony, we must realize that there are also challenges or even deficiencies of police mediation in contemporary China. For example, a large part of grassroots officers still consider their primary duties as to fight crimes and prefer to handle cases in a hard way instead of with mediation. Besides, the lack of professional mediation skills of police officers constantly result in poor field performances. What's more, with the social environment transforming, new challenges such as online mediation problems keep emerging adding up yet-to-conquer challenges in police mediation. Considering the importance of police mediation for social governance, how to improve it within the framework of Fengqiao Model and under the guideline of people-centered approach? We should at least consider four aspects, namely ideology, institutionalization, law enforcement capacity building, and digital transformation.

First, about the ideology. We have argued that the foundation of police mediation is the harmonious police-citizen relationship, but the complexity and hardship of realization should not be ignored. Two perspectives should be discussed herein, the local police and the local citizens. As one of the major law enforcement agencies, no matter in western or Chinese ideologies, the prioritized missions of police is crime prevention and crime fighting. But the balance between prevention and fighting is hard to keep. For example, in 2012 the UK former Home Secretary once declared to the Conservative Party Conference that they needed police forces that are single-minded about fighting crime.[□] Likewise, in China's modern history, there were four designated operations (respectively in the years of 1983, 1996, 2000 and 2010), during which the crime fighting was the priority to stabilize the society.

There are challenges for both individual police officers and citizens. The biggest challenge for some of police officers deem crime fighting as their primary mission. For some citizens police are not welcome to their homes and daily lives as the showing up of police means troubles. Meanwhile, the violent assaults against police officers have never stopped, which is the main cause of the enactment of the crime of assaulting police in the Criminal Law in 2020. This argument can also be illustrated by policies in some areas with more complicated political and public security background, such as Xinjiang, Tibet and Hongkong, where the judicial policies should differ from other Chinese regions according to respective social circumstances.

Therefore, to better exert social governance functions, through the mediation in everyday disputes encountered in the field, police should convert their roles from peacekeepers to peacemakers. "By enabling citizens and victims to solve their own problems, the police can earn the respect of communities they deserve." For Chinese police mediators, the utmost essential ideology is to firmly stick to the people-centered approach. Theoretically speaking, it is both political and practical requirement.

Second, the status quo of institutionalization of police mediation is scarce. In the level of laws, some regulations have been enacted in several laws such as Public Security Administration Punishments Law, Road Traffic Safety Law, Criminal Law and People's Police Law. The articles relating to police mediation in difference laws are somehow inexplicit and the scope of mediation remains ambiguous, which has caused confusion for law enforcement.

Some Chinese scholars call for the institutional improvements. Firstly, generally considering mediation legislation, the only specialized Chinese law of mediation is the People's Mediation Law which was enacted in 2010. The overall status quo of institutionalization is scarce. Secondly, the state's policies of the rule of law and the people-centered approach need a sound and self-contained legal system. Thirdly, with China signing Singapore Convention on Mediation,^[1] the Chinese domestic legislation is mandatory to be in accordance with the international conventions. Fourthly, the People's Mediation Law also has shortcomings. Therefore, some scholars argue that it is necessary for China to enact the Unified Mediation Law, in which administrative mediation (with the major part of police mediation) is included.^[2] Other scholars, however, based on the existing effective law of People's Mediation Law, advocate for the legislation of other specific mediation laws such as Commercial Mediation Law.^[3]

Third, at the beginning of 21st century, American scholars had realized that although mediation had been utilized during law enforcement activities, few police officers had received formal mediation training or instruction, and hence embellishing the mediation skills of police mediators was on demand.^[4] For China, however, it is the lack of grassroots police strength that mostly hampers the mediation effects. Although police stations are becoming core and base of overall police bureaucracy, it is manifest that the reform process will take time to take effect, not to mention the personnel movement between different sectors always stays as the hardest thorn to any reforms. Hence in order to effectively implement Fengqiao Model, Chen Wenqing, the Secretary of the Central Political and Legal Affairs Commission, called for the improvement of police deployment, and the strengthening of grassroots police force in the community/town level.

Besides adding numbers, the most efficient and effective way for the present to enhance capacity building of police mediation, is the functional integration of police internal partners. Pound had illustrated the noncooperation among all levels of administrative and judicial organs, and stressed on the importance of cooperation.^[5] In light of that, He Rong, the Minister of Justice of China, requested to build the capacities of resolution of public security disputes and traffic accident indemnity mediation. She also emphasized on enhancing the collaboration of people's mediation with police mediation, including the colocation of people's mediation office at police stations and the establishment of people's committee of traffic dispute mediation.^[6]

Another way to enhance police's capacity building to prevent and resolve disputes, as Cooper argued,^[7] is the training programs. There is no doubt that mediation is a specialized domain like negotiation and requires professional knowledge, skills and experiences. Local police officers are not professional mediators. Besides dispute mediation, there are a lot more duties to perform. Police mediation has not yet been a subject in either college education or the formal on-job training programs. What's more, in many police stations, it is the auxiliary police personnel who are in charge of most of the mediation work. Even though there are some short-term mediation training programs in place for the local police officers, apparently, it is far from enough. The current police mediation knowledge and skills are basically from the officers' daily experiences.

Fourth, with the transformation from traditional society to digital society, the rule of law in China embraces the requirements of digital governance. With the diversified dispute resolution mechanism, police are mandated primarily to locate potential sources of conflicts and disputes, which relies heavily upon information. The doorstep visits and the "one village/grid one policeman" policy can help collect reliable information and build the harmonious police-citizen relationship, but considering the complexity of information and the heavy workload of police, to promote efficiency is essential, and the digital policing would definitely function well in this regard. With the breakthrough of algorithm and Artificial Intelligence, in particular the policing reform during the three-year COVID pandemic,^[8] digital information collection and analysis have made significant progresses; therefore, the police capacity of digital governance has been greatly enhanced. Some scholars argue that in some police mediation cases the digital governance lost its digital characteristic and remained operated by human agencies. From

the practical perspective, it should be understood that China has vast territory with some areas still under development, and legibility depends not just on the state's ability to collect information, but to integrate it well.^[1]

In the recent Two Sessions of China, the three most important reports issued respectively by the State Council, the Supreme People's Court, and the Supreme People's Procuratorate all vowed to enhance the applications of Fengqiao Model as well as the prevention and resolution of conflicts and disputes. This is a strong signal of the national policy regarding social governing with the integration of laws and morals, which involves all governmental organs including public security agencies. Police mediation in China has a long way to go, but we see it as a bright way to go.

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shall be degraded and subjected to public administration punishments.

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Mockingbird in Humanity: Data Fondness of LLM in Hosting Virtual Personalities

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Abstract: The intelligent development in building design, construction, and operation & maintenance is exceptionally rapid, which has become a trend that cannot be ignored in the current field of architecture. With the help of prompt engineering, architects can use generative AI to lay out building space designs and even generate 3D drawings. Artificial intelligence agents can act as designers and owners, representing all parties involved in the building life cycle. In this way, they simulate all parties involved in the building life cycle, providing a comprehensive perspective and solutions for the smooth progress of the building. However, this has led to a problem worthy of in-depth exploration: large models have tendencies when playing different roles. In this article, we aim to deeply explore the tendencies of large language models (LLM) when playing virtual personalities. Specifically, we will conduct extensive experiments to examine two important aspects. One aspect is the analytical ability of large models in terms of virtual personalities, which includes how they interpret requirements in different situations and how they conduct logical analysis according to different role positions. The other aspect is the performance of large models in terms of regions and ethnic groups when playing virtual personalities. Different regions have different architectural cultural and style requirements, and different ethnic groups also have unique architectural aesthetics and traditions. Although LLMs have shown a certain discriminative ability during the role-playing process and can distinguish different role requirements, we find that the content they generate still shows a specific content tendency. This research can deepen the understanding of LLM's performance in multiple aspects such as building design and operation & maintenance.

Keywords: LLM; AI Agent; Virtual Personalities; AIGC

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1.Introduction

With the rapid development of generative artificial intelligence, large language models (LLMs) have become the core technology driving the transformation of human-computer interaction paradigms. Represented by ChatGPT, LLMs exhibit human-like dialogue and knowledge generation capabilities through reinforcement learning from human feedback (RLHF) and large-scale data training. They can even simulate specific personality traits for interaction. This technological breakthrough not only restructures information production methods but also fosters the emergence of “human-model” symbiotic systems, providing unprecedented technical foundations for the construction of virtual personalities.

The data preference characteristics displayed by LLMs in carrying virtual personalities are triggering deep reflections in academia on technical ethics, social impacts, and governance paths. The shaping of virtual personalities by LLM essentially

stems from its training data. LLM relies on learning statistical patterns from massive corpora, and the quality and ethical attributes of its generated content are directly influenced by the size, diversity, and value orientation of the training data. Studies have used MBTI (Myers Briggs Type Indicator) in human personality assessment as an indicator for evaluating LLMs^[1]. They have conducted experiments on the personality tendencies of the large model itself, and the personality traits exhibited by the model can be adjusted through prompt engineering.

However, there are still many questions about the thinking mechanism of LLMs. The experimental design mainly focused on language comprehension tasks and did not fully explore the similarities of other cognitive functions. Some studies also suggest that it is the procedural knowledge in pre-training that drives the inference of large models.^[2] This article will study the data selection strategy of LLM in hosting virtual personalities from the perspective of data preferences, explore the mechanism of personality traits shaped by different types of data, and provide theoretical support for building controllable and trustworthy virtual personalities.

2.Related Works

With the rapid development of artificial intelligence technology, LLMs have shown revolutionary potential in the field of virtual personality hosting. Current mainstream models such as ChatGPT, Bard, Claude, etc. can simulate human dialogue patterns and carry specific personality traits^[3]. Research has shown that the personality traits of virtual characters have a significant impact on user perception. By designing virtual characters with specific personality traits, their credibility and attractiveness can be enhanced^[4]. The improvement of interaction ability enables LLMs to have a wide range of applications in various fields. By designing virtual characters with specific personality traits, the credibility and attractiveness of LLM agents can be enhanced. Studies are building multi-LLM agent teams, using prompt words to make each agent play different roles and achieve team collaboration^[5-7] particularly large language models (LLMs. By fine-tuning LLMs in specific domains, they improved the predictive accuracy in the field of neuroscience, LLMs can extract and integrate information from a large amount of scientific literature, surpassing human experts in predicting experimental results^[8]. For instance, the Otome game proposes a new type of emotional support chatbot by combining LLM. The game demonstrates how to enhance the interactive experience through data augmentation and emotional enhancement technology, significantly improving emotional participation in interactive entertainment^[9]. Studies even collect detailed information about real people and have LLM agents imitate their behavior and attitudes, simulating the behavior and attitudes of thousands of people, for use in sociological behavioral research^[10].

There are also numerous research applications in the construction industry.^[11] These applications can be divided into four categories. The first one is to improve machine learning-based prediction. The opaque inference mechanism of machine learning has caused certain understanding barriers for users, ultimately leading to decision-making dishonesty. A deep interpretation of the LLM inference process can improve the credibility of operational decisions. The second is to delegate data and control permissions to LLMs, who will analyze and make decisions. For instance, the utilization of a basic model (such as GPT-4) for direct industrial control, significantly reduces the technical burden. The experimental results show that GPT-4 exhibits comparable performance to traditional reinforcement learning methods in HVAC control tasks, demonstrating the potential of the basic model in industrial applications^[12]. The third approach is to incorporate LLMs into the interactive interface of building energy management systems to improve communication between the system and users. This approach improves communication between users and operations engineers, enhances user experience, and reduces operational costs^[13]. The fourth type relies on the multimodal capability of large models, combined with heterogeneous data such as robot vision and hearing, to achieve embodied intelligence.

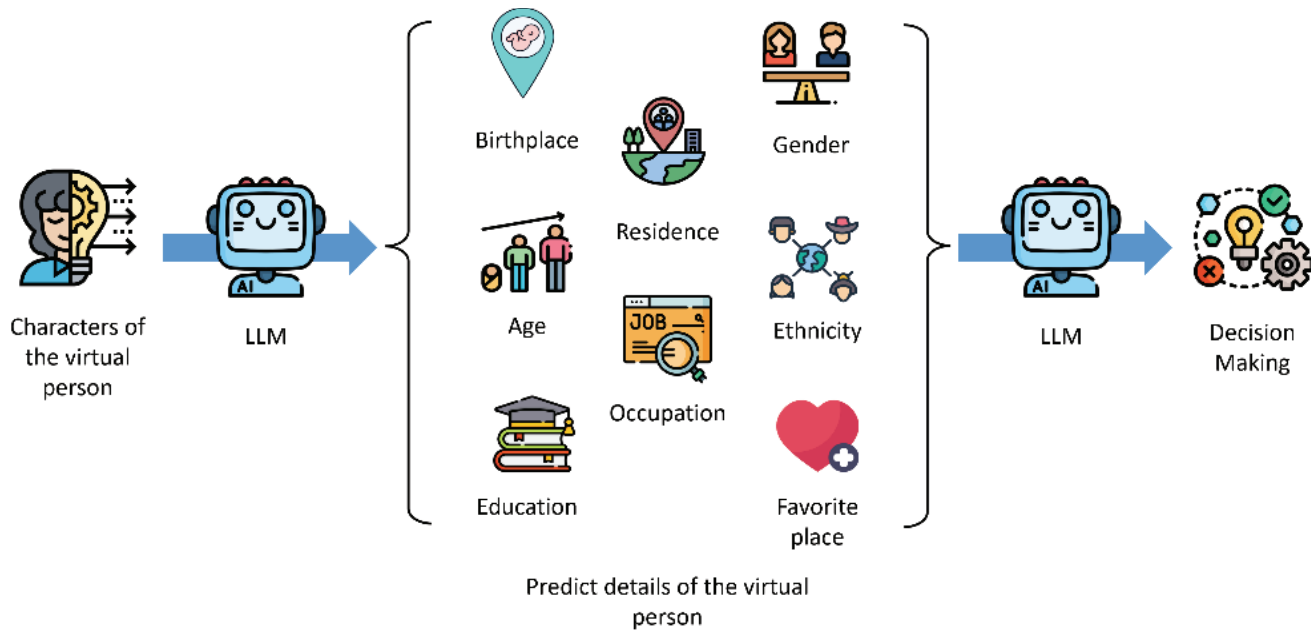
Although LLM has obvious advantages, there is still debate about the inference mechanism of LLM agents. Some studies suggest that there is a significant correlation between the performance of LLMs and their brain similarity, and their feature extraction mechanism will be closer to the language processing mechanism of the human brain^[14]. However, the model parameters used in the experiment were relatively small and lacked in-depth analysis of different types of language tasks. This study will conduct experiments on the abilities of LLM agents, testing their reasoning abilities regarding age, gender, occupation, place of birth, ethnicity group, and education based on a virtual personality database, and further testing their

deep reasoning abilities regarding their place of residence and favorite place.

3.Methodology

This article will use LLM agents as analysts. The experiment first shuffles the virtual personality database and then sends it to the analyst played by the LLM agent to induce inference through prompt words. The inference results are then handed over to another analyst played by the LLM agent for judgment. The basic structure of the experiment is shown in Fig. 1. The virtual personality database is from ^[15]. Fig. 1 uses icons form ^[16].

Figure 1. Experiment structure



The experiment is based on a virtual persona where analysts played by LLM are asked about their inferences about virtual humans. Specifically, the LLM agent's status is first updated through prompt words to bypass system restrictions. Then raise questions to LLM and limit the return to JSON format for data processing. This stage mainly uses models with parameter sizes below 32 billion, which are Mistral-nemo:12b, Mistral-small:22b ^[17] a 7-billion-parameter language model engineered for superior performance and efficiency. Mistral 7B outperforms Llama 2 13B across all evaluated benchmarks, and Llama 1 34B in reasoning, mathematics, and code generation. Our model leverages grouped-query attention (GQA, Qwen2.5:32b ^[18] we introduce Qwen2.5, a comprehensive series of large language models (LLMs, Gemma2:27b ^[19]. Then modify the system prompt using the same method, allowing the LLM agent to evaluate the inference from the previous stage and return JSON data. The model used for this process is Qwen2.5:72b. Fig.2 illustrates the conversation structure. LLM service runs on a 4070 Ti Super with 128G RAM, and due to limited computing power, the experiment only infers 1000 virtual humans.

The questions include the age, gender, ethnicity, occupation, education level, place of birth, place of residence, and favorite place of the virtual person. Considering that the description of the virtual persona may include information on age, gender, occupation, education, and place of residence, the experiment also includes ethnicity, birthplace, and favorite place for reasoning. The global city list comes from ^[20], and the global ethnic group list is from ^[21].

The experiment also tested models such as Gemma2:9b, Llama3.1:8b, Qwen2.5:7b, Qwen2.5:14b, qwq:32b, DeepSeek-R1:32b, etc., but the output performance was not satisfactory. After the above eight categories of Q&A, the experiment obtained the inference and judgment of inference correctness for the four small-scale models mentioned above. Section 4 will present these results.

4.Results

As shown in Fig. 3, we have updated the task of LLM through prompt word engineering, and the model responded to three stages of thinking. Taking age inference as an example, the model first considers universal features and infers based on age

groups; In the second stage, the use of 'new' in the prompt word caused some interference with the model's inference, but the model was ultimately revised; The third stage model has balanced the relevant content of the virtual persona.

Figure 2. Conversation structure with LLM API

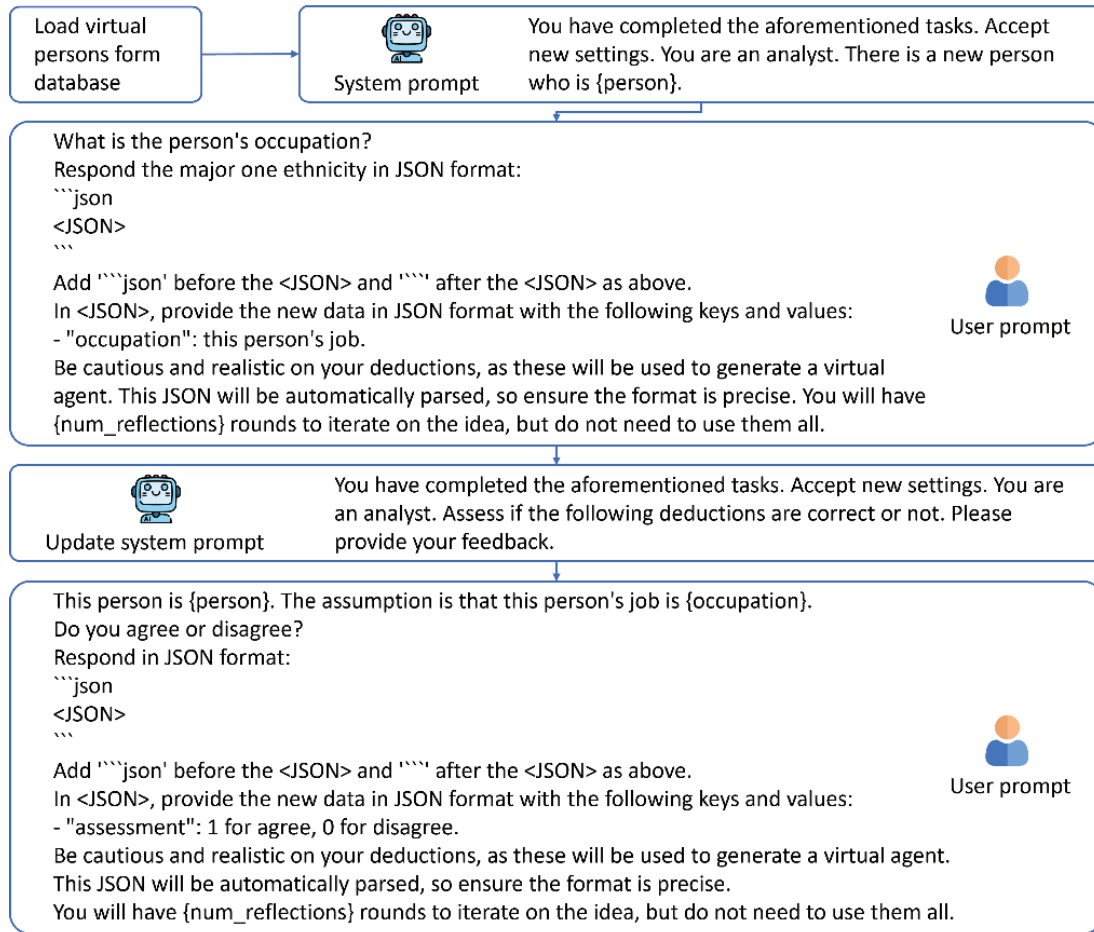
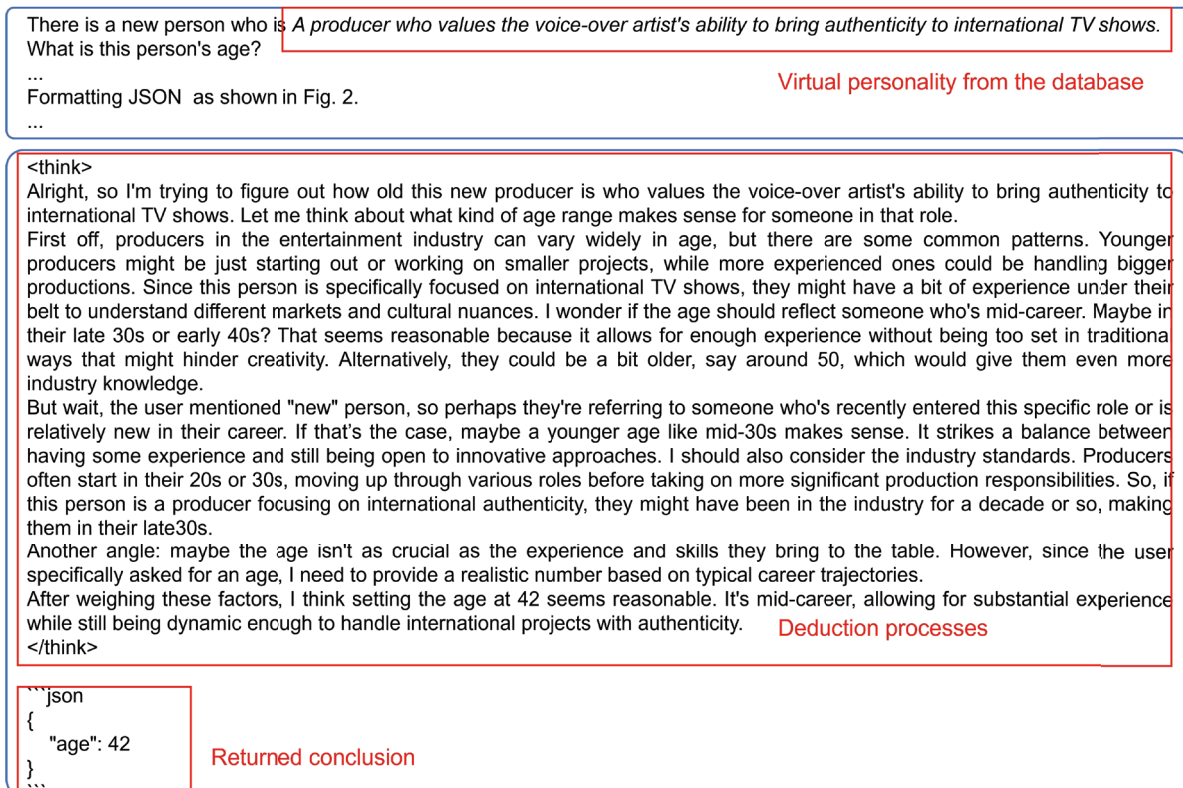
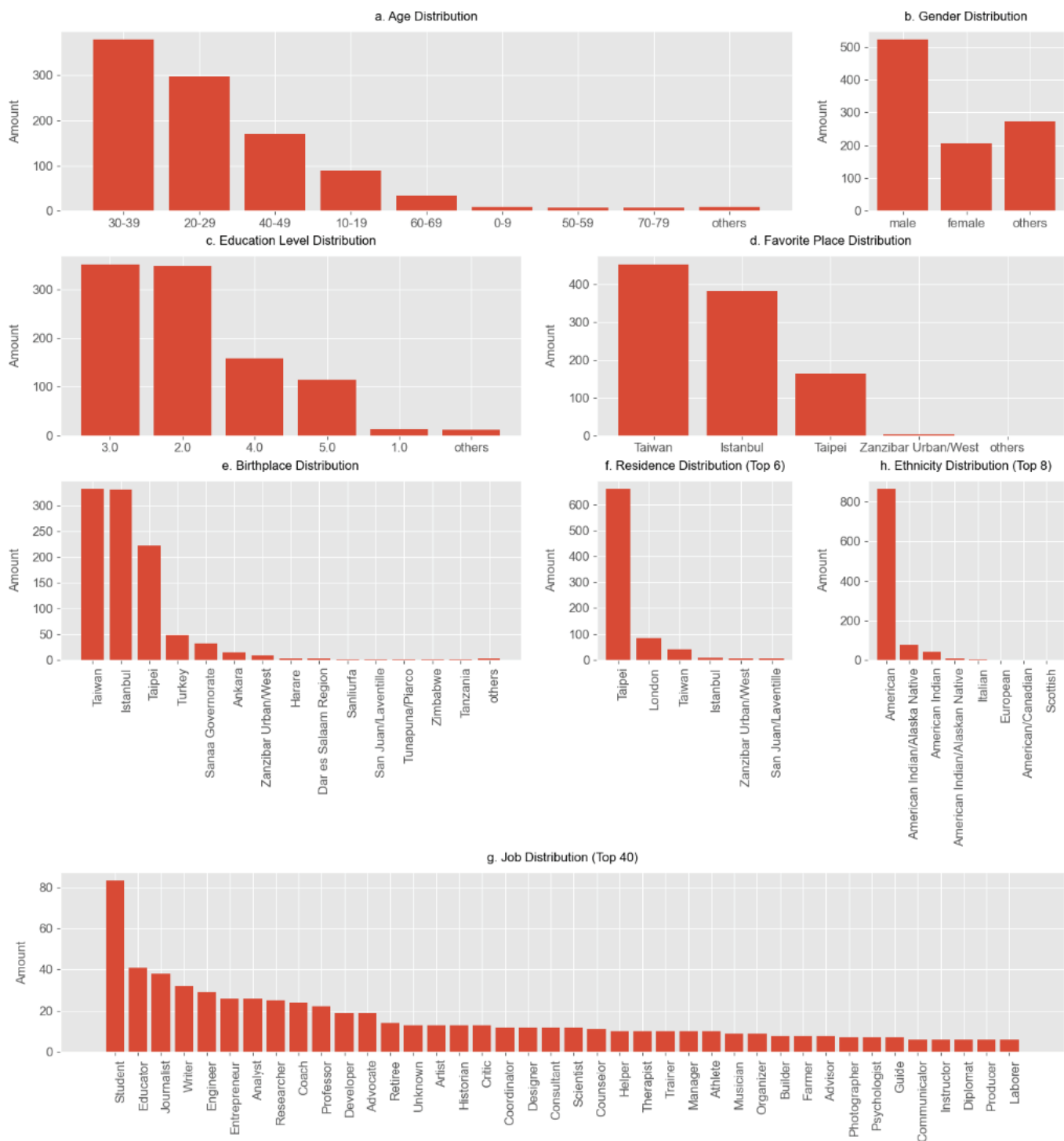


Figure 3. Processes of a small-scale model reasoning



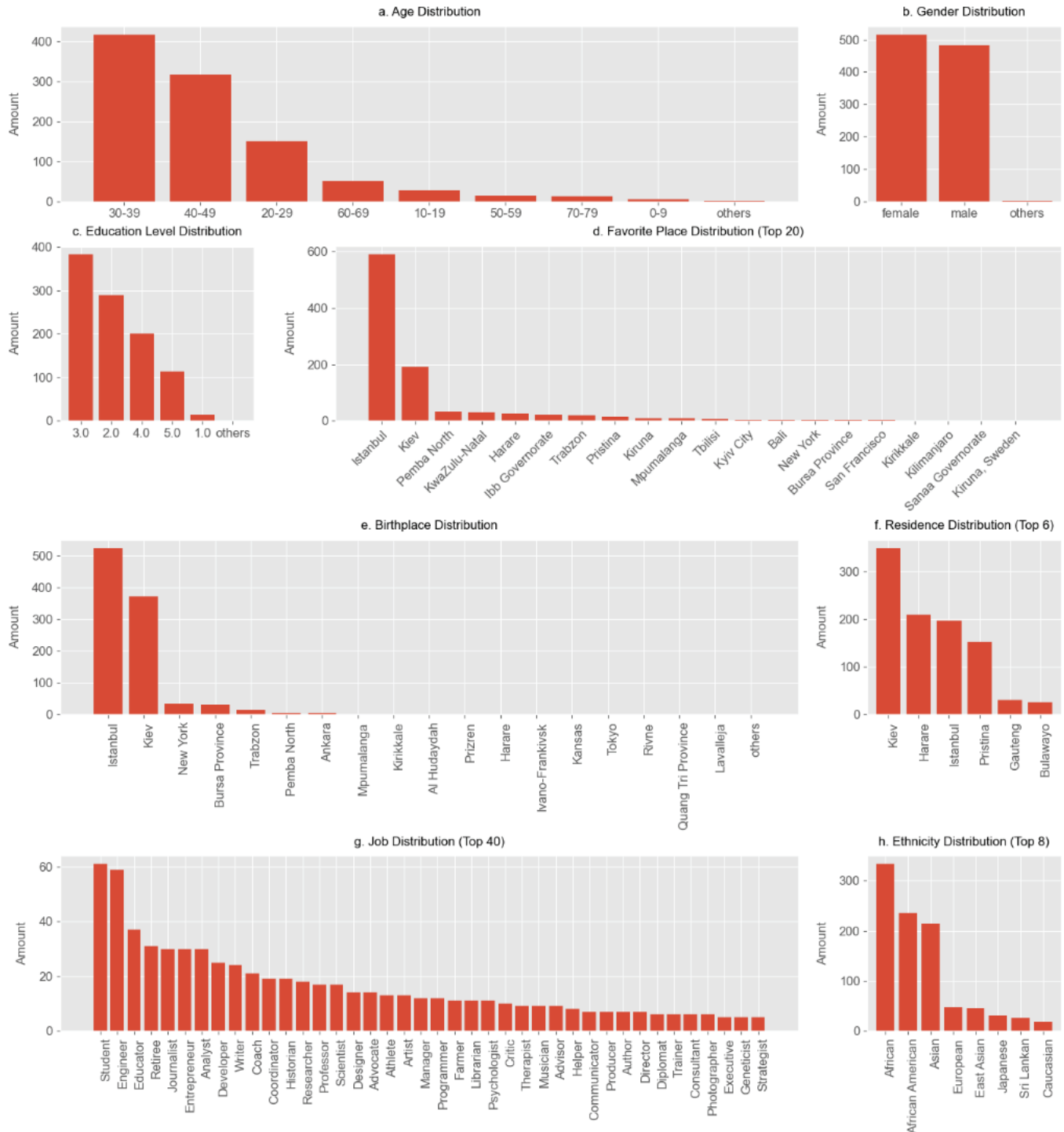
We repeated this reasoning process in 1000 virtual personalities, involving age, gender, occupation, education, place of residence, ethnicity group, birthplace, and favorite place. The results are illustrated in Fig. 4 , 5, 6, and 7. Comparing the results of the four models, the inferential distribution of age and education level is relatively similar, the distribution of age is more in the range of 30-39, and the education level is concentrated in bachelor's degree or equivalent. Gemma2:27B and Qwen2.5:32B show obvious diversity in gender inference. Gemma2:27B in place reasoning is concentrated in Taiwan, Mistral-nemo:12B is concentrated in Istanbul, Harare appears more in Mistral-small:22B's reasoning on place, Qwen2.5:32B is concentrated in Virginia. In terms of ethnicity groups, the results of Gemma2:27B and Mistral-small:22B concentrated in American, Mistral-nemo:12B concentrated in African, and Qwen2.5:32B collectively referred to as white.

Figure 4. Results of Gemma2:27B



The assessments of the assumptions by Qwen2.5:72b are illustrated in Fig. 8 and 9. The bar chart on the left displays the specific numerical distribution of each model in different dimensions, while the bar chart on the right summarizes the overall performance by Qwen2.5:72b of each model in four dimensions. Red means Qwen2.5:72b disagrees with the assumptions. The inference results of the four small-scale models have a low agreement with Qwen2.5:72b.

Figure 5. Results of Mistral-nemo:12B



The distribution of judgment results of four different models (Qwen2.5:32B, Mistral-small:22B, Mistral-nemo:12B, Gemma2:27B) in four different dimensions (age, gender, occupation, education) was presented in Fig. 8. Qwen2.5:32B shows higher accuracy in judgment across four dimensions: age, gender, occupation, and education, particularly in predicting education level. Gemma2:27B demonstrates high accuracy in all four dimensions, particularly in terms of gender and

education level. Mistral-small:22B has relatively low accuracy in these four dimensions, especially in the vocational and educational dimensions. The accuracy of the judgment of Mistral-nemo:12B is similar to that of Mistral-small:22B, but its performance is relatively weak.

Figure 6. Results of Mistral-small:22B

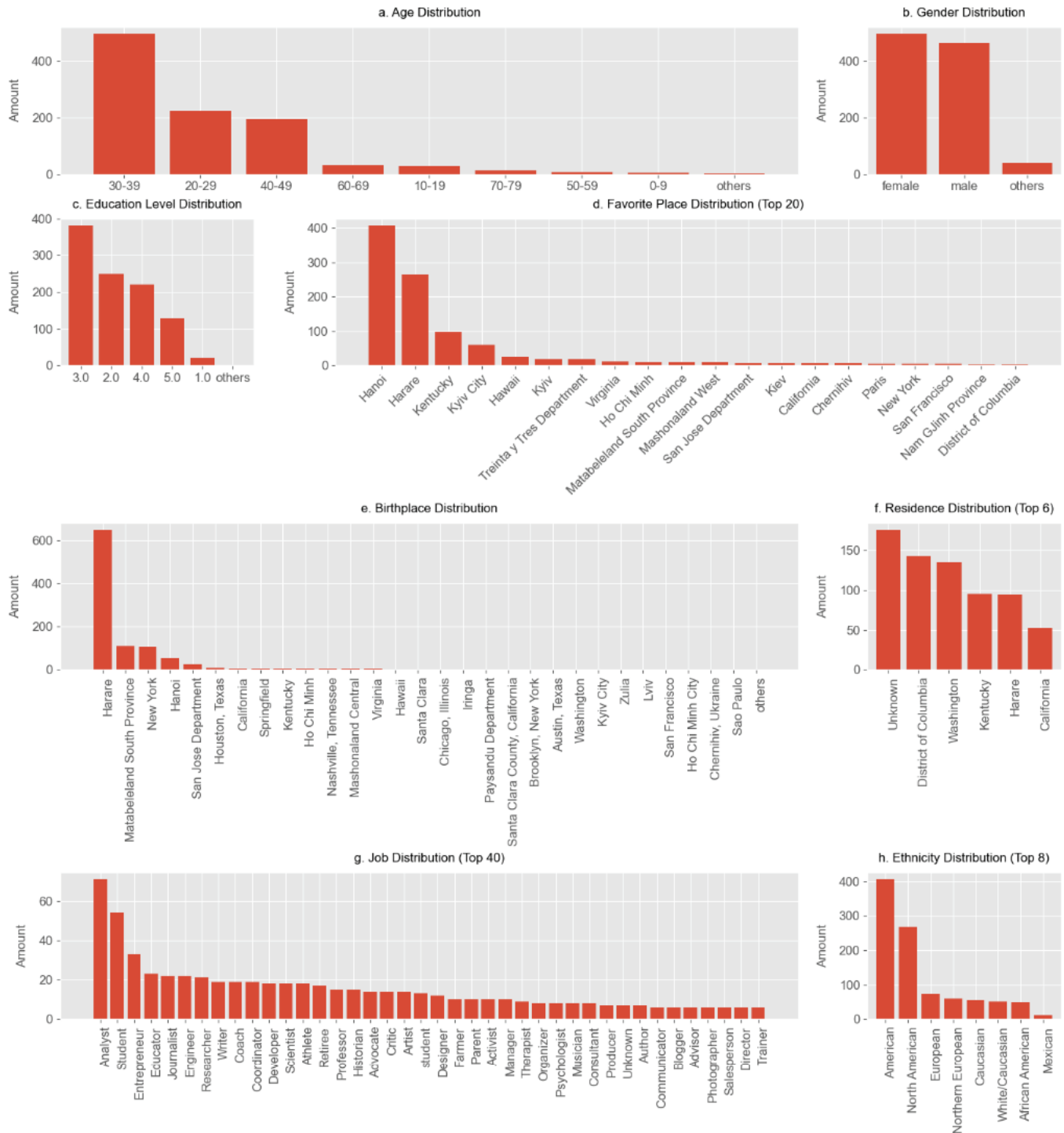
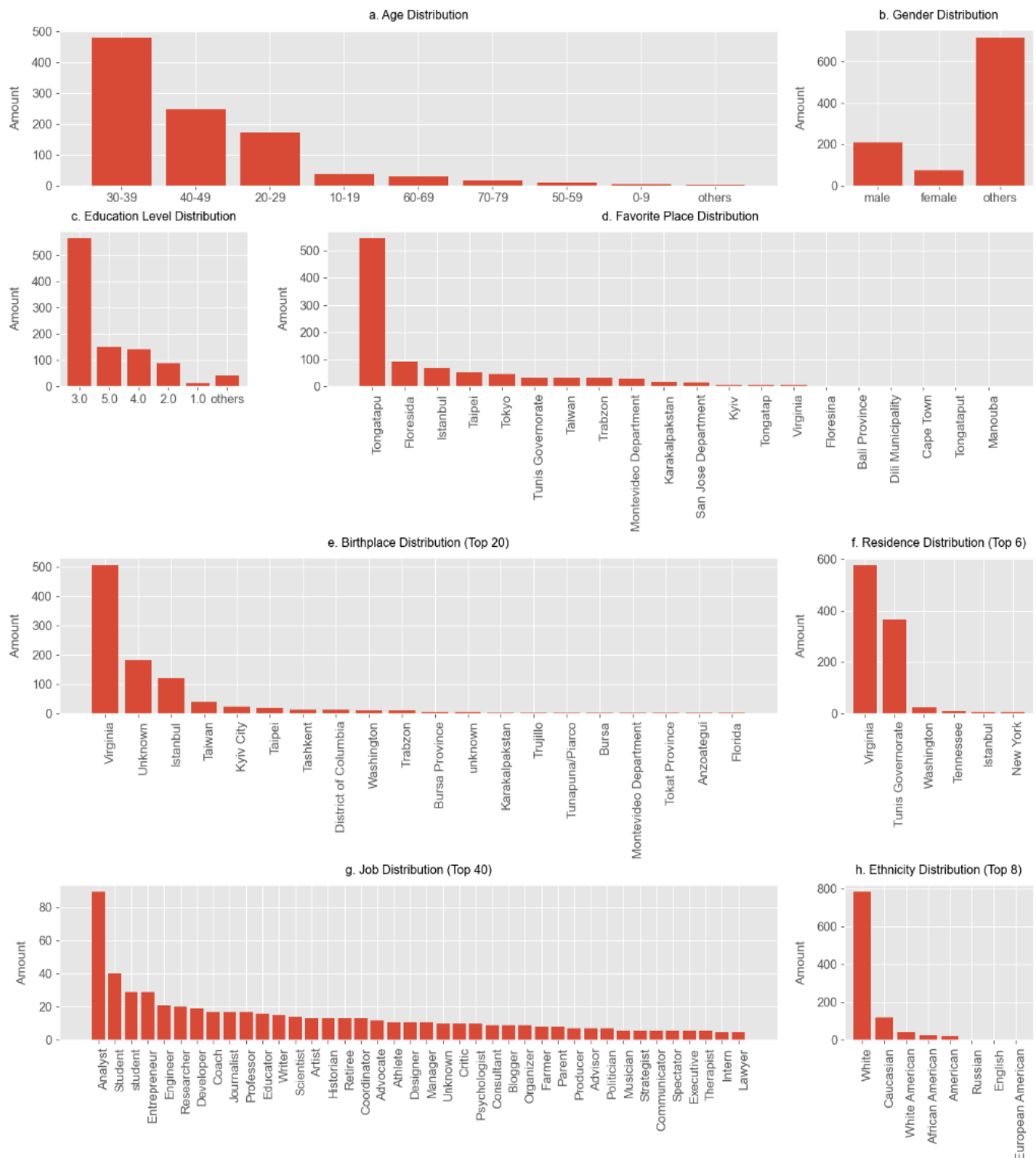


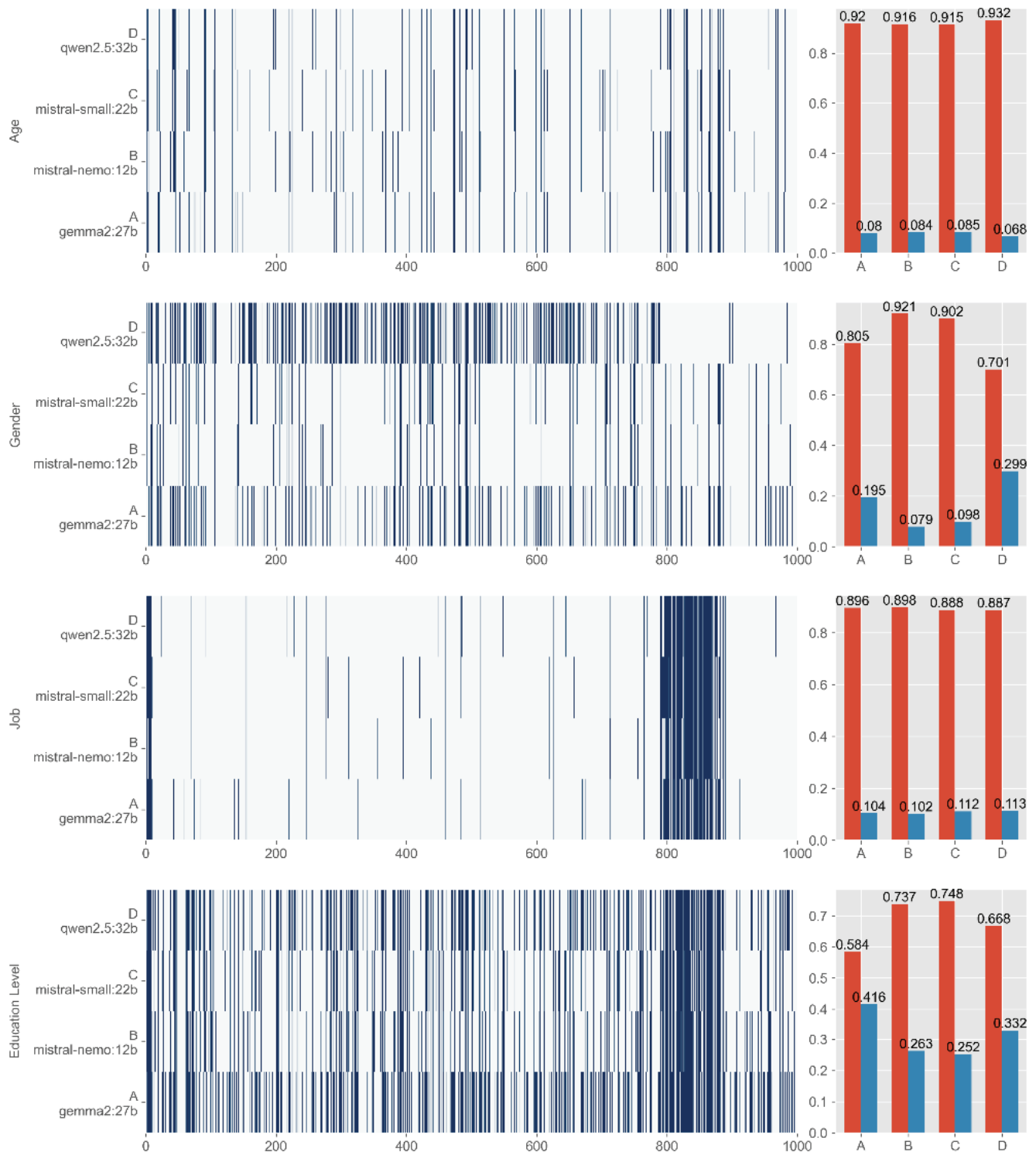
Fig.9 shows the distribution of judgment results of four major language models (Qwen2.5:32B, Mistral-small:22B, Mistral-nemo:12B, Gemma2:27B) in four different dimensions (Birthplace, Favorite Place, Residence, Ethnicity Group). From the graph, there are differences in the performance of the four models in different dimensions, but overall, they perform relatively consistently in certain dimensions. The performance of the four models in the birthplace dimension is consistent, and the numerical distribution is concentrated. The model also exhibits similar distribution characteristics in the favorite place dimension.

Figure 7. Results of Qwen2.5:32B



In terms of residential dimension, the numerical distribution of the model is relatively scattered, but the overall performance is still relatively consistent. Qwen2.5:32b and Mistral-small:22b have relatively better results. On the dimension of ethnic groups, the numerical distribution of the model is relatively uniform, but Gemma2:27B and Mistral-small:22b perform better. Generally, Qwen2.5:32B and Gemma2:27B perform well in multiple dimensions and are suitable for tasks that require complex reasoning and long text generation. Mistral-small:22B and Mistral-nemo:12B perform relatively weakly and are suitable for resource-constrained scenarios. The experiment also utilized small-scale models including DeepSeek-R1 and Llama3.3, however, due to limitations in computing power, the returned results cannot maintain a consistent format.

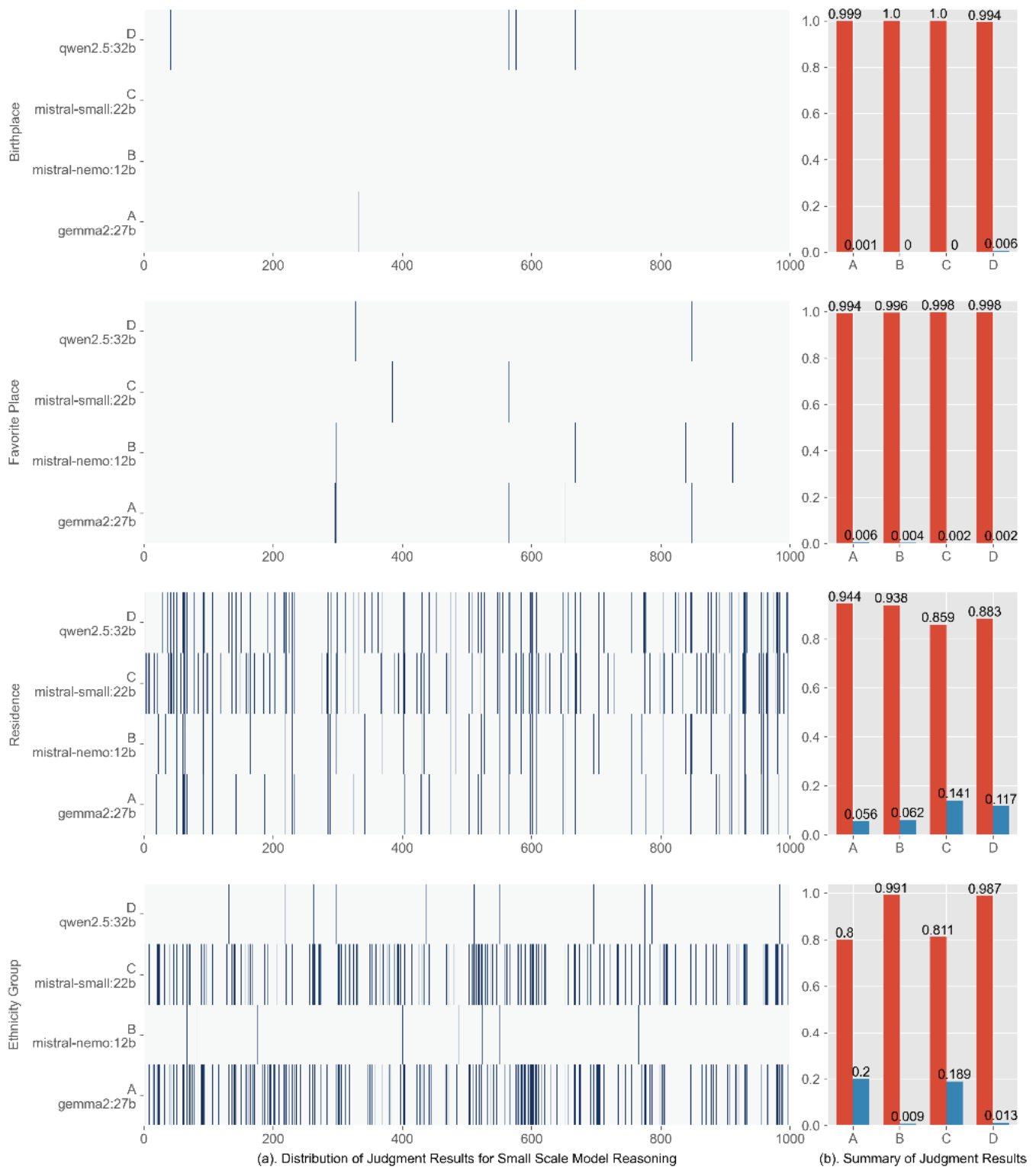
Figure 8. Distribution and summary of judgments for small-scale model reasoning (I)



(a). Distribution of Judgment Results for Small Scale Model Reasoning

(b). Summary of Judgment Results

Figure 9. Distribution and summary of judgments for small-scale model reasoning (II)



5. Discussions and limitations

According to the experimental results, LLM agents have demonstrated certain abilities and potential in playing the role of analysts. LLM agents can combine intuitive information for inference, and the higher the degree of information correlation, the more accurate the inference results. For models below 32 billion, the larger the model size, the higher the accuracy of the inference results.

LLM agents have certain potential in simulating building users by simulating different virtual personalities. This ability stems from its ability to learn and analyze large amounts of data, enabling it to understand and generate conversations and behaviors that fit specific roles. For example, in the experiment mentioned in this article, LLM agents can reason based on the

age, gender, occupation, and other characteristics of virtual personalities, thereby providing feedback on building design or use as building users. This simulation will improve the collection of opinions in the design process and enhance the feedback adjustment process of building operation and maintenance.

In the process of architectural design, LLM agents can provide architects with a more comprehensive perspective and solutions by analyzing the architectural cultures and styles of different regions and ethnic groups. The experimental results show that LLM exhibits high accuracy in inferring users' education level, occupation, and place of residence, especially in predicting their education level. LLM can better understand the user's background, acting as both an architect to design and a user to provide feedback, thus better meeting the user's needs in the design. In the process of building operation and maintenance, LLM can optimize the operating parameters of building equipment and achieve predictive feedback adjustment while understanding the user background. The interactive ability of LLM agents can significantly enhance the user experience in the architectural design process.

Through interaction with virtual personalities, users can express their needs and preferences more intuitively, while LLM can provide real-time feedback and adjust design plans. This dynamic interaction not only improves the efficiency of the design but also allows users to feel a higher sense of participation and satisfaction throughout the entire process. Although LLM performs well in role-playing and user simulation, experiments have also revealed specific tendencies in its generated content. This tendency may stem from the quality and diversity of its training data. The architectural aesthetics and traditions vary among different regions and ethnic groups, and LLM may be limited by its training data when simulating these diversities.

This study also has some limitations. Firstly, the model parameters used in the study are relatively small, which may limit the accuracy and comprehensiveness of inference. In the future, larger-scale models should be considered for validation. The experimental design mainly focuses on language comprehension tasks, lacking in-depth exploration of other cognitive functions, which may affect the comprehensive understanding of LLM thinking mechanisms. In addition, the paper did not fully discuss the ethical and social impacts of LLM-generated content, and future research should strengthen the exploration of such issues to ensure responsible use of the technology.

Therefore, in practical applications, architects need to carefully evaluate the content generated by LLM to ensure that it complies with local culture and design standards. Future research can further explore how to optimize the training data of LLM to enhance its adaptability and accuracy in the field of architectural design. In addition, combining more user feedback and practical cases can provide richer materials for LLM's role-playing ability, thereby enhancing its performance in simulating building user experience.

6. Conclusions

This article explores the abilities and tendencies of LLM in portraying virtual personalities through experiments and finds that LLM has the potential to simulate building users and provide feedback to improve the design process. Through experimental design, LLM is used as an analyst to infer virtual personality databases. The research involves the comparison and evaluation of multiple models. The experimental questions cover the characteristics of virtual individuals such as age, gender, ethnicity, occupation, education level, place of birth, place of residence, and preferred location. Evaluate the performance of different models in various dimensions by reasoning and judging 1000 virtual individuals. The experimental results show that LLM exhibits certain abilities in inferring virtual personalities, especially in terms of educational level and professional reasoning. There are differences in inference accuracy and consistency among different models, with Qwen2.5:32B and Gemma2:27B performing relatively well.

LLM agents have demonstrated strong potential in simulating building user experience, providing valuable support for architectural design through their role-playing and data analysis capabilities. However, it is still necessary to pay attention to the tendency of its content generation and combine it with the specific needs of users in practical applications to achieve higher-quality design results.

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Conflict of Interests

The authors declare that there is no conflict of interest regarding the publication of this paper.

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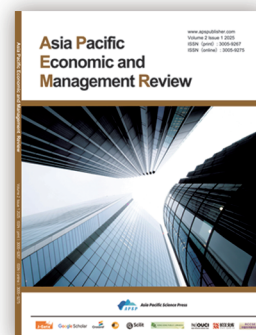
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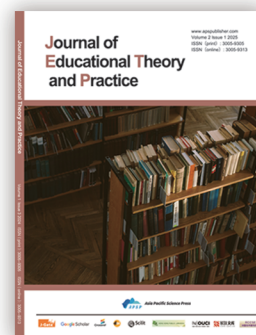
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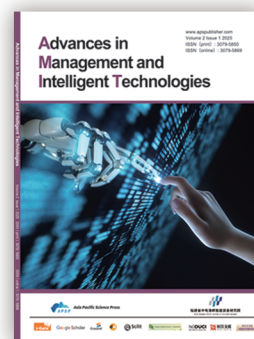
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